THE
RADIO CONSTRUCTOR

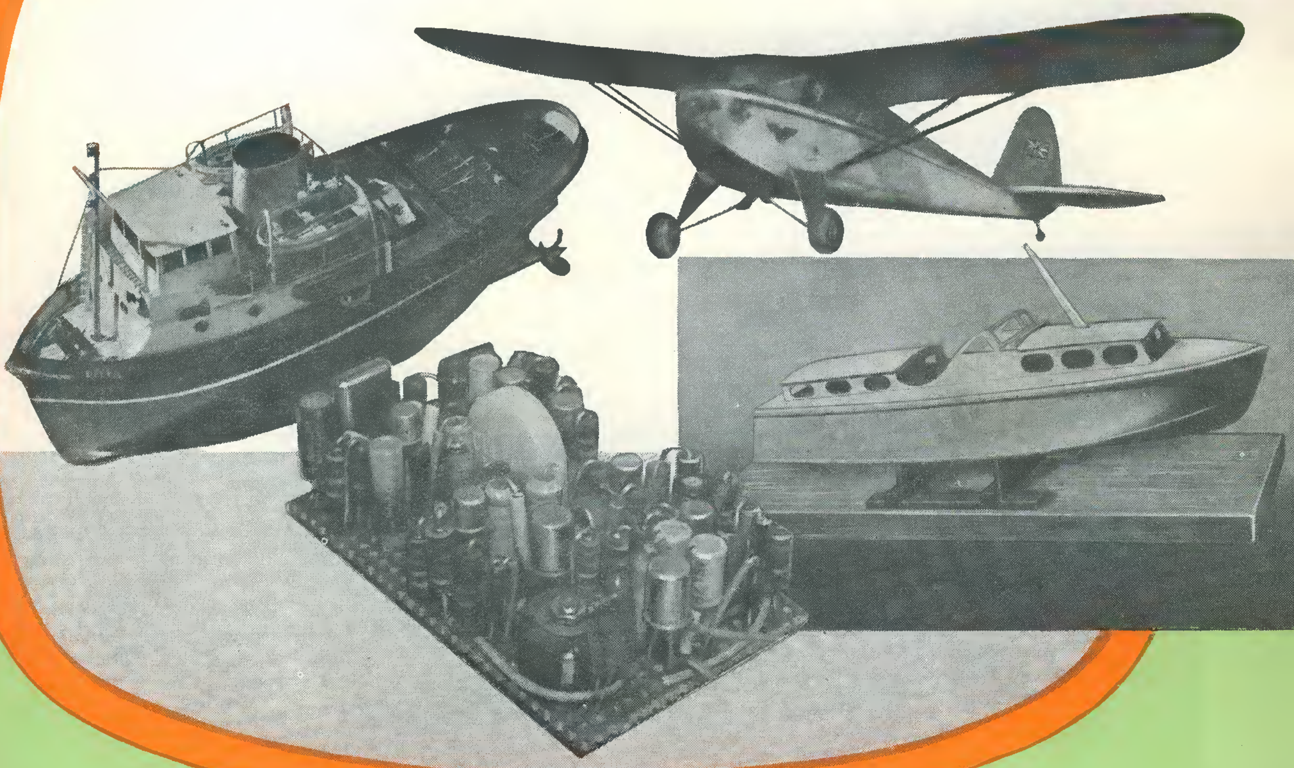
Vol 21 No 1

AUGUST 1967
2/6

A DATA PUBLICATION

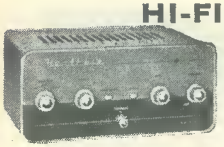
RADIO · TELEVISION
ELECTRONICS · AUDIO

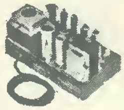
The SCT/RS1 Superhet Model Control Receiver



10 Watt P.A. Amplifier ★ Windscreen Wiper Programmer ★ Simple Short Wave Converter ★ Combined AF/RF Signal Generator

HI-FI AMPLIFIERS — TUNERS — RECORD PLAYERS


3+3W STEREO AMP. S-33H


10W POWER AMP. MA-12

10W POWER AMPLIFIER. Model MA-12. 10W output, wide freq. range, low distortion. For use with control unit. Kit **£12.18.0** Assembled **£16.18.0**

STEREO CONTROL UNIT. Model USC-1. Ideal for use with the NA-12 power amplifiers. Push button selection, ganged controls, tumble and variable low-pass fitters. Kit **£19.19.0** Assembled **£27.5.0**

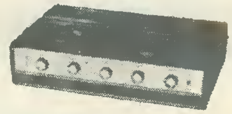
DE LUXE STEREO AMPLIFIER. Model S-33H. 3+3 watt output with two-tone grey perspex panel, and higher sensitivity necessary to accept the Decca Deram pick-up. Kit **£15.17.6** Assembled **£21.7.6**

HI-FI STEREO AMPLIFIER. Model S-99. 9+9W output. Ganged controls. Stereo/Mono gram., radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£28.9.6** Assembled **£38.9.6**

TRANSISTOR PA/GUITAR AMPLIFIER, PA-2. 20W amplifier. Four inputs. Variable tremolo. **New Low Price** Kit **£39.19.0** Assembled **£54.10.0**

50W VALVE PA/GUITAR AMP., PA-1. Kit **£54.15.0** Assembled **£74.0.0**


GARRARD PLAYER AT-60


20+20W STEREO AMP. AA-22U

TRANSISTOR MIXER. Model TM-1. A must for the tape enthusiast Four channels. Battery operated. Similar styling to Model AA-22U Amplifier. With cabinet. Kit **£11.16.6** Assembled **£16.17.6**

20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U. Outstanding performance and appearance. Kit **£39.10.0** (less cabinet).. Assembled **£57.10.0** Attractive walnut veneered cabinet £2.5.0 extra.

GARRARD AUTO/RECORD PLAYER. Model AT-60. less cartridge **£14.12.10** With Decca Deram pick-up **£19.7.4** incl. P.T. Many other Garrard models available, ask for Lists.

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Attractive modern styling. Kit **£11.9.6** Assembled **£15.15.0**

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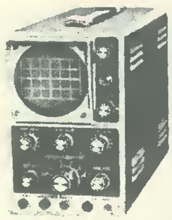
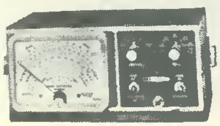
INSTRUMENTS


OS-2

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" × 7½" × 12" deep. Wt. only 9¾lb. "Y" bandwidth 2 c/s-3 Mc/s ±3dB. Sensitivity 100mV/cm. T/B 20 c/s-200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling. Kit **£23.18.0** Assembled **£31.18.0**

5" GEN-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s–4.5 Mc/s ±3dB. T/B 10 c/s–500 kc/s. Kit **£35.17.6** Assembled **£45.15.0**


IM-13U

DE LUXE LARGE-SCALE VALVE VOLTMETER. Model IM-13U. Circuit and specification based on the well-known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling. Kit **£18.18.0** Assembled **£26.18.0**

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%, 10V sine wave output metered in volts and dB's. Kit **£23.15.0** Assembled **£31.15.0**

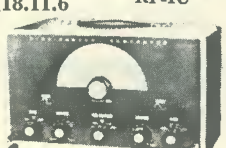

V-7A

VALVE VOLTMETER. Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1 Ω to 1,000M Ω with internal battery. D.c. input resistance 11M Ω. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery. Kit **£13.18.6** Assembled **£19.18.6**


RF-1U

MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0.2 Ω to 20M Ω. 4½" 50μA meter. Kit **£12.18.0** Assembled **£18.11.6**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100mV output. Kit **£13.18.0** Assembled **£20.8.0**

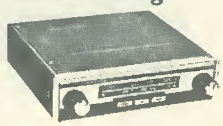

IG-82U

SINE/SQUARE GENERATOR. Model IG-82U. Freq. range 20 c/s–1 Mc/s in 5 bands less than 0.5% sine wave dist. less than 0.15μ sec. sq. wave rise time. Kit **£25.15.0** Assembled **£37.15.0**

TRANSISTOR POWER SUPPLY. Model IP-20U. Up to 50V, 1.5A output. Ideal for Laboratory use. Compact size. Kit **£35.8.0** Assembled **£47.8.0**

MO Prices quoted Retail Prices in general slightly higher.

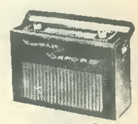
Complete your motoring pleasure with this outstanding CAR RADIO, Model CR-1



Will give you superb LW and MW entertainment wherever you drive. Tastefully styled to harmonise with any car colour scheme. Available for your convenience in two separate parts, RF Amp. Kit £1.13.6 incl. P.T. IF/AF Amp. Kit £11.3.6.

Total Price Kit (excl. Loudspeaker) **£12.17.0** incl. P.T. 8" × 5" Loudspeaker £1.16.1 incl. P.T.

TRANSISTOR RADIOS


UXR-2

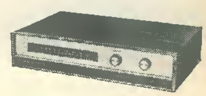
"OXFORD" LUXURY PORTABLE. Model UXR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Kit **£14.18.0** incl. P.T.


UXR-1

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" × 4" loud-speaker. Real hide case. Kit **£12.11.0** incl. P.T.

JUNIOR EXPERIMENTAL WORKSHOP Model EW-1. More than a toy! Will make over 20 exciting electronic devices, incl: Radios, Burglar Alarms, etc. 72 page Manual. The ideal present! Kit **£7.13.6** incl. P.T.

STEREO TRANSISTOR FM TUNER
(Mono version also available)
14 transistor, 5 diode circuit. Tuning range 88–108 Mcc/s. Designed to match the AA-22U Amplifier. Available in separate units, can be built for a total price.
Kit (Stereo) **£24.18.0** incl. P.T.
Kit (Mono) **£20.19.0** incl. P.T.
Cabinet extra £2.5.0.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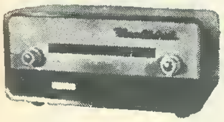
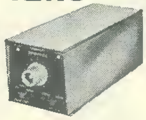


FM TUNER FM-4U

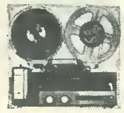


STEREO DECODER SD-1

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and I.F. amplifier unit, with power supply and valves (£13.13.0). May be used free standing or in a cabinet. Total Kit **£16.8.0**
(Multiplex adapter available, as extra.)

HI-FI AM/FM TUNER. Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£22.11.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Kit **£27.5.0**
(Multiplex adapter available, as extra.)

STEREO DECODER. Model SD-1. Converts FM Mono receivers to stereo at low-cost. Styled to match Heathkit models FM-4U and AFM-1 Tuners. Kit **£8.10.0** Assembled **£12.5.0**



TRUVOX DECK

AM/FM TUNER

MAGNAVOX "363" TAPE DECK. The finest buy in its price range. Operating speeds: 1⅞", 3¾" and 7½" p.s. Two tracks, "wow" and "flutter" not greater than 0.15% at 7½" p.s. **£13.10.0**

TRUVOX D106 TAPE DECKS. High quality stereo/mono tape decks. **D106,** ½ track, **£39.15.0 D108,** ¼ track, **£39.15.0**

TAPE RECORDING/PLAYBACK AMPLIFIER
Mono Model TA-IM kit **£19.18.0** Assembled **£28.18.0**
Stereo Model TA-IS kit **£25.10.0** Assembled **£35.18.0**

HI-FI CABINETS. A wide range available for example: Malvern Kit **£18.1.0** incl. P.T. Gloucester Kit **£18.10.0**

MONO CONTROL UNIT. Model UMC-1. Designed to work with the MA-12 or similar amplifier requiring 0.25V or less for full output. 5 inputs. Baxandall type controls. Kit **£9.2.6** Assembled **£14.2.6**

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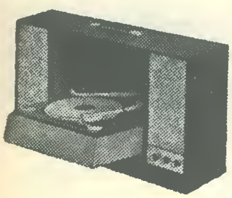
New! Portable Stereo Record Player, SRP-1



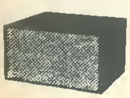
Automatic playing of 16, 33, 45 and 78 rpm records. All transistor—cool instant operation. Dual LP/78 stylus. Plays mono or stereo records. Suitcase portability. Detachable speaker enclosure for best stereo effect. Two 8in x 5in. special loudspeakers. For 220-250V a.c. mains operation. Overall cabinet size 15 9/16 x 3⅞ x 10¼in.

Compact, economical stereo and mono record playing for the whole Family—plays anything from the Beatles to Bartok. All solid-state circuitry gives room filling volume.
KIT £27.15.0 Assembled **price on request.**

SPEAKER SYSTEMS

SSU-1

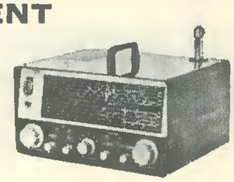
HI-FI SPEAKER SYSTEM, Model SSU-1
Ducted-port bass reflex cabinet in the white: Two speakers, vertical or horizontal models with legs. **KIT £12.12.0,** without legs, **KIT £11.17.6** incl. PT.



AVON MINI SPEAKER SYSTEM
6¼" Bass, 3¾" Treble speakers and crossover unit. Kit **£4.18.0** incl. PT. Beautiful. Walnut veneered fully-finished cabinet, **£8.18.0,** Total price Kit **£13.16.0** incl. PT.

"AMATEUR" EQUIPMENT

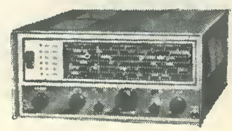
THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transfilters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuits, telescopic aerial, tuning meter and large slide-rule dial.
Kit **£37.17.6** Assembled **£45.17.6**



GC-1U

AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.
Kit **£39.6.6** Assembled **£52.10.0**

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained.
Kit **£81.10.0** Assembled **£106.15.0**



RG-1

COMMUNICATIONS TYPE RECEIVER. Model RG-1. A high performance, low cost receiver for the discriminating listener. Frequency coverage: 600 kc/s-1.5 Mc/s and 1.7 Mc/s–32 Mc/s.
Kit **£39.16.0** Assembled **£53.0.0**

Low-cost 3 + 3W Transistor Stereo Amplifier, TS–23

Incorporating all the essential features for good quality sound reproduction from record, radio and other sources. 16 Transistor, 4 diode circuit. Good frequency response 6 position selector switch. Modern slim line styling.

Kit (less cabinet) **£17.15.0**

Kit (with handsome finished cabinet) **£18.19.0**

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4 2G417 Trans. Eqvt. AF117	10/–
2 200 Mc/s Sil. Trans. NPN BSY26/27	10/–
2 Bi-directional Trans. ASY66 PNP	10/–
3 Zener Diodes 400mW 33V 5% Tol	10/–
4 High Current Trans. OC42 Eqvt.	10/–
2 Power Transistors 1 OC26 1 OC35	10/–
5 Silicon Rects. 400 PIV 250mA	10/–
3 OC71 Transistors Mullard Type	10/–
3 OC75 Transistors Mullard Type	10/–
3 NPN Silicon Trans. 70 Mc/s	10/–
1 Power Trans. OC20 100V	10/–
5 OA47 Gold Bonded Diodes	10/–
4 OA202 Sil. Diodes Sub-min	10/–
2 Low Noise Trans. NPN 2N929/30	10/–
1 Sil. Trans. NPN VCB 100 ZT86	10/–
8 OA81 Diodes (CV448)	10/–
3 OC72 Transistors Mullard Type	10/–
3 OC77 Transistors Mullard Type	10/–
5 Metal Alloy Transistors Mat Type	10/–
4 Sil. Rects. 400 PIV 500mA	10/–
5 GET884 Trans. Eqvt. OC44	10/–
5 GET883 Trans. Eqvt. OC45	10/–
2 GET20 Germ. PNP Trans. with Heat-sink	10/–
3 VHF Sil. Epoxy Trans. NPN 100 Mc/s	10/–
2 2N708 Sil. Trans. 300 Mc/s NPN	10/–
4 GT41/45 Germ. Trans. PNP Eqvt. OC71	10/–
2 GT31 LF Low Noise Germ. Trans. PNP	10/–
6 IN914 Sil. Diodes 75 PIV 75mA	10/–
8 OA95 Germ. Diodes Sub-min IN69	10/–
3 NPN Germ. Trans. NKT773 Eqvt. AC130	10/–
2 OC22 Power Trans. Germ.	10/–
2 OC25 Power Trans. Germ.	10/–
2 OC73 Mullard Trans.	10/–
4 AC128 Trans. PNP High Gain	10/–
2 AC127/128 Comp. pair PNP/NPN	10/–
10 Assorted Gold Bonded Diodes	10/–
5 TK22C Germ. Switching Trans.	10/–
3 2N1307 PNP Switching Trans.	10/–
3 OC76 Mullard Trans.	10/–
20 Germ. Diodes General Purpose	10/–
7 CG62H Germ. Diodes Eqvt. OA71	10/–
3 OC170 Trans. Mullard Type	10/–
3 AF116 Mullard Type Trans.	10/–
12 Assorted Germ. Diodes Marked	10/–
1 30 Amp Power Rectifier 100 PIV	10/–
4 AC126 Germ. PNP Trans.	10/–
5 1 Amp Germ. Rect. 200 PIV	10/–
4 OA5 Gold Bonded Diodes	10/–
1 ORP61 Photo-conductive cell	10/–
4 Silicon Rects. 100 PIV 750 mA	10/–
3 AF117 Trans. Mullard Type	10/–
7 OC81 Type Trans.	10/–
3 OC171 Trans. Mullard Type	10/–
1 ORP12 Photo-conductive cell LDR03	8/6
2 10A 600 PIV Sil. Rects. IS425R	15/–
3 BC108 Sil. NPN High Gain Trans.	15/–
2 Zener Diodes 25W 18 and 22V	15/–
1 2N910 NPN Sil. Trans. VCB100 80 Mc/s	15/–
2 1000 PIV Sil. Rect. 1.5A RS310 AF	15/–
3 High Volt. AF Trans. PNP ACY17	15/–
3 BSY95A Sil. Trans. NPN 200 Mc/s	15/–
3 OC200 Sil. Trans. Mullard	15/–
2 Sil. Power Rects. BYZ13	15/–
1 AF139 VHF Germ. Trans. 1500 Mc/s	15/–
1 Sil. Power Trans. NPN 100 Mc/s TK201A	15/–
6 Zener Diodes 3–15V Sub-min	15/–
1 2N1132 PNP Epitaxial Planar Sil. Trans.	15/–
2 2N697 Epitaxial Planar Trans. Sil.	15/–
4 Germ. Power Trans. Eqvt. OC16 Mullard	15/–
1 Unijunction Trans. 2N2646 Eqvt. D5E29	15/–
2 Sil. Trans. 200 Mc/s 60Vcb ZT83/84	15/–
1 Sil. Planar Trans. NPN 100 Mc/s BSY25	15/–
1 Sil. Trans. IS104 150 Mc/s HFE 200 NPN	15/–
2 SCRs 50 PIV 1A TO–5 can	15/–
1 Tunnel Diode IN3720 (TD5) G.E.	15/–
1 Unijunction Trans. 2N2160 TO–5 can G.E.	15/–
2 Sil. Rects. 5A 400 PIV Stud Type	15/–
2 Germ. Power Trans. OC28/29	15/–
1 10A Sil. Stud Rect. 800 PIV	15/–
1 Tunnel Diode AEY11 1050 Mc/s STC	15/–
2 2N2712 Sil. Epoxy Planar HFE225 max.	15/–
1 2N1257 PNP Sil. Planar TO–5 can	15/–
1 Sil. Power Trans. NPN 2S721 85W	15/–
6 2N2926 NPN Sil. Planar Trans.	20/–
6 BY100 Type Sil. Rects.	20/–
25 Sil. and Germ. Trans. Mixed all Marked New	30/–

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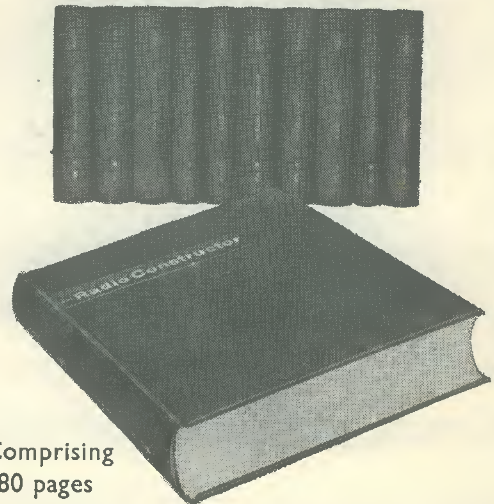

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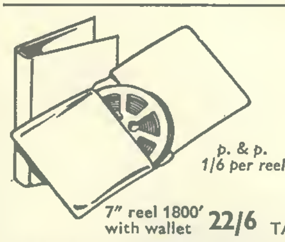

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AF116 ...	3/–	OC41	2/6	2N706 ...	5/–	OC28	5/–
AF117 ...	4/–	OC71	2/6	2N711 ...	10/–	OC35	5/–
AF118 ...	3/6	OC72	2/6	2N1302	4/–	DIODES	
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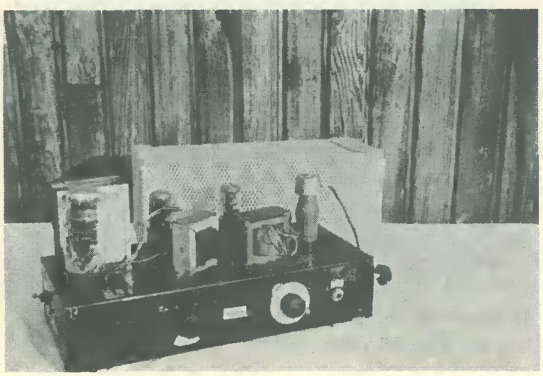
★ 10 WATT P.A. AMPLIFIER

by L. MASON

One method of obtaining public address without tears is to fall back on the tried and trusty valve designs which have given such dependable service over the years. Our contributor describes two amplifiers built up to a sure-fire 10 watt circuit whose operating principles are easy to follow and which employs low-cost valves. Many of the parts should be found in the average spares box and, since layout is not very critical, it is possible to press a discarded radio chassis into service and thereby avoid time-consuming metalwork

In these days of hi-fi, 0.1% distortion, and all that goes with first class musical reproduction, it must not be forgotten that there is still a need for high gain amplifiers with less exacting requirements and at a reasonable cost. For public address systems, sound reinforcement in large halls and even for party music, 5% distortion would hardly be noticeable and is probably much better than is given by the average TV or radio.

Moreover, a considerable saving of cost can be made if existing components from the spares box can be used and a former radio chassis is adapted for rebuilding. Many radio sets of twenty years vintage and using octal valves are ready for dismantling, and will yield a good chassis complete with valveholders. The reliability of octal valves which are still easily and cheaply obtainable, makes them ideal for p.a. work.



The amplifier of Fig. 2 with the cover removed. Note the screened top-cap connector for V_1

The writer uses an extremely trouble-free octal amplifier design offering 10 watts output for p.a. work.[1] This amplifier has no negative feedback, and an output of 10 watts with only 5% distortion can be obtained from a microphone input of 15mV. Musical reproduction is also quite satisfactory. The writer has built two of these amplifiers on old radio chassis, one of which has had two years' regular use for speech reinforcement in a Church building measuring approximately 60 by 40ft. It drives two column units, each containing three loudspeakers.

Circuit design

The first stage, see Fig. 1, consists of a pentode voltage amplifier. If particularly low noise and hum qualities are required, the Mullard EF37A is ideal here. The phase splitter is a Schmitt cathode coupled stage using a high-mu double triode type 6SL7GT. The first stage is resistance-capacitance coupled to one grid of the phase splitter and the Gram input is fed into the second grid, each input being governed by a volume control. The output stage consists of two 6V6G or 6V6GT beam tetrodes in push-pull, with a common cathode bias resistor and bypass capacitor. The screen grids are fed from a potential divider which includes the cathode resistor and maintains very stable working of this stage. The high wattage ratings of these resistors must be adhered to. R18 in particular gets quite hot and must be given adequate ventilation and kept clear of adjacent components.

Construction

Component layout depends entirely upon the

[1]This is based on a design published in the Brimar valve manual series, and due acknowledgement is given to Thorn—A.E.I. Radio Valves and Tubes, Ltd.

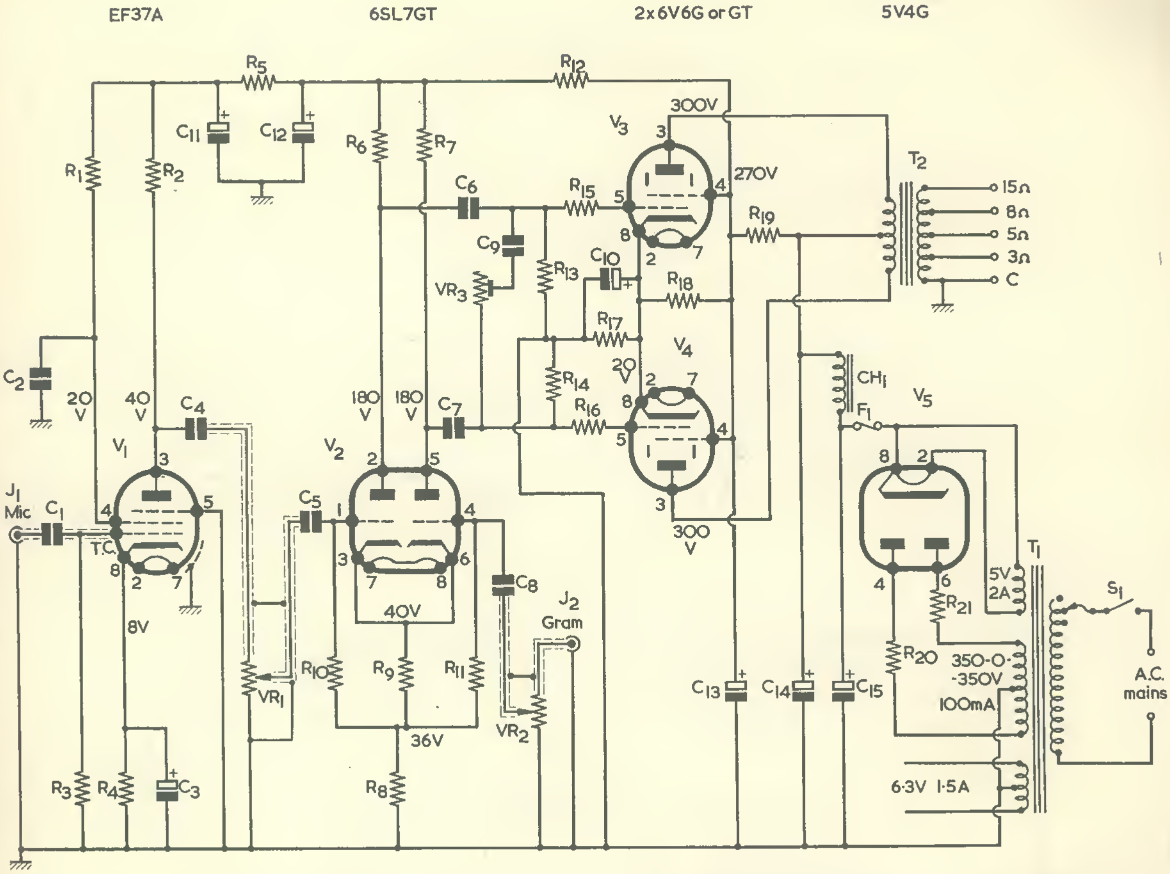


Fig. 1. The circuit of the push-pull 6V6 amplifier. The voltage readings shown were obtained with a 2,000 ohm per volt meter. The current ratings given for T_1 heater secondaries are minimum figures, and currently available mains transformers with the requisite h.t. secondary will normally have higher heater current ratings

chassis available and, to give an idea of what is required, two practical layouts are shown. Small components can be mounted on tagboards, the exact size and location of which again depends upon availability. It is best to use one board for the h.t. resistors and one for the grid and cathode components. Double-ended tags are preferred. The chassis wiring can then be soldered to one end of the tags and the components to the other, making any component replacement easier. Since the electrolytic capacitors are of low value, small tubular types of adequate voltage rating can be used, these being mounted under the chassis.

The two greatest difficulties in high gain amplifiers are the elimination of mains hum and the avoidance of feedback causing instability. With the adequate h.t. decoupling used on this amplifier, instability is easily avoided if anode, grid and cathode wires are kept separate to avoid capacitative coupling between these circuits. The elimination of hum will be discussed as the construction of different parts of the circuit is described.

A chassis of approximately 12 x 8in or equivalent area, and 3in deep, will give ample room for all the components, and a steel chassis will give greater freedom from hum than an aluminium one. Valve and transformer positions should first be decided upon. The existing valve positions will usually suffice. If there are not enough valveholders, one can be fitted in a hole originally provided for an upright electrolytic capacitor or an intermediate frequency transformer.

Since a new mains transformer of sufficient current rating will probably have to be purchased, an upright mounting one will be easier to fit and will give greater freedom from hum. It will also take up no under-chassis space, as would a drop-through type. Its size will probably decide its location, which should be nearer the rectifier and output valves.[2]

[2]The advertisements for the mains transformer specified in the Components List do not normally mention the existence of a centre-tap on the 6.3 volt heater winding, as is shown in Fig. 1. R.S.C. Hi-Fi Centres Ltd. advise us, however, that such a tap is in practice provided with this transformer.—Editor.

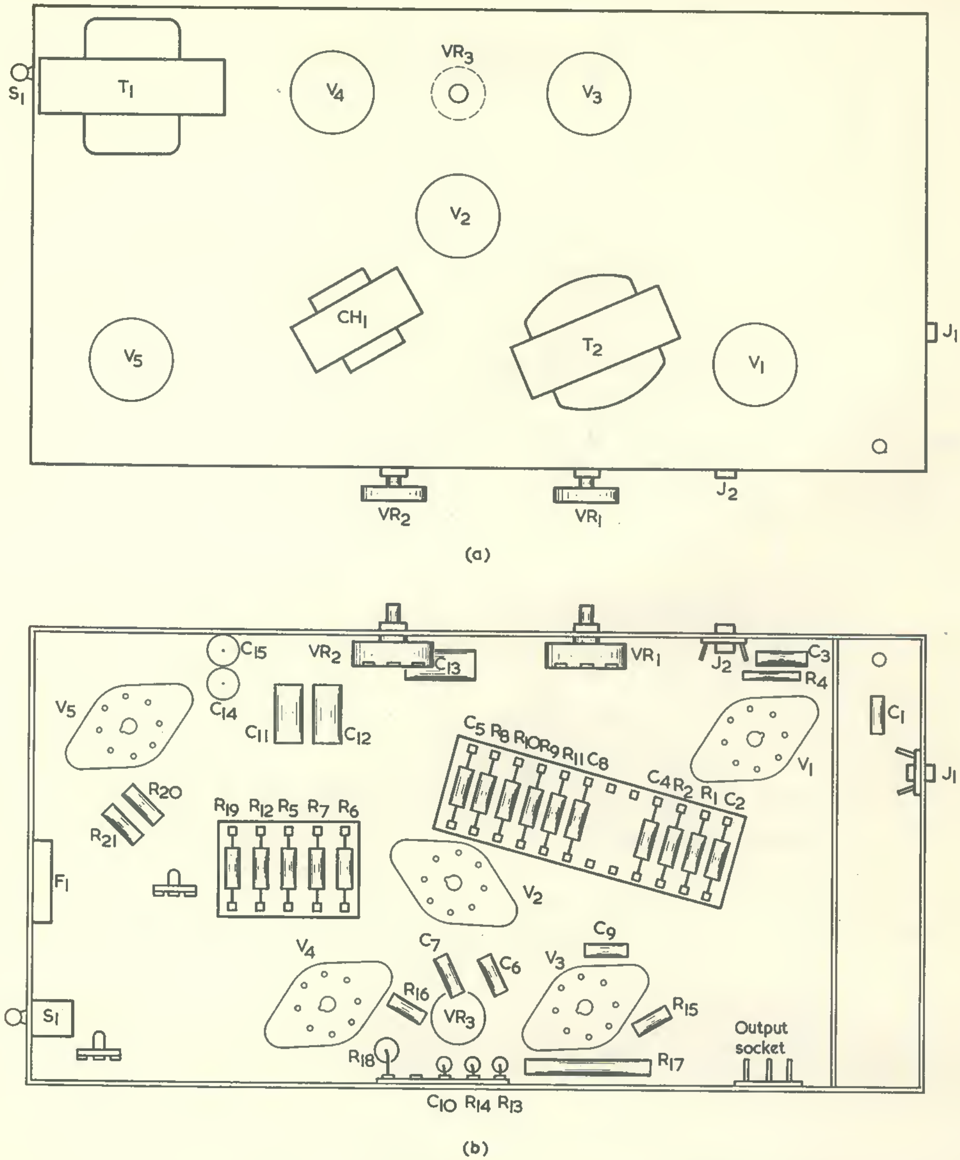


Fig. 2. Above-chassis view (a) and below-chassis view (b) of one of the amplifiers built by the author. This is constructed on a discarded radio chassis which already had five convenient holes suitable for octal valveholders

Any isolated valve position is best used for the first valve and the valves may be located as nearly as possible in the order in which they appear in the circuit.

Having determined the best location of the valves and mains transformer, the choke can now be positioned for minimum hum pick up. The choke requires an adequate current rating and a former TV choke will often prove suitable. To insure that no mains hum will be induced into the choke from the mains transformer, a pair of headphones is connected to the choke and, after making quite certain that its secondary leads are safely insulated and not shorting, the mains transformer can be connected to the mains supply temporarily by means of a small terminal block. When the choke is held close to the mains transformer, a slight hum will be heard in the phones. The choke should then be moved an inch or so away and rotated until a hum-free position is found. The output transformer can be positioned similarly,

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)

R_1	1 MΩ, high stab.
R_2	220kΩ, high stab.
R_3	220kΩ, high stab.
R_4	1kΩ
R_5	47kΩ
R_6	100kΩ, 5%
R_7	100kΩ, 5%
R_8	47kΩ
R_9	2.2kΩ
R_{10}	1MΩ
R_{11}	1MΩ
R_{12}	22kΩ
R_{13}	220kΩ, 5%
R_{14}	220kΩ, 5%
R_{15}	4.7kΩ
R_{16}	4.7kΩ
R_{17}	220kΩ, 5 watt
R_{18}	15kΩ, 10 watt
R_{19}	1.5kΩ, 5 watt
R_{20}	100–500Ω (see text)
R_{21}	100–500Ω (see text)
VR_1	500kΩ potentiometer, log
VR_2	500kΩ potentiometer, log
VR_3	250kΩ potentiometer, linear, preset

Capacitors
(All capacitors 450V wkg. unless otherwise stated)

C_1	0.01μF, 150V wkg.
C_2	0.1μF
C_3	12μF, electrolytic, 6V wkg.
C_4	0.02μF
C_5	0.01μF, 250V wkg.
C_6	0.01μF
C_7	0.01μF
C_8	0.01μF, 250V wkg.
C_9	0.002μF, 150V wkg.
C_{10}	50μF, electrolytic, 25V wkg.
C_{11}	4μF, electrolytic
C_{12}	4μF, electrolytic
C_{13}	8μF, electrolytic
C_{14}	8μF, electrolytic
C_{15}	8μF, electrolytic

Inductors

T_1	Mains transformer, upright mounting. Secondaries: 350–0–350V, 100mA; 6.3V, 4A, c.t.; 0–5–6.3V, 3A. (See caption to Fig. 1)
T_2	Push-pull 10–12 watt, to match 2 6V6's to 3, 5, 8 or 15Ω
CH_1	10H, 100mA

(All inductors may be obtained from R.S.C. Hi-Fi Centres Ltd., 102 Henconner Lane, Bramley, Leeds 13)

Valves

V_1	EF37A
V_2	6SL7GT
V_3	6V6G or 6V6GT
V_4	6V6G or 6V6GT
V_5	5V4G

Fuse

F_1	250mA fuse, with holder

Switch

S_1	s.p.s.t., toggle

Sockets

$J_{1,2}$ Input jacks
5 octal valveholders
Speaker outlet socket (see text)

Miscellaneous

Screened top cap connector (for V_1)
2 knobs
Screened wire
Chassis (see text)

with the headphones connected to the primary winding. If a new output transformer has to be purchased, one of adequate wattage rating, to match two 6V6 valves in push-pull, should be obtained. It will be worth the few extra shillings to obtain a transformer with a tapped secondary winding to suit any combination of loudspeakers likely to be used. The transformers and choke can now be bolted to the chassis using any available holes, and near enough to the suitable positions. This partly accounts for the angles at which the components appear in the typical layouts of Figs. 2 and 3.

The tagboards are then fixed under the chassis. Often some of the bolts can be used both for transformers above and tagboards beneath. There will probably be enough holes in the front or ends of the chassis for the volume controls and input sockets. If there are no end pieces, it will be advisable to make some from sheet metal to protect the components and to give complete screening.

The position of the small components has now to be determined and a sketch may be made of the tagboards and valveholders, showing point to point wiring. The h.t. electrolytic capacitors may be held in clips and additional small tagstrips will be required for the heater connections to the mains transformer and the rectifier anode stopper resistors. Coloured wiring helps in identification and the drawing can be similarly coloured. Usual colours are:

H.T. and anode wiring	—Red
Screen grid wiring	—Orange
Control grid wiring	—Green

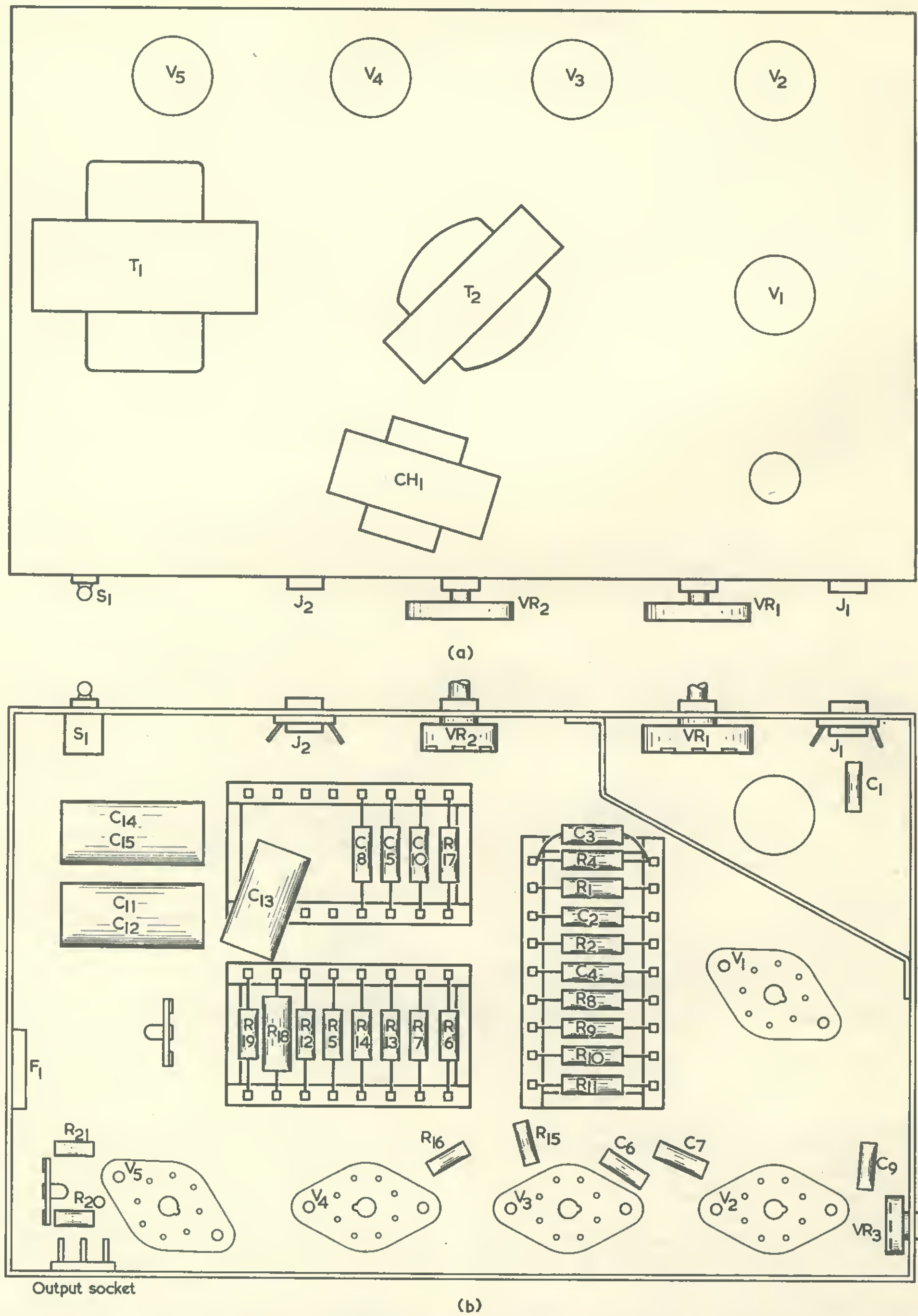


Fig. 3. As an illustration of the ease with which discarded radio chassis may be employed for the amplifier, this diagram gives the top view (a) and below-chassis view of another amplifier constructed to the circuit of Fig. 1. Note that, both here and in Fig. 2, valveholders appear in virtually the same order as in the circuit diagram, with V_1 farthest away from V_5. In this layout C_5 and C_8 connect to the grids of V_2 via screened cable

Cathode wiring —Yellow
Earth wiring —Black or bare
High voltage a.c. wiring —Blue or violet.

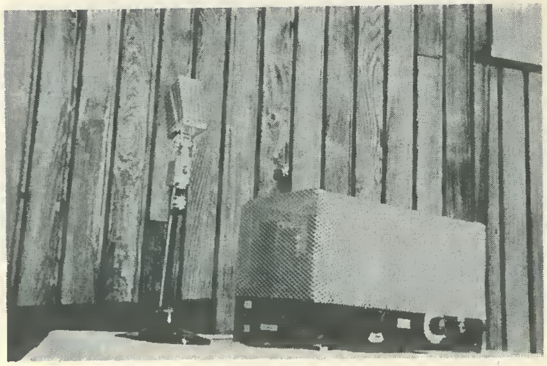
When wiring passes through the chassis, the holes should always be fitted with grommets. The provision of an h.t. fuse is a wise precaution.

Wiring

Chassis wiring commences with the valve heater leads. Mains twin flex, p.v.c. covered is ideal. Flex with "figure-8" section should be twisted before fitting, and twisted flex should be more tightly twisted to cancel hum fields. The heater leads from the mains transformer can be connected to the heater wiring via a three-way tagstrip with the centre tap on the earthed fixing tag. This tag should also be used for earthing the h.t. secondary winding centre tap and the h.t. electrolytic capacitor negative leads. Heater wiring should run close to the chassis and be isolated from all other wiring as far as is practicable. The rectifier valve heater is of course wired to the appropriate winding on the mains transformer, one end of which is at h.t. potential.

The remainder of the chassis wiring can next be proceeded with. Particular attention should be given to the wiring that will earth the appropriate components to the chassis, since bad earthing is one of the chief causes of hum. There are two basic systems of satisfactory earthing. With a steel chassis, common earthing of each stage will probably be quite satisfactory. All the necessary components related to a particular stage are earthed to one tag bolted to the chassis at the nearest convenient point. With an aluminium chassis, bus-bar earthing is often recommended. In this system, a bus-bar of thick wire is looped into all the tags connecting the earthy ends of the components. This bus-bar is connected to the chassis at one point only, this being at the microphone input socket. However, this system is not infallible, since its success depends upon the order of connecting the components to the bus-bar, which is an experimental matter in each amplifier built. A good arrangement can work well, whilst a bad one is worse than separate earthing of each stage. Since one of the purposes of this article is to encourage the constructor to learn the principles of amplifier building by experience, it is hoped that he will work in this spirit and be prepared to experiment. The writer can only say that both of the amplifiers shown were quite satisfactory, the separate stage earthing used with the steel chassis (Fig. 2) being actually better than the bus-bar earthing used on the aluminium chassis (Fig. 3). Screening of the microphone input socket may be required to obviate high frequency instability, which makes itself evident by a very high pitched whistle.

The components may next be mounted on the tagboards and it will be advisable to have the high wattage resistors stand clear on longer leads to ensure sufficient ventilation and to prevent them overheating adjacent components. The grid stopper resistors of the output valves should be wired direct from the tagboards to the valveholders, and the coupling capacitors can, if desired, be wired from the appropriate anode pins to the tagboards. All wiring to the volume controls should be screened, as should also the lead from the microphone input socket to the first valve top cap. A screened top cap connector should be used, with the grid resistor soldered into the cap. A preset potentiometer will suffice for the tone control. This control provides just a little treble cut to remove stylus scratch from old records or any pronounced sibilants from a crystal microphone.[3] It will probably only require occasional adjustment and can be mounted in any position convenient for wiring.



The Fig. 2 amplifier installed in a Church building, complete with microphone

Testing

Before switching on, a check should be made with an ohmmeter to ensure that there are no short-circuits between h.t. positive wiring and the chassis or between grid wiring and either h.t. lines or the chassis. The cathode bias resistors can be likewise checked. It is advisable to test the output stage first, then add the other valves successively, checking each in turn. The amplifier should be switched off before inserting a fresh valve. To avoid the appearance of excessively high a.f. voltages across the primary of T_2, the amplifier should not be operated without a speaker connected.

With the rectifier and output valves in place, the amplifier may be switched on and the h.t. voltages checked. The output anodes may have up to 350 volts on them, but 300 volts would be a good value for long life whilst still giving sufficient output. The h.t. voltage may be varied by changing the value of the rectifier anode limiter resistors, R_{20} and R_{21}. These should both have the same value, between 100 and 500Ω, and must be of adequate wattage rating (1 to 2 watts, according to value). With the h.t. voltage adjusted, the cathode voltage of the output

[3]A crystal microphone should not be used with the amplifier if good quality reproduction is required, as the relatively low input impedance of the amplifier will cause attenuation of the lower audio frequencies. On the other hand, a crystal microphone may be useful for testing purposes or where reduced low frequency response is not considered important. This problem is absent if a moving-coil microphone is employed, as discussed later in the article. It may be helpful to insert a 1MΩ resistor in series with the Gram input to VR_2 in order to reduce low frequency attenuation with crystal or ceramic pick-ups.—Editor.

valves should be of the order of 18 to 20 volts and the screen grid voltage about 30 volts lower than the anode voltage. There should be slight background noise in the loudspeaker, but no hum.

The phase splitter valve may next be inserted and its voltages should be of the order shown on the diagram. A signal from a record player pick-up or radio may be applied to each volume control in turn, and the amplifier should be found to give satisfactory reproduction.

The first valve should finally be inserted and the complete circuit tested. Since any hum or noise in the first stage receives the greatest amplification, particular attention must be given to this stage. Noise reduction will be improved if high stability resistors are used for the anode load, and screen grid and control grid resistors. It should also be remembered that noise will be much more apparent in a small loudspeaker used for testing than in larger speakers used in a hall, so it might be as well not to be too critical at first. Any hum, more noticeable now that the first stage is complete, may be reduced if the chassis is connected to a real earth via the earth continuity conductor of the mains lead. Also a metal base panel may effect an improvement, by completely screening the chassis, provided it is electrically connected to the chassis. Neither of the writer's amplifiers actually required a metal base and only the one with the aluminium chassis required a real earth. If a metal base is used, it should be perforated to allow for ventilation.

Unless perfection is sought, the criterion for hum and noise level will be the proportion that can be tolerated for the amount of gain at which the amplifier will normally be used. With a microphone connected, the gain will be limited to the point at which acoustic howl feedback is developed. This will vary according to the positioning of the microphone and loudspeaker, and also according to the type of microphone and the design of the loudspeaker cabinet. If felt necessary it may be worth experimenting with a damping resistor of, say, 100kΩ to 500kΩ across the input terminals to achieve greater gain before howling occurs. The theory of this may seem rather doubtful since the resistor attenuates the input somewhat, but it often works quite well in practice, perhaps by damping out a resonant frequency at which the howling occurs. When the best acoustic conditions have been found, the user will then be in a position to decide whether the hum and noise level is sufficiently low.

A moving coil microphone is the best all-round type for p.a. work so far as the amateur is concerned. A high impedance microphone (50kΩ) may be connected directly into the amplifier. If a very long lead is necessary, the low impedance setting (50Ω) of a dual-impedance microphone can be used with ordinary flex for the lead, provided that a screened microphone transformer is fitted at the amplifier end of the lead. Only a special mu-metal screened transformer can be fitted inside the amplifier. If an ordinary microphone transformer is used in a metal screening box it will probably have to be at least 18in from the amplifier to avoid hum pick up. The high impedance lead from the transformer must, of course, be screened cable.

Final Finish

Unless a metal base has been found necessary, the amplifier should be completed by the provision of a light base panel to protect the components under the chassis. This may be made from peg-board or from the back fret from an old TV or radio set. Rubber feet should be added to avoid jarring the amplifier when it is set down and to give clearance for cool air to be drawn in through the base panel. A top cover may be folded from expanded metal and handles added if much carrying is anticipated. Alternatively, a ready made cover may be obtained of approximately the right size, and wood fillets added if necessary to make up any differences.

Conclusion

It may be gathered from this article that the building of simple but very effective p.a. amplifiers using the circuit of Fig. 1 is not at all difficult, provided the constructor is prepared to experiment a little and to use a little commonsense judgement with regard to choosing a suitable layout. The accompanying photographs show two views of the amplifier of Fig. 2. The microphone employed is a Calrad DM16HL dual-impedance moving-coil unit. Its 50kΩ output is applied directly to the amplifier without a transformer.

10th Annual Mobile Radio Rally
Rykneld Schools, Derby—Sunday August 13th 1967

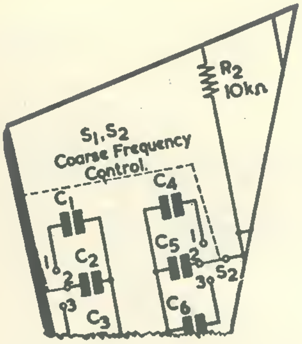
The above event is one of the most popular attractions in the Amateur Radio enthusiasts calendar. It is a social event that is eagerly awaited every year by large numbers of mobile Radio Amateurs and their families.

The Derby Rally has always been known as a family event and this year's attractions will have all the family in mind. Last year there were over 6,000 visitors, no fewer than 8 Special Displays and 12 Trade Stands.

Events will include all the old favourites, i.e. Treasure Hunt, Prize Draw, Junk Sale, Film Show, Radio Controlled Model Aircraft, etc., etc.

Admission and parking at the Rally is FREE. There is also ample indoor accommodation should the weather be unkind. The usual Ice-Cream, Coca-Cola and Refreshments will be available at very reasonable charges.

Any further information required can be obtained by contacting Mr. Tom Darn G3FGY, Hon. Rally Organiser, "Sandham Lodge", 1 Sandham Lane, Ripley, Derbyshire. Ripley 2972.



Simple D.C. Heater Supply for A.F. Amplifiers

SUGGESTED CIRCUIT No. 201

by G. A. FRENCH

One of the major design problems with sensitive mains-driven a.f. amplifiers is the reduction of hum caused by the a.c. supply. If the amplifier employs valves, hum is particularly likely to result from unwanted couplings between the signal circuits and the heater wiring, and considerable care has to be taken with component and wiring layout to ensure that such couplings are kept to a minimum.

The first stage of the amplifier is, of course, that which is most susceptible to hum, and it is common practice to use a low-noise pentode, such as the EF86, in this position. The EF86 can exhibit a hum level of 1μV only when fed with a centre-tapped a.c. heater supply, but it is still necessary to pay careful attention to the valveholder type, valveholder wiring and component positioning if a figure as low as this is to be achieved in a practical working circuit.

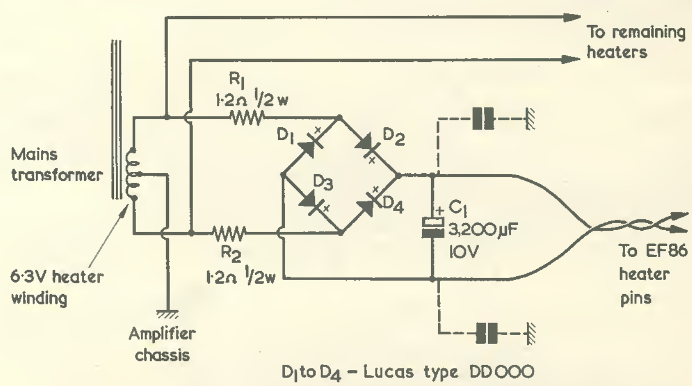
Hum in the first stage due to unwanted couplings with the heater wiring can be completely eradicated if the heater of the first valve is fed with d.c. instead of a.c. Whilst this represents an obvious solution to the hum problem, there is a tendency to assume that the provision of the necessary direct current involves the use of special mains transformers and expensive rectifier circuits, whereupon it becomes economically unattractive. Now that small silicon rectifiers and high-value electrolytic capacitors are available, however, the situation is changed, and the cost of a d.c. heater supply need not be as excessive as would have occurred with earlier components.

This month's "Suggested Circuit" presents a simple method of applying a d.c. supply to the first valve of an a.f. amplifier, the alternating voltage being obtained from a normal 6.3V centre-tapped mains transformer secondary. The suggestion will be of greater interest from the point of view of application than of circuit operation, since the circuit consists quite simply of a standard bridge rectifier plus several "trimmings". The circuit has the advantages that few components are required, that a standard mains transformer can be employed, and that the heaters of the remaining valves in the amplifier may be run in normal manner from the same 6.3V winding. It must be emphasised that the circuit does not provide a completely *pure* direct current, since the voltage applied to the valve heater carries a ripple having a peak-to-peak value of the order of 0.2V. However, this figure is much lower than the peak-to-peak value of an alternating 6.3V heater supply with the result that the circuit can offer a very significant reduction in hum pick-up in the first stage of an amplifier, even though it may not give the complete eradication of hum that would result from a fully smoothed d.c. supply. With the components specified, the circuit is suitable for feeding the heater of an EF86 or any other valve requiring a heater voltage of 6.3 at a current of 200mA.

The Circuit

The circuit of the d.c. supply is given in the accompanying diagram and it consists of a full-wave bridge rectifier running direct from a 6.3V heater winding of the mains transformer. For the circuit to function it is essential that the rectifiers have a low forward resistance and that the capacitor following the bridge has a large value. The rectifiers specified for the bridge are silicon types and thereby meet the first requirement, whilst the capacitor is an electrolytic component having a value of 3,200μF.

In order to keep switch-on surge currents to a low value it is desirable to insert limiting resistance between the transformer winding and the rectifiers. This limiting resistance



By means of this simple rectifier circuit, the first valve of a sensitive a.f. amplifier may be heated by direct current (plus a small ripple) whilst the remaining valve heaters are supplied in normal manner. The two capacitors shown in dotted line may be required in some instances.

must not, however, be too high or the required rectified voltage will not be obtained. In the present circuit the limiting resistance is 2.4Ω, this representing a compromise figure. With a limiting resistance of 2.4Ω the rectified voltage applied to the heater of an EF86 is 6.1V, and it was considered that this is sufficiently close to the nominal value of 6.3V to be acceptable.

The 2.4Ω limiting resistance is split up into two physical resistors of 1.2Ω, as shown, in order to maintain symmetry. It will be appreciated that, on succeeding half-cycles, each of the d.c. heater lines becomes effectively coupled first to one side of the 6.3V secondary and then to the other, whereupon it is desirable to keep the circuit symmetrical in order that the d.c. lines remain balanced about chassis potential. This approach ensures that the 0.2V ripple on the d.c. lines has minimum effect. In this context it is important to note that the 6.3V transformer winding *must* be centre-tapped, with the centre-tap connected to chassis. If, instead, one end of the 6.3V winding were connected to chassis, each of the d.c. heater lines would be taken through some 6.3V on alternate half-cycles and the whole object of the circuit would be defeated!

Components

As is shown in the diagram, the four rectifiers, D_1 to D_4, are Lucas type DD000, these having a peak inverse voltage of 50 and a forward current rating of 500mA. The electrolytic capacitor employed for C_1 in the prototype was a Mullard component in the C431BR series, with a value of 3,200μF and a voltage rating (which should not be exceeded) of 10V. It may be added that the rectified voltage across C_1 will rise to nearly 9V should the EF86 be removed from its valveholder, and this fact has to be borne in mind when deciding upon the working voltage of the capacitor. In general, it would be preferable to switch off the power supply if the EF86 is to be removed and re-fitted, since a slightly excessive current could momentarily flow in its heater if it were plugged in with the supply switched on and C_1 charged to peak rectified voltage.

It will probably be necessary to make up R_1 and R_2 from short lengths of resistance wire, as their value is outside the range normally available for fixed resistors from home-constructor retail sources. Care should be taken to ensure that the resistors have the required value within ± 5%.

When the d.c. supply circuit is fitted to an a.f. amplifier all the rectifier components should be mounted near the mains transformer. A tightly twisted pair may then be used to couple the rectified voltage across C_1 to the heater pins of the EF86. A twisted pair is recommended since the d.c. supply still carries the 0.2V ripple voltage.

As was stated earlier, the prototype circuit provided 6.1V at 200mA for an EF86 heater using the components specified. The writer does not recommend that the circuit be employed for valves requiring 6.3V at 300mA since the greater current would necessitate reducing the values of R_1 and R_2, whereupon switch-on surges could become excessively high.

A final point is that the rectified voltage across C_1 is "floating" during the periods in the cycle when the diodes are not conducting and it is feasible that, under some conditions, this could result in a modulation hum being imposed on the a.f. signal being handled. Should this occur, both terminals of C_1 should be coupled to chassis via 0.5μF capacitors, as shown in dotted line in the diagram.

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 Oscilloscope Model OG10.—B. C. Herring, 710 N.B.S. Building, Port Elizabeth, South Africa, —borrow or purchase circuit diagram. Please write airmail—payment in sterling.

Indicator Type 62A (10Q/37).—A. Thompson, Thursley Cottage, Church Road, East Molesey, Surrey—this unit is fitted with VCR97 tube and EF50 (VR91) valves. Any information on modifying this to an oscilloscope or a circuit using the valves and tube in an oscilloscope, loan or purchase.

F. M. Tuner.—P. G. Tanner, 48 The Crescent, Mortimer, Berks—has constructed this unit (published in Brimar Valve Manual some years ago) and requires advice from any reader who has been successful with this tuner unit.

V.H.F. Receiver Type AP67590A.—T. D. Hackney, 3a Clumber Crescent South, The Park, Nottingham—would like to purchase or borrow the circuit or any other information.

Wavemonitor Type 1464A,—E. R. Bellas, 41a Nevill Street, Southport, Lancs—wishes to communicate with a reader who has any experience with this equipment, help is required in obtaining a horizontal trace.

S.T.C. Receiver B46.—A. Whipp, 1 Bridge Street, Lumb, Rossendale, Lancs—manual or any information.

March 1961 Issue.—J. R. Owen, 40 Kingslea Road, Withington, Manchester, 20—urgently requires this copy of "*The Radio Constructor*", expenses met.

'Panda Explorer' 150W Transmitter.—R. P. Neave, 24 Mayfield Road, Writtle, Chelmsford, Essex, —manual, purchase or loan.

Windscreen Wiper Programmer

by T. J. Daborn

Intended for the reader who is conversant with the simple car electrics involved, this article describes an ingenious programming unit which allows the windscreen wipers of a car to operate once every 2 to 30 seconds as desired under conditions of light rain or drizzle

THE WINDSCREEN WIPERS OF MOST MODERN cars are very efficient; they manage to clear the screen under all conditions except perhaps an exceptionally heavy downpour. Drizzle or light rain is usually cleared by one wipe, after which the wiper rubbers scrape on the dry screen. This means that the wipers must continually be switched on and off, which is not desirable in today's driving conditions when all one's attention needs to be on driving itself. A variable speed facility seemed to provide an answer for this problem, but was rejected due to the high current, high wattage components required. It was also felt that slow moving wiper blades would be more distracting than if they moved quickly.

COMPONENTS

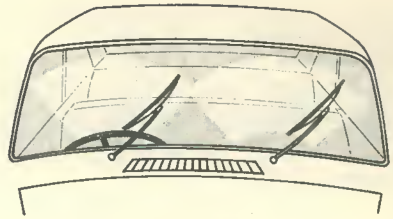
Resistors
(All fixed resistors $\frac{1}{2}$ watt 10%)
R_1 1.5kΩ
R_2 100Ω (see text)
R_3 10kΩ
R_4 200Ω (see text)
VR_1 50kΩ potentiometer, linear

Capacitor
C_1 2,000μF electrolytic, 25V wkg.

Transistors
TR_1 OC71
TR_2 OC72

Switch
S_1 (*a*), (*b*) d.p.s.t. switch, 5 amp rating

Relay
A/2 See text



Programming Circuit

The programming circuit shown in Fig. 1 was eventually evolved and can be fitted to most cars having wipers with *self-parking facility*. The circuit is basically a Schmitt trigger, and it operates in the following manner.

On closing S_1, TR_2 conducts heavily and TR_1 is cut off. The normally closed contacts, A1 and A2, of the relay, then open. C_1 begins to charge via R_1 and VR_1 until the base voltage of TR_1 rises above its emitter voltage. TR_1 then starts to conduct and the base and emitter voltages of TR_2 begin to fall, causing TR_1 to conduct more heavily and resulting in the circuit switching rapidly to the state when TR_1 is fully conductive and TR_2 is cut off.

Contact A1 then closes, discharging C_1 via R_2. At the same time A2 closes across the windscreen wiper switch (see Fig. 2) causing the wipers to commence to wipe. As (due to the discharge in C_1) the base of TR_1 falls below its emitter voltage, the circuit switches rapidly back to its original state, and is ready to start the cycle again. Contact A2 opens, but the wipers carry on until they return to the self-park position, where they stop.

The self-parking facility is normally a switch in series with and powered by the motor, as shown in Fig. 2, and is open when the wipers are in the self-park position. The manual on-off switch is then put in parallel with this self-parking switch. Contact

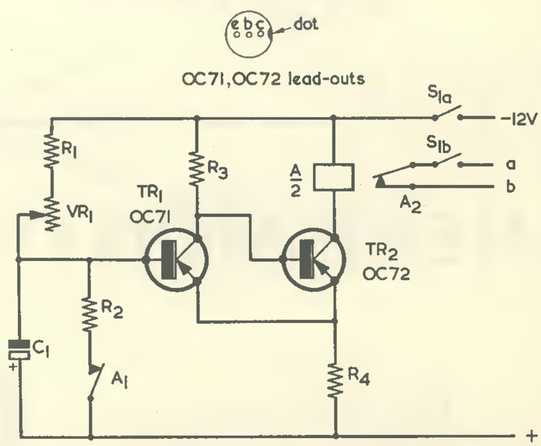


Fig. 1. The circuit of the programmer unit. Relay contacts A1 and A2 are both normally closed

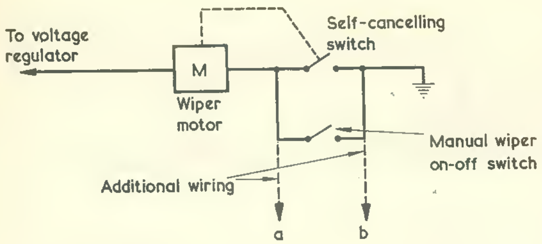


Fig. 2. How the unit is wired to the wiper motor. The "additional wiring" couples to points a and b of Fig. 1

A2 is wired via one pole of S_1 across the manual wiper switch.

When TR_2 is cut off during the cycle, contact A1 immediately begins to discharge C_1 via R_2 and quickly returns the circuit to its original state. The time that A1 and A2 stay closed must be long enough for the wiper motor to start wiping and close its self-park switch (approximately 0.5 second). This time can be varied, if necessary, by adjusting R_4 and R_2 slightly. VR_1 determines the charging rate of C_1 and hence the time between wipes. With the prototype, VR_1 offered a range of 2 to 30 seconds.

VR_1 and S_1 can be mounted side by side on a bracket or on the dashboard. Under normal rain conditions the wipers are turned on in the usual way; in drizzle, however, the wiper on-off switch is turned off and S_1 is closed instead. VR_1 is then adjusted to keep the screen clear without the annoying scraping of the wiper rubbers.

The writer's unit was built on a small piece of tagboard and mounted with the relay in a convenient place under the dashboard.

Before making up the unit and connecting it into the windscreen wiper system, the reader should take care to check from the car-maker's handbook that the car circuit is the same as in Fig. 2. The author's car, to which the prototype is fitted, is a 1961 Triumph Herald saloon.

The relay employed by the author was a Post Office type which was to hand, this having a 2,000Ω coil. Both contact sets are normally closed, and contacts A2 should be capable of switching at least 3 amps. Readers may be able to obtain a suitable relay through surplus channels.

Editor's Note

It will be noted that no protective diode is connected across the relay coil (to prevent the application of a high back-e.m.f. to TR_2 when the relay de-energises) since this was not found to be necessary with the prototype.

Suitable relays are available from L. Wilkinson (Croydon) Ltd., Longley House, Longley Road, West Croydon, Surrey, at 21s. each. When ordering please specify as: Post Office Type 3000 relay, 2,000Ω coil, with one set of light-duty N/C contacts and one set of 3 amp N/C contacts, energising voltage 10 or less.

Simple Short Wave Converter

by R. L. A. Borrow, B.Sc.

This self-contained single-transistor converter operates over the range 15 to 30 Mc/s, and provides an output at medium waves. It may be used with any medium wave receiver having screened aerial coils instead of a ferrite frame, which would pick up interfering medium wave signals at night-time—although a ferrite frame receiver could possibly be used in a screened environment such as a car

The converter described in this article was designed for use with a car radio, but it can be used with any medium wave receiver having aerial coils instead of a ferrite rod aerial.

When using the converter the higher frequency end of the medium waveband of the receiver is employed for the final stages of intermediate frequency amplification, consequently any signals picked up on medium wave frequencies will interfere with the short wave signals. This difficulty does not usually occur with a car radio because of the good screening of all of the radio frequency circuitry of the receiver. On the other hand the portable type of medium wave receiver is designed to pick up signals without an external aerial. When using this type of receiver it is necessary to first tune it to some frequency where no signals are present, although it may be difficult to find a suitable point at night-time. With a car radio this difficulty does not occur and it is possible to use the car radio tuning to obtain a similar facility to that provided by a bandspread tuning control.

The circuit of the converter is shown in Fig. 1. A single transistor was used as a mixer-oscillator and the output was taken from a broadly tuned inductor, L_5, in the collector circuit of the transistor. The converter was coupled to the receiver aerial and earth terminals via coaxial cable.

The converter was constructed on an aluminium chassis which formed part of the containing box. The power supply was taken from a small 3-volt battery housed inside the case.

Chassis Construction

The chassis and cover were made from 16 s.w.g. aluminium sheet, as shown in Fig. 2. Two pieces of sheet were used, one being 5 x 5½in and the other 10¼ x 5⅝in. The first piece formed the chassis and the second piece formed the cover. The cover was attached to the chassis by means of self-tapping screws passed through the holes shown in Fig. 2 (*b*).

The construction of the battery holder is shown in Fig. 3. To prevent short-circuits, a strip of insulating material should be interposed between the base of the battery holder and the chassis surface when the holder is secured in place.

All the major components, with the exception of the battery holder and oscillator coil (L_3, L_4), were mounted on the vertical 2 x 5in section of the chassis. See Fig. 4. The battery holder was mounted on the horizontal 3 x 5in section and the oscillator coil on the end plate of the 2-gang capacitor.

The 2-gang capacitor was a 150 + 150pF component, and was fitted with its own trimmers, these appearing as C_1 and C_8 in Fig. 1.

The coils were wound on polystyrene ¼in diameter formers with adjustable iron dust cores. The aerial tuning coil, L_2, was wound with 7 turns of 28 s.w.g. enamelled wire spaced by winding in a second wire of 28 s.w.g. which was later removed. The aerial coupling winding, L_1, consisted of 5 turns of 28 s.w.g. enamelled wire close-wound and positioned close to the earthy end of the tuned coil.

The oscillator tuned coil, L_3, was wound with 8 turns of 28 s.w.g. enamelled wire spaced as for L_2. The collector winding, L_4, has 5 turns of 28 s.w.g. enamelled wire, these being wound in the spaces between the tuned winding at the earthy end.

The coil used for the output

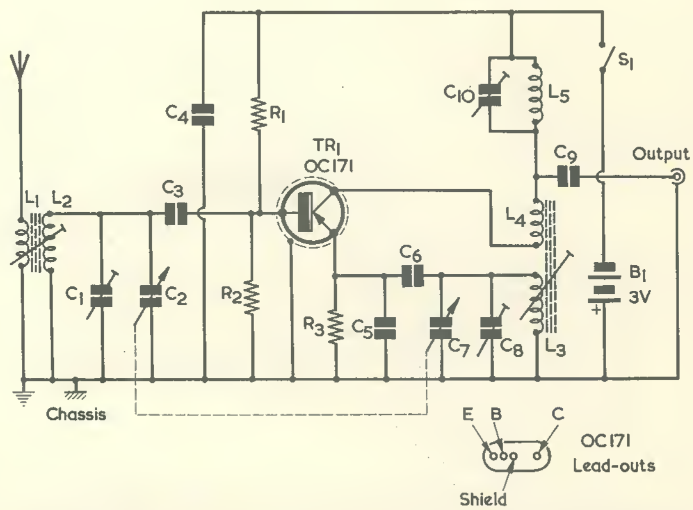
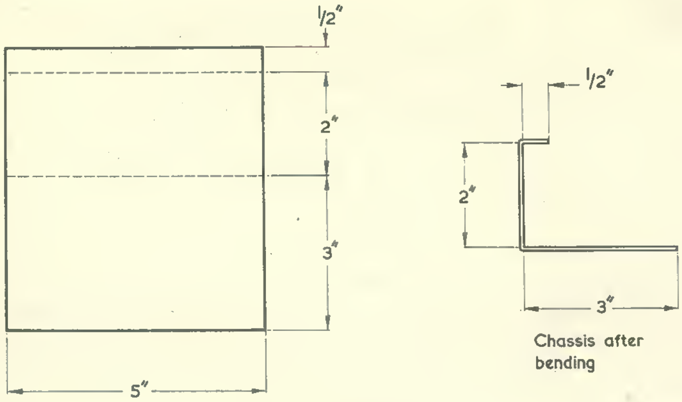
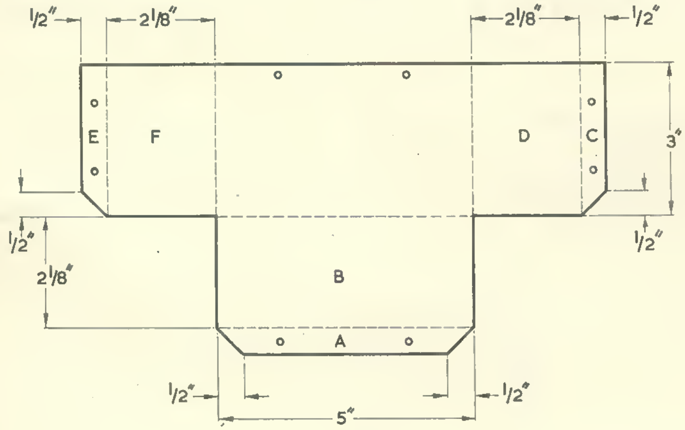


Fig. 1. The circuit of the short wave converter. L_2 is the signal frequency tuned coil, and L_3 is the oscillator tuned coil. L_5 is an air cored medium wave coil

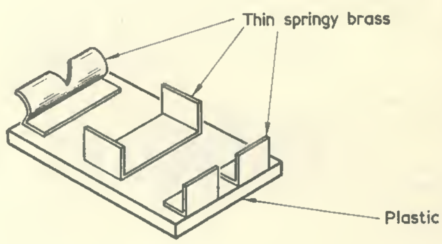


(a)



(b)

Fig. 2 (a). Details of the chassis. This is bent as shown (b). The cover. All parts are bent inwards (i.e. towards the reader) along the dashed lines. A convenient order of bending would follow the order ABCDEF. The holes are clearance for self-tapping screws



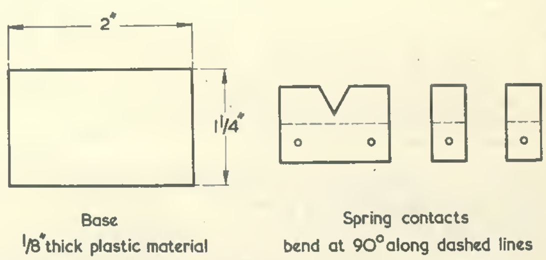


Fig. 3. The battery holder. Dimension the springy brass parts to take two U12 cells. Any convenient insulating material may be used for the base. Connections are taken from the two single contacts

inductor, L_5, was an air cored medium wave r.f. coupling coil type PHF2, with no connections made to the coupling winding.

Alignment

The converter is connected to a car radio, or a similarly suitable receiver, which is tuned to slightly higher than mid-scale on the medium wave range, and an aerial is connected to the converter input terminal. The oscillator trimmer, C_8, is set to about mid-capacitance. A weak signal is obtained at the high frequency end of the converter range and the aerial trimmer, C_1, adjusted for maximum response. The converter is then set to the low frequency end of the scale and the aerial coil adjusted by means of its iron dust core. Finally, the trimmer across the output coil, C_{10}, is adjusted for maximum signal. Adjustments to the oscillator coil core and trimmer may be made, if required, to improve tracking or alter the range covered.

The converter frequency range is about 15 to 30 Mc/s but this can of course be altered to suit the user's requirements by changing the number of turns on the aerial and oscillator coils.

The converter as described has been found to bring in a very large number of stations, particularly from across the Atlantic.

Due to lack of selectivity before the mixer it may sometimes be found that transmissions from local high power v.h.f. transmitters are heard. This is due to their combining with harmonics of the oscillator. To overcome this difficulty, if it occurs, it will probably be necessary to introduce an extra circuit tuned to signal frequency between the aerial and the converter, this possibly incorporating an r.f. amplifier stage. The writer hopes to include these refinements in a more sophisticated design of converter.

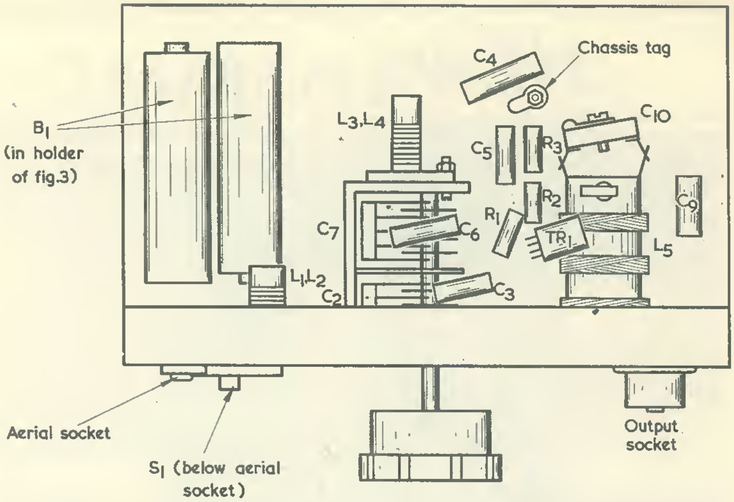


Fig. 4. Component layout used in the prototype. The ½in flange of the chassis is nearest the reader and partly obscures the components which are secured to the 2 x 5 in front panel. The tags of C_2, C_7 and L_5 provide anchor points for most of the resistors and capacitors. The emitter of TR_1 is anchored at the junction of R_3, C_5 and C_6, and the base is anchored at the junction of R_1, R_2 and C_3. If components having fairly stiff lead-outs are employed, these anchor points are quite stable

Editor's Note

The 150 + 150pF 2-gang capacitor with trimmers specified for C_2, C_7 may not be readily available through home-constructor channels, but a suitable alternative would be the 176 + 176pF capacitor type "00" with screen made by Jackson Bros. Small 20 or 30pf trimmers can be added to this capacitor. If desired, a simple epicyclic slow-motion drive, or similar, may be fitted to the front panel for tuning. Any medium wave single tuned coil (or medium wave r.f. coupling coil with the coupling winding unused) intended for valve receivers may be employed in the L_5 position instead of the PHF2 coil specified. Avoid using a medium wave *aerial* coupling coil, as the unused aerial coupling winding may give undesirable absorption effects.

Good tracking could be achieved with either the oscillator frequency above or below the signal frequency, but it will probably be found better here to have the oscillator frequency below. Bad tracking will, of course, occur if the oscillator frequency is above the signal frequency at one end of the band and below it at the other.

If it is found that C_{10} does not provide sufficient capacitance for the medium wave frequency required, a fixed silver mica capacitor of around 100pF may be connected across it.

COMPONENTS

Resistors
(All ⅛watt 10%)

R_1	39kΩ
R_2	22kΩ
R_3	5.6kΩ

Capacitors

C_1, C_8	trimmers (fitted to C_2, C_7)
C_2, C_7	2-gang 150+150pF (see text)
C_3	4.7pF silver mica
C_4	0.01μF paper or plastic foil
C_5	100pF silver mica
C_6	47pF silver mica
C_9	100pF silver mica
C_{10}	140pF trimmer

Coils

$L_{1,2}$	See text
$L_{3,4}$	See text
L_5	R.F. coupling coil type PHF2 (Wearite)

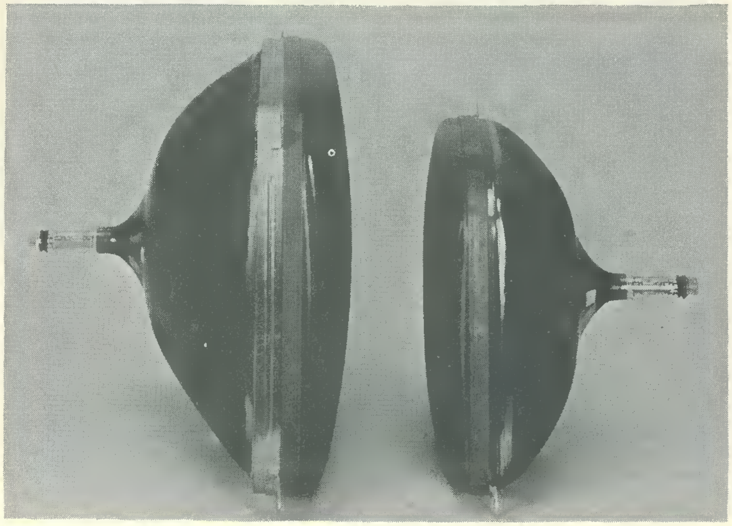
Transistor
TR_1 OC171

Switch
S_1 Miniature on-off slide switch

Battery
B_1 Two U12 cells (Ever Ready) in series

Miscellaneous
1 aerial input socket
1 coaxial socket
2 coil formers ⅞ x ¼in dia. Cat. No. CR4 (Home Radio)
2 iron dust cores, Cat. No. CR5 (Home Radio)

NEWS . . . AND .



New Mazda CRTs for Push-Through Presentation

The use of cathode ray tubes which do not require separate implosion protection panels is now well established in the field of domestic television. MAZDA have played a prominent part in the development of this new trend in styling and have introduced to the trade, successively, Twin Panel, Rimguard I, Rimband and Rimguard II implosion protected tubes.

MAZDA now introduce the Rimguard III system of implosion protection which retains the advantage of light weight but offers the additional attraction of being able to be used in "push-through" presentations.

In both the 19in and 23in sizes, illustrated above, the Rimguard III reinforcement consists of a metal shell fitting closely to the bulb in the rim region and bonded to the glass with a specially selected resin. Over this shell a band of steel strip is applied and tightened to an accurately controlled tension. The important feature in which Rimguard III reinforcement differs from Rimguard I and II is that the shell does not extend so far forwards towards the face, so permitting "push-through" presentation.

The metal shell is in the form of two halves which meet with an overlap in the centres of the vertical sides.

In the case of the 19in size this shell is close-fitting to the bulb to which it is bonded by a special resin.

On the 23in tube this shell fits tightly at its forward edge but is separated from the glass at its rear edge by a gap of a few millimetres. This gap is filled with a suitable resin. Strengthening ribs are formed in the shell, parallel and close to its rear edges.

In both 19in and 23in tubes an accurately tensioned steel band is applied over the shell which carries brackets for mounting the tube.

This reinforcement results in an extremely strong tube which will not fail in a violent manner when subjected to such thermal or mechanical shocks as are likely to be encountered even in extreme circumstances.

ALCONBURY

Radiowise, Alconbury is in the news on two counts.

Firstly, it was the venue, on 18th June, of the Amateur Radio Mobile Society's International Mobile Rally. This event is claimed by the organisers to have been the biggest and most successful amateur radio event ever held.

Although estimates as to the number of people attending varied from just under 4,000 to nearly 5,000, based on the average number of passengers per car, the police say they checked in a thousand vehicles, and apparently the double line of parked cars stretched for a mile, which meant a long walk for latecomers. So if you intend going to next year's rally—to save your legs—get there early!

Also at Alconbury is the USAFE/UK Redistribution and Marketing Centre. Here are held, from time to time, auction sales of electrical and radio equipment of all kinds.

The sales are not conducted like an ordinary auction. The bidder fills in a bid form stating the price he is prepared to pay for the item listed in the catalogue, and enclosing a deposit of 20% of the bid value. These are known as spot bids.

There are also sealed bids; a similar form is completed and placed by the bidder not later than a fixed time before the sale commences.

Both types of bid may be sent by post.

If you would like further information write to Mr. David Peller, Chief Contracting Officer, Marketing Branch, USAFE/UK Redistribution & Marketing Centre, R.A.F. Alconbury, Huntingdon.

"Proper little resistor, aren't you"

. . . COMMENT

Society's Progress

It is very pleasant to record the progress of The Institution of Electrical and Electronics Technician Engineers.

In the report of the Council for the year ended 31st March, 1967 it is shown that the Institution made further substantial progress; lecture programmes; regional development work expanded; the designatory initials denoting corporate membership more widely used; establishments of further education included the IEETE qualifications in their lists of nationally-recognised awards. This latter point is an indication of the growing standing of the society as a professional body.

Incorporated in February 1965 the membership at the end of March stood at 7,800, an increase over the year of 1,300 members.

The report quotes from the speech of Sir Harold Bishop at the first Annual Dinner referring to those technician engineers, holding senior positions, who possess no academic qualifications. He said that the IEETE had such engineers especially in mind and he pointed out that the Institution's Associate Grade had been designed particularly to meet their needs.

Another interesting item culled from the report mentioned a one-day conference, organised in collaboration with the National Council for Quality and Reliability, on "Quality and Reliability and the Technician Engineer". The conference, held at Queen Mary College, University of London, in April, was staged not only as the Institution's contribution to Quality and Reliability Year but to increase awareness of the technician engineer regarding factors contributing to the reliability of electrical and electronic equipment.

Quote

Pilfering at a large Birmingham jewellers has been cut by 70% since the installation of a television operated security system. But while it has been successful in scaring away the light-fingered gentry, the television is proving to be almost too popular with customers. Some leave their children in the store to amuse themselves spotting each other on the screens, and a group of regular viewers have put in a request for colour.

From *The Times Business News.*

New Method of Checking Small Printed Circuits and Transistors

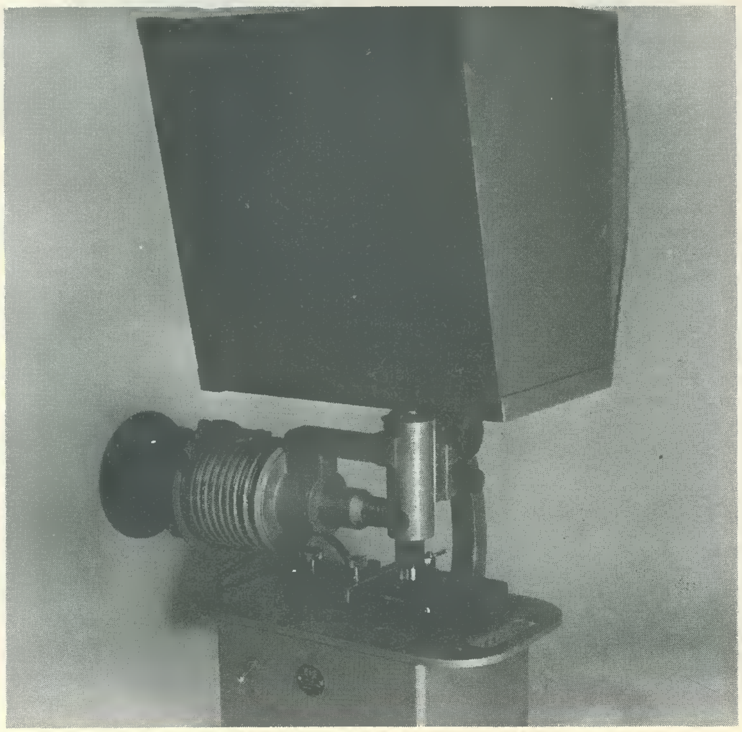
A new method of checking small printed circuits and transistors is being used by major aircraft and electronics companies, following a joint operation by C & D Scientific Instruments Limited of Boxmoor, Herts, and Plannair Limited, the air thermal specialists.

The result of this joint exercise is a projection microscope, illustrated below, which shows an enlarged image of the components on a hooded screen, to enable careful inspection and hair line precision adjustments to be made accurately and without strain on the operator.

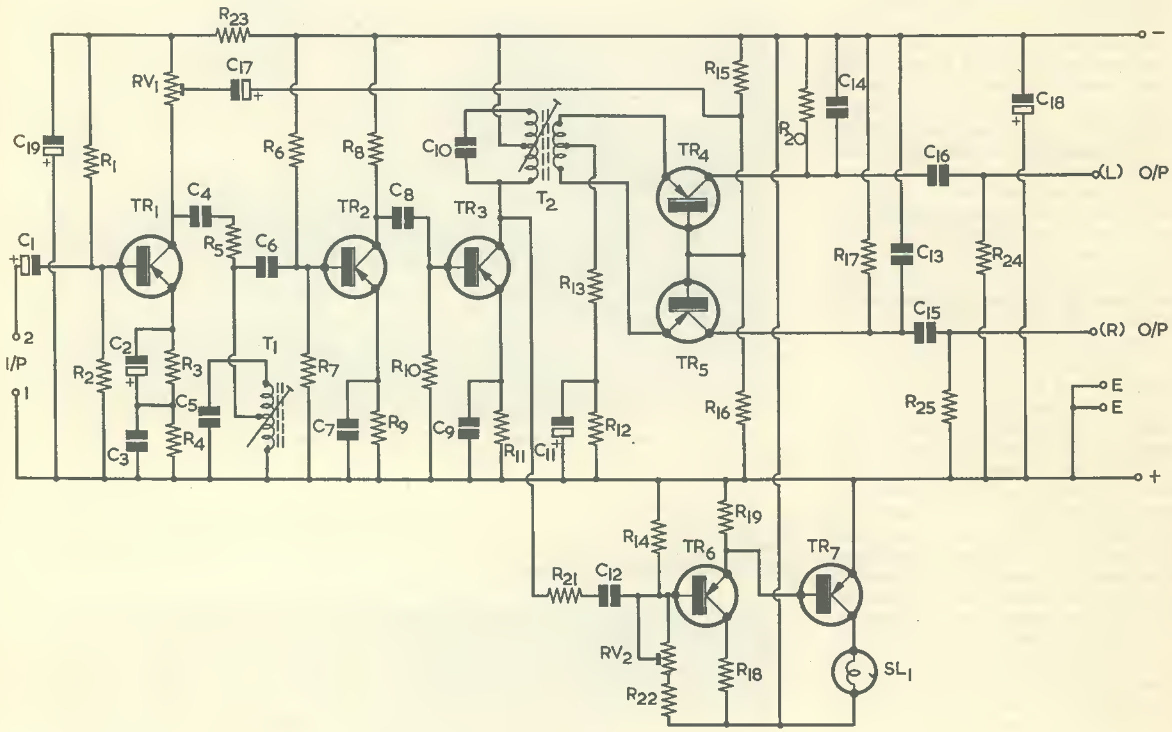
The microscope has a ten times magnification with light provided by a high intensity quartz iodine lamp. Plannair's aid was sought to reduce the heat produced by the 150 watt lamp working in a small enclosed space. It was essential that the cooling fan, although running at 2,600 r.p.m., should be vibration-free, and Mr. E. Chandler, one of the directors of Scientific Instruments, said: "the fan was easy to fit and very good indeed because it works completely without vibration. We are so satisfied with the performance of this unit and with the large range of cooling equipment Plannair has, that we are shortly going to start making a smaller version of the projection microscope with a smaller fan from the Plannair range. Already hundreds of this smaller version have been ordered by large electronic companies".

The present projection microscope is already being used by one major aircraft company for the inspection of guided weapons components; similar equipment is being used to inspect circuits and transistors for international firms in the electronics industry.

This is one of the many ways in which Plannair is helping highly specialised companies at the heart of the changing industrial scene to overcome difficult design problems. The company has over a thousand fans and blowers of all shapes and sizes and supplies a wide range of industry from avionics to computers.



STEREO DECODER UNIT



Available from Henry's Radio, Ltd. is a 7-transistor stereo decoder in kit form, this being intended for use with any valve or transistor f.m. tuner having a minimum bandwidth of 300 kc/s. The decoder offers compatible operation and, during mono broadcasts, allows the single signal then transmitted to pass straight through to the subsequent left and right channel amplifiers. The decoder may be operated from a 12 or 9 volt supply. When stereo transmissions are in progress current consumption is of the order of 50mA whilst, during mono transmissions, consumption is 10mA or less.

A special feature of the circuit is the provision of an indicator lamp which lights up when stereo transmissions are in progress. The assembled kit is simple to set up and align, and its circuit appears in the accompanying diagram.

Circuit Operation

Readers interested in stereophonic broadcast reproduction will recall that B.B.C. stereo transmissions use the Zenith-G.E. multiplex system. At the transmitter, the left hand channel (A) and the right hand channel (B) are summed to give an A+B signal which frequency modulates the transmitter carrier in the normal manner. Thus, a mono receiver reproduces the A+B signal, this being sufficiently close to a normal single-source signal to provide satisfactory mono reception. At the same time, an A—B signal is also formed, this being amplitude modulated on a suppressed 38 kc/s subcarrier, resulting in the production of a range of sidebands from about 23 to 53 kc/s. These are above the frequencies to which a mono receiver can respond. Also, when the A and B signals are equal (whereupon A—B=0) the sidebands drop out. In order that the 38 kc/s subcarrier may be reclaimed at the receiver a 19 kc/s pilot tone is transmitted, this being doubled to the required 38 kc/s in the decoder. The 19 kc/s pilot tone also has no effect with a mono receiver. For decoding to take place, the decoder has to mix the two signals so that the following results are obtained:

$$(A+B)+(A-B) = 2A$$
$$(A+B)-(A-B) = 2B.$$

Thus, with suitable mixing, the original left and right hand channels may be recovered from the transmitted A+B and A—B signals.

In the Henry's Radio decoder, the input from the discriminator of an f.m. tuner is applied to capacitor C_1. This input consists of the A+B modulation, plus the 19 kc/s pilot tone and the modulation on the suppressed 38 kc/s subcarrier. Transistor TR_1 amplifies all signals and enables an adjustable multiplex signal to be available from RV_1. Transformer T_1 is resonant at 19 kc/s and causes the 19 kc/s pilot tone to be applied to TR_2. TR_2 amplifies the 19 kc/s tone and feeds it to TR_3, which operates without a base bias resistor from the negative supply rail. The consequent distortion in TR_3 allows doubling to take place and the 38 kc/s signal at its collector appears across the primary of T_2 and C_{10}, these forming a tuned circuit resonant at that frequency.

The centre-tapped secondary of T_2 feeds the 38 kc/s signal in anti-phase to the emitters of TR_4 and TR_5, whilst the multiplex signal from RV_1 is fed to the bases in phase. The requisite mixing then takes place, enabling the left and right hand outputs to be obtained, as shown. The two points marked "E" in the circuit diagram are the earthy terminals for the left and right hand outputs respectively.

In the absence of a stereo signal no 19 kc/s pilot tone is transmitted, and no 38 kc/s signal appears at TR_3 collector. On the other hand, a relatively high amplitude 38 kc/s signal is given at TR_3 collector when a stereo signal is being transmitted. This 38 kc/s signal is passed through limiter resistor R_{21} to the base of TR_6. An amplified signal is next applied to the base of TR_7, which passes sufficient current to cause pilot lamp SL_1 to be illuminated. The sensitivity of the pilot lamp circuit is controlled by RV_2, since too high a sensitivity may cause the lamp to occasionally flash when tuning across the v.h.f. band.

One method of alignment of the assembled decoder consists of adjusting the cores of T_1 and T_2 for maximum brightness in the indicator lamp whilst a stereo broadcast is in progress. Final adjustments are made with RV_2 adjusted for low lamp sensitivity. RV_2 is then set for the desired operational sensitivity. The output of the decoder is approximately 1 volt per channel which can be reduced, as necessary, by RV_1.

The design has been developed by S. Neagle, and the complete kit is available from Henry's Radio Ltd., 303 Edgware Road, London, W.2., at £5-19-6d, plus 2s postage and packing.

An "Integrated" Crystal Oscillator

by James M. Bryant, B.Sc.

Micro-miniaturisation for the home-constructor! By employing sub-miniature components it is possible to fit a complete oscillator circuit inside the case of an FT241A crystal, thereby obtaining an "integrated" 2-pin crystal oscillator module. An instrument soldering iron and a steady hand are necessary

FT241A QUARTZ CRYSTALS ARE PLENTIFUL ON the surplus market and cost only a few shillings each. They cover the range 22–36 Mc/s on the 54th harmonic, so their fundamental frequencies lie between some 400 to 650 kc/s. Their lower harmonics fall within several of the amateur bands and these crystals also find uses in i.f. filters, crystal markers, clocks and simple frequency meters. In these days of micro-miniaturisation, a drawback of most quartz crystals is their comparatively large size. The present article describes an oscillator circuit which may be built into the crystal case to save space.

COMPONENTS

Resistors
(Sub-miniature 1/8 or 1/10 watt, excluding R_1 if fitted externally)
R_1 3.3kΩ
R_2 470kΩ

Capacitors
(Both sub-miniature ceramic or polystyrene)
C_1 200 to 1,000pF (see text)
C_2 100pF

Transistor
TR_1 2N2926, 2N3904, 2N3708 or BC118 (see text)

Crystal
Crystal type FT241A

The Circuit

The circuit of the oscillator, shown in Fig. 1,

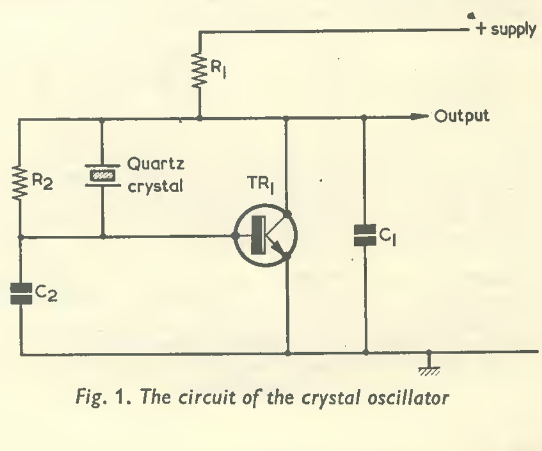
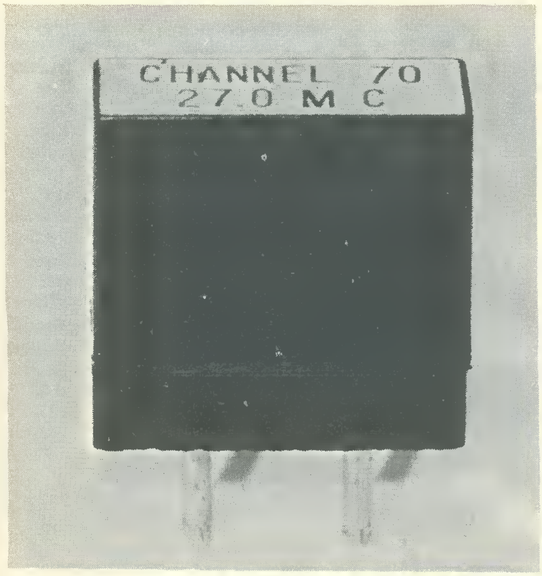


Fig. 1. The circuit of the crystal oscillator



The crystal case. This contains the complete oscillator of Fig. 1 less, in this instance, resistor R_1

contains only six components including the crystal. If the collector load resistor, R_1, is left outside the crystal case only two connections need be made to the remainder of the circuit and the original crystal pins may be used. It is perfectly possible to fit R_1 into the crystal case but an extra connection must then somehow be made.

The transistor is a plastic encapsulated silicon planar n.p.n. type. A similar p.n.p. type could be used if the power supply were reversed. In the original oscillator a Motorola transistor type 2N3904 was used but the General Electric type 2N2926 (widely advertised at about five shillings), the Texas Instruments type 2N3708 and the S.G.S.-Fairchild BC118 all work in the circuit.* Lead-out connections to these various transistors are shown in Fig. 2.

*The 2N2926 is available from L.S.T. Components, 23 New Road, Brentwood, Essex. The FT241A crystal used for the prototype oscillator was obtained from Henry's Radio Ltd.—Editor.

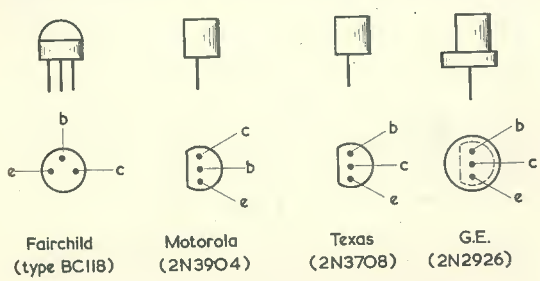


Fig. 2. Illustrating transistor lead-out connections. Any of the transistors shown here may be employed in the oscillator

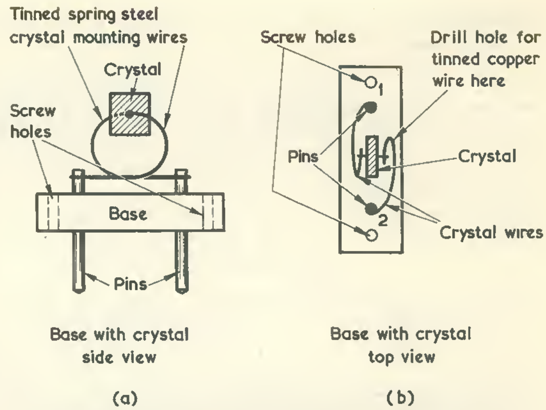
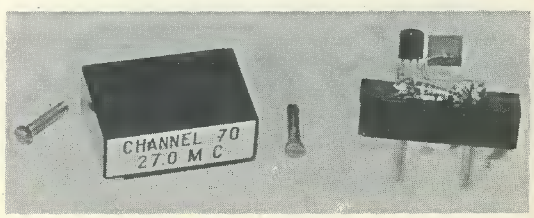


Fig. 3 (a). When the crystal cover is removed, the crystal plate may be seen supported on its two mounting wires
(b). The additional tinned copper anchor wire is fitted as illustrated here

The resistors are 1/8 or 1/10 watt hearing aid types and the capacitors sub-miniature polystyrene or ceramic components. The capacitance of C_1 affects the shape of the output waveform and stops oscillation altogether if it becomes too large. A low capacitance gives an irregular waveform, rich in harmonics, which may be used as a marker, or a drive to a frequency multiplier. A higher one gives a waveform of smaller amplitude, but one more nearly approaching a sine wave. If desired, a temporary circuit with components outside the crystal case can be initially set up to find the value of C_1 which best meets the requirements of the constructor. The components may then be fitted into the crystal case.

The power supply may be any value between 3 and 20 volts at not more than 5mA.

If other than FT241A crystals are used, the capacitances should be increased or decreased as the frequency of oscillation decreases or increases (e.g. if a crystal giving 100 kc/s were used, C_1 would be 1,000 to 5,000pF, and C_2 500pF; for 1 Mc/s they would be 100 to 500pF and 50pF respectively). The whole circuit may be used in a crystal oven up to 100°C without damage if the supply is less than 12 volts.



The crystal oscillator disassembled. The two screws are removed, enabling the base, with its added components, to be withdrawn from the case

Construction

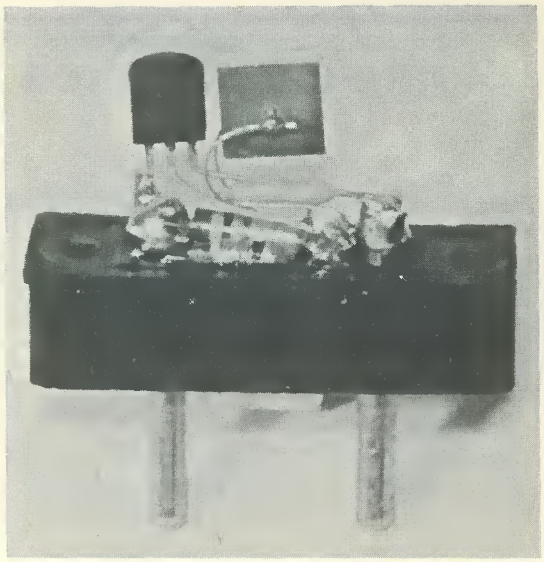
If the two screws at the base of the FT241A case are removed, the assembly may be dismantled into three parts: the case, the base with pins and crystal, and a rubber washer between them. The base and crystal are illustrated in Fig. 3 (*a*). Care should be taken at all times not to handle or chip the crystal, which is fragile.

A small hole should be drilled in the base as shown in Fig. 3 (*b*) and a piece of tinned copper wire fixed into it, this touching the adjacent crystal wire. The tinned copper wire is used as an anchor for the crystal wire, and the two wires are soldered together quickly, using a hot iron. After this, the rest of the crystal wire from this junction to pin 2 is removed. (The pins are arbitrarily numbered 1 and 2 in Fig. 3 (*b*) for convenience of explanation.) Capacitor C_1 should then be soldered between pins 1 and 2, R_2 between pin 1 and the piece of tinned copper wire just introduced, and C_2 between pin 2 and the tinned copper wire. The leads should be kept as short as possible and the components as near to the centre of the base as possible. The leads should be sleeved if necessary.

Resistor R_1 should be soldered to pin 1 if it is desired to fit it in the case and the positive lead brought out past the rubber washer or through a hole drilled in the case or the base.

Finally, cut the transistor base and collector leads to $\frac{1}{16}$in and solder thin flexible insulated leads to them. Cut the emitter lead to $\frac{3}{16}$in and solder the transistor by it to pin 2 so that the transistor is directly over pin 2. Now solder the collector and base leads to pin 1 and the tinned copper wire respectively.

A red spot is painted near pin 1 (which corresponds to the output terminal in Fig. 1) to identify it, and the case is reassembled. Take care that neither the circuit nor the crystal fouls the case during assembly.



Another view of the prototype oscillator. The crystal is the central square plate, with the transistor to its left, above pin 2. C_1, R_2 and C_2 are beneath the crystal plate and transistor. Component dimensions may be adjudged from the fact that the two pins have $\frac{1}{2}$in spacing

Testing and Use

If power is now applied to the oscillator an output may be detected at pin 1 by an oscilloscope, wavemeter, or a suitable radio receiver.

When the oscillator is in use, the output may be taken from pin 1 by a capacitor. If the input impedance of the stage being driven is low, the coupling capacitor should not be too large.

New Trimmer Potentiometer

A low-cost trimmer potentiometer just developed by Potentiometer Division, Standard Telephones and Cables Limited, the Type T10, has a body volume of less than half a cubic inch (0.417 cu. in.) and yet has a power rating of 3W—three times that of conventional units of similar size.

Intended as a more efficient replacement of the now obsolete W2 and W3 trimmers, the T10 is a precision device of a completely non-hygroscopic construction designed to provide accurate dependable settings in control circuit applications employing wide-tolerance components.

Both body and shaft are moulded in "Delrin" a highly stable non-hygroscopic plastic which has excellent high-temperature characteristics.

Another construction feature of this new trimmer is that, unlike conventional trimmers which are wound on a composition fibre card, the T10 is wound on a rectangular insulated copper mandrel which provides good resolution and is also non-hygroscopic.

Suitable for printed circuit mounting, the T10 is available in nine values from 100 ohms to 50k ohms.

Home-Constructed Radio Alarm

by A. G. Blewett

How to modify a domestic alarm clock so that it switches on your transistor radio in the morning

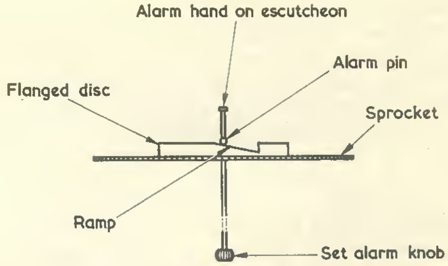


Fig. 2. Detail illustrating the disc and sprocket assembly

THE RADIO ALARM TO BE DESCRIBED CAN UTILISE almost any make of alarm clock and transistor radio, and it provides a highly effective means of being woken up in the morning. A very simple modification to each item is required, and both the alarm clock and the radio can be used normally and separately, as before, after the modifications.

The completed unit has been in continual use by the author (who would sleep through an air raid) for over a year, and has never let him down once.

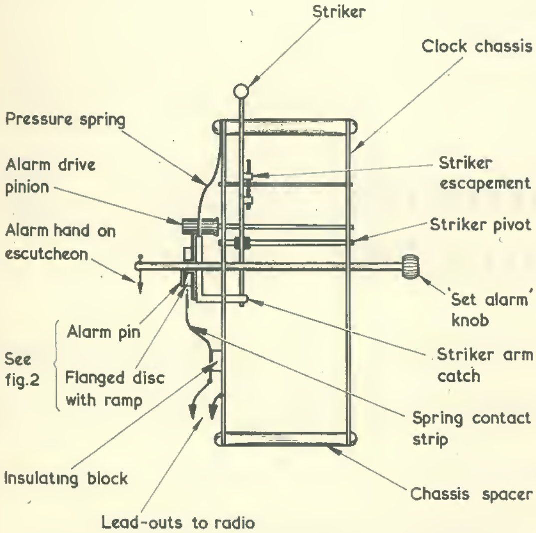


Fig. 1. The basic mechanism of an alarm clock. Also shown is the contact strip introduced by the modification

Alarm Clock Mechanism

It is first necessary to understand how the alarm clock rings at the appropriate time. Fig. 1 gives details of a typical alarm mechanism, and it will be seen that the heart of this comprises an axle, which has the "Set Alarm" knob at one end, and the alarm hand on the clock escutcheon at the other end. The axle also carries an alarm pin, on which a flanged disc bears under the influence of a pressure spring attached to the chassis. The flanged disc is free to rotate on the axle, and is driven round by a pinion in train with the main clock drive. Fixed to the pressure spring is a striker arm catch which prevents the bell striker from operating until the catch is withdrawn.

As the main clock drive rotates it carries with it the flanged disc, which has a ramp, as shown in Fig. 2. When the alarm pin reaches the vertical part of the ramp, the whole disc and sprocket assembly moves forward under the influence of the pressure spring, whereupon the striker arm catch is withdrawn and the alarm rings. The time at which the clock rings is determined by the relative position of the ramp and the alarm pin, the latter being preset by the "Set Alarm" knob at the back of the clock.

This basic method of operation should be found in practically all spring-wound alarm clocks. The reader should first examine the particular clock mechanism he intends to modify in order to confirm that this is so and, also, to identify the clock part which moves forwards when the striker mechanism is set off. The modification consists of adding a contact strip which will connect to the disc and sprocket assembly when the latter moves forward, thereby allowing a circuit to be completed via the chassis of the clock. The added contact strip is shown in Fig. 1. The circuit completed via the contact strip and the clock chassis switches on the transistor radio.

Modifying The Clock

The main modification required to the clock is to fit the contact strip, insulated from the chassis, such that it makes reliable contact with part of the disc and sprocket assembly when this moves forward. In the prototype the strip was made from thin shim brass ⅛in wide, and was secured to the insulator (which can be made from ebonite or Perspex, etc.) with a small self-tapping screw. The insulator was then fixed to the clock chassis with Araldite. A hole is drilled in the clock case at a convenient place to take the lead-out wires, which in the prototype were made from miniature twin flex from an old hearing aid earpiece, although any small flexible twin wire would do. One of the flex leads connects to the added contact, and the other to the clock chassis at any convenient point. The flex is terminated with a miniature jack plug which fits into a socket on the radio.

Modifying The Radio

Most transistor radios have an earphone socket. In the author's prototype, this socket was disconnected and used as the power switching socket. See Fig. 3. If, however, it is desired to retain the earphone facility, a separate miniature jack socket, with switching contact, will have to be fitted where space permits in the receiver. Normally, the receiver operates with its internal speaker connected via the closed contacts of the earphone socket, but when the earphone plug is introduced the internal speaker circuit is broken and the output is fed to the earphone. The dotted resistor, R in the diagram, is used in some receivers to protect the output circuit from damage with high resistance loads, and where fitted should be retained *in situ* after the modification.

Alternative earphone circuits will be found in some radios and the reader should check that receiver performance is not altered when disconnecting the existing wires to the earphone socket. If the existing socket does not have a switching contact, it will have to be replaced with one which has.

With the modification incorporated, one of the leads from the internal battery to the radio chassis is routed via the closed contacts of the socket, as shown in Fig. 3 (*c*). When the plug from the alarm clock is inserted these contacts open, whereupon the battery connection is completed, at the preset time, by the contacts in the clock.

In the evening, the author pretunes his radio to the Light Programme at the required volume with the plug out, plugs in the clock and—presto!—an unfailing early call results.

Other Applications

The alarm switch can also be used for switching on any other low-current battery-operated equipment requiring a time delay, or operation at any preset

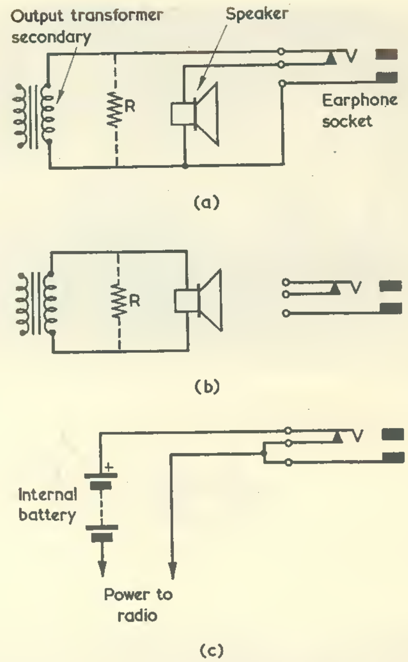


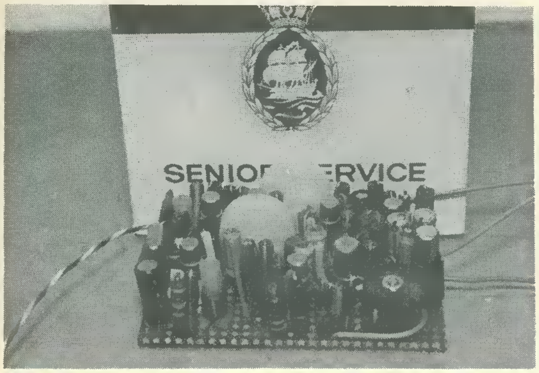
Fig. 3 (a). The original earphone socket circuit in the author's receiver
(b). The connections to the socket were removed, and the speaker wired directly to the output transformer secondary
(c). One lead of the internal battery of the radio was then routed via the contacts of the earphone circuit, as shown here

time. The author's clock switches on and stays on for approximately 45 minutes. The time during which the clock contacts remain closed depends on the gradient of the ramp, and this will vary with different clocks.

It is most important to note that the chassis of the clock is common to one side of the alarm switch, and that the switch should not on any account be used to control high voltages or to switch mains-operated equipment on and off. The alarm switch should only be employed to control low voltage battery circuits such as are encountered in battery-operated transistor radios and similar equipment.

The exposed metalwork (including aerials) on the cases of some transistor radios may be at a different potential to the battery lead switched by the clock. The clock should not therefore be allowed to touch such metalwork.

Finally, it should be mentioned that a few transistor radios have two internal batteries in series, their junction also connecting into the receiver circuit. These radios require a double-pole on-off switch, and the single-pole switching circuit offered by the modified alarm clock could not then be used.



The SCT/R... Rec...

In last month's issue the SCT/RR1 super-re... was fully described. We now introduce a... superhet receiver which may also be emplo... "tone" transmitter. Despite the fact that thi... it offers a ground-to-air range of well over a... use of transfilters obviates the n...

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FOLLOWING LAST MONTH'S DESCRIPTION OF THE SCT/RR1 super-regenerative receiver, we deal now with the alternative superhet receiver which has been specially designed for use in conjunction with the SCT/T1 single channel "tone" transmitter. This new receiver uses a total of eight transistors and embodies a number of unique features which give it a really superlative performance. Sensitivity is better than 2μV, giving a ground-to-ground control range of over 1,000 yards, and a ground-to-air range of well over 1 mile. Also, the unit is crystal controlled and features a tuned filter relay-less output stage, this combination giving near-perfect interference rejection and making it possible to operate as many as 50 independent models at the same time.

A further point is that the normal i.f. transformers have been eliminated from the circuit and replaced by transfilters, so that no i.f. lining-up procedure is required. The receiver operates from a 9 volt supply, and draws a no-signal current of approximately 5mA; the complete unit measures $2\frac{3}{4}$ x $1\frac{3}{8}$ x $\frac{7}{8}$in. A kit of parts is available from Teleradio Electronics.

Basic Design Considerations

Most readers will no doubt be familiar with the basic block diagram for a normal superhet radio receiver, as shown in Fig. 1 (*a*). Here, radio signals are picked up by the antenna and the required band of frequencies is then selected by the r.f. stage and passed on to the mixer, where it beats with a signal provided by the local oscillator to produce an i.f. (intermediate frequency) signal at the mixer output. This i.f. signal is equal to the difference between the r.f. and the local oscillator frequencies. Thus, if the r.f. signal being received is 27,000 kc/s, and the local oscillator frequency is 26,535 kc/s, the difference frequency, or i.f. will be 465 kc/s. This i.f. signal, which retains the same modulation as the original r.f. signal, is next subjected to several stages of i.f. amplification. The

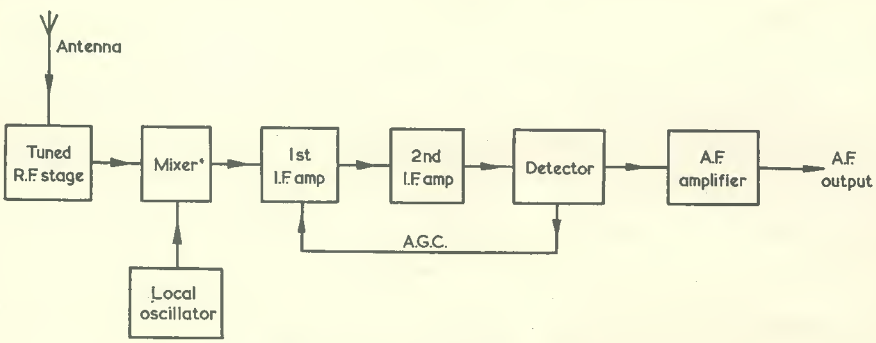


Fig. 1. Block diagram for a conventional superhet

Basic Radio Co...
by ...

RS1 Superhet ceiver

Cover Feature

ntrol (7)

F. L. Thurston

generative receiver for model control a more sensitive and sophisticated ployed with the SCT/T1 single channel his receiver measures only $2\frac{3}{4} \times 1\frac{5}{8} \times \frac{7}{8}$in, a mile. An attractive feature is that the necessity for i.f. alignment

amplified i.f. signal is then demodulated in the detector stage and the resulting audio signal is passed on to the a.f. (audio frequency) amplifier and finally on to the output of the circuit. Part of the signal from the detector is also fed back to the first i.f. amplifier in the form of an automatic gain control (a.g.c.) signal. This compensates for different strengths of r.f. signal and prevents overloading of the amplifier stages on receipt of powerful signals.

The basic *principles* outlined above apply to all superhet circuits irrespective of the actual application in which the circuit may be used, but considerable differences in design *details* may be encountered in practical circuits, these depending on the precise performance that is required. In an ordinary broadcast receiver, for example, the tuning of the r.f. and local oscillator circuits must be variable so that different stations may be selected, while in a radio control circuit the tuning must be fixed and exceptionally stable. Again, an ordinary broadcast receiver does not require a particularly high degree of sensitivity, and a figure of 200μV is usually regarded as acceptable in pocket superhets. In radio control work, on the other hand, far greater sensitivity is required, and a figure of at least 10μV is regarded as essential. Finally, a broadcast receiver is required to faithfully reproduce, without distortion, the complex audio signals that are used to modulate the carrier signal at the transmitter, but in radio control equipment the same distortionless performance is not *necessarily* required.

The considerations just discussed have to be

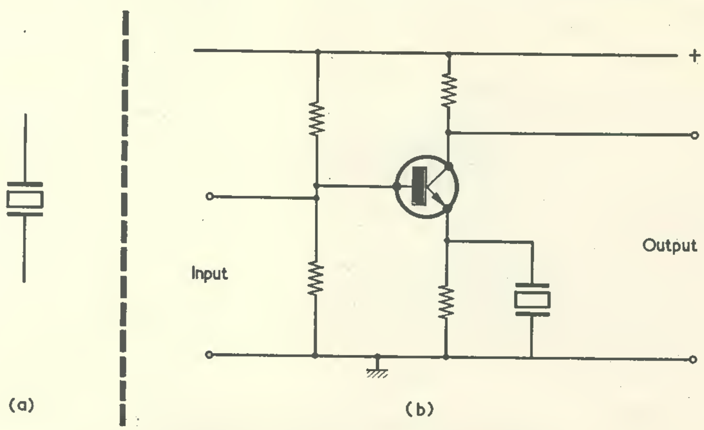
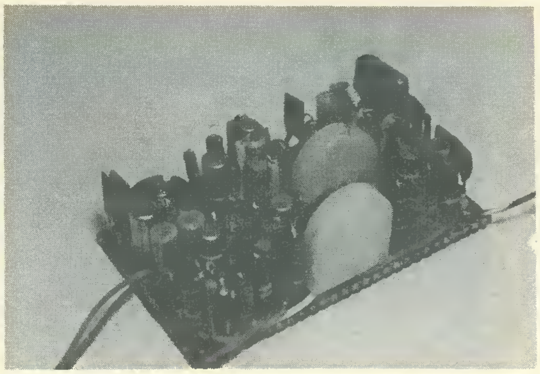


Fig. 2 (a). The symbol for a "TF" transfilter
(b). When a "TF" transfilter replaces the emitter bias capacitor, the amplifier becomes frequency selective



The extremely compact layout of the complete 8-transistor receiver may be judged from this illustration, which shows all the components mounted on the $2\frac{3}{4} \times 1\frac{5}{8}$in Veroboard panel

taken into account before starting the design of any new piece of equipment, since such equipment will have its own unique performance requirements. The design considerations taken into account when developing the SCT/RS1, and the solutions accepted, were as follows:

(*a*). Fixed tuning, with very high stability, is essential. This can be achieved by the use of a pre-set r.f. filter and a crystal controlled local oscillator.

(*b*). For maximum possible control range a very high degree of receiver sensitivity is required, which means that the circuit must give a very high overall gain. Extra gain can be achieved in a number of ways, e.g. by including an extra stage of r.f. amplification, an extra stage of i.f. amplification, an extra stage of a.f. amplification, or by a combination of these methods. In the SCT/RS1 the extra gain is achieved in the i.f. and a.f. stages.

(*c*). Very good rejection of interference from electric motors, etc., is required. Interference is particularly troublesome in high gain circuits, so that the requirements of (*b*) and (*c*) do in fact conflict. With the SCT/RS1, however, this problem is overcome by incorporating a tone filter in the a.f. stages so that only the correct tone modulation signal can reach the output circuitry, and interference has no effect on the output of the receiver.

(*d*). So far as distortion is concerned, a single-channel tone receiver is required simply to reproduce the single modulation tone frequency that is applied at the transmitter, and it is therefore of no importance if this signal happens to be distorted. In the SCT/RS1 distortion is deliberately introduced in the a.f. stages, and contributes to the high performance that is obtained from the circuit. In multi-channel tone work, of course, complex modulation signals may have to be reproduced, and in such cases it may be necessary to keep distortion to a minimum.

(*e*). Since the circuit is intended for assembly by the amateur, it is important that it should be possible to complete the unit without difficult lining-up procedures, and in the SCT/RS1 this is achieved by replacing the conventional i.f. transformers with ceramic transfilters, which require no adjustment.

Transfilters

Transfilters are piezoelectric ceramic devices which give a performance that is not unlike that of a conventional crystal, and they can therefore be used to simulate normal L-C tuned circuits. Two basic types of transfilter are available.

The first of these basic types consists of a ceramic disc with a silvered electrode on each of its two faces. When an a.c. signal is connected across these electrodes the disc vibrates mechanically; or, alternatively, if the disc is mechanically made to vibrate an a.c. signal is generated across the electrodes. The ceramic disc has, like a normal crystal, a fundamental resonant frequency at which it is particularly active, and this frequency will depend on the dimensions of the disc and the mode in which it is used; the operating frequency can be established during the manufacturing process with considerable accuracy. Transfilters are designed to resonate in the radial mode, since the overtones of operation are not then harmonically related, the first overtone being 2.6 times the fundamental resonant frequency and the second overtone being 3.9 times the fundamental.

These two-electrode transfilters, which are manufactured by the Brush Clevite Company, are given the symbol shown in Fig. 2 (*a*). They appear in the Brush Clevite TF series, and are intended to operate on their fundamental frequency. At its fundamental frequency, a TF transfilter presents an impedance of about 15Ω, but at other frequencies its impedance is relatively high. In consequence, a TF transfilter can be used to replace the emitter bypass capacitor of a common emitter amplifier, as shown in Fig. 2 (*b*), thereby making the circuit sharply frequency selective, since at the resonant frequency the emitter is effectively bypassed via the low impedance of the TF transfilter and the stage gain is high, while at other frequencies the transfilter exhibits a high impedance and the stage gain is low. The TF transfilter used in the SCT/RS1 circuit has the code number TF-O1B, and is designed to resonate at 465 kc/s.

The second basic type of transfilter appears in the TO series, and is given the symbol shown in Fig. 3 (*a*). Here, one face of the ceramic disc is silvered over its complete surface, the silvering being used as a common terminal; whilst the other face has two electrodes on it, one being a central "dot", to which the input is connected, and the other a "ring" around the dot, which forms the output connection. When an a.c. signal (at the resonant frequency) is connected to the input of the transfilter (between the dot and the common terminal), the ceramic disc resonates mechanically, and this mechanical movement then generates a sympathetic a.c. signal at the output terminals (between the ring and the common terminal) although no d.c. path exists between input and output. Since the dimensions of the dot and the ring are different, a transformation takes place between the impedance levels of the input and

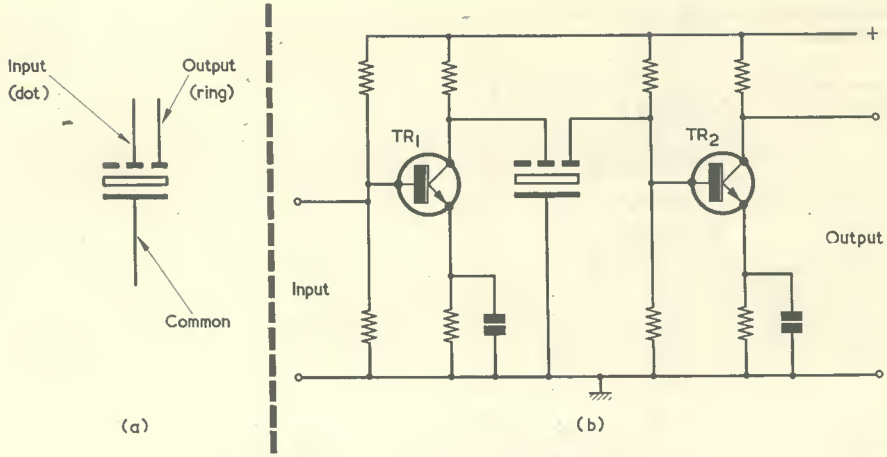


Fig. 3 (a). The symbol for a "TO" transfilter

(b). A "TO" transfilter employed in a simple i.f. amplifier

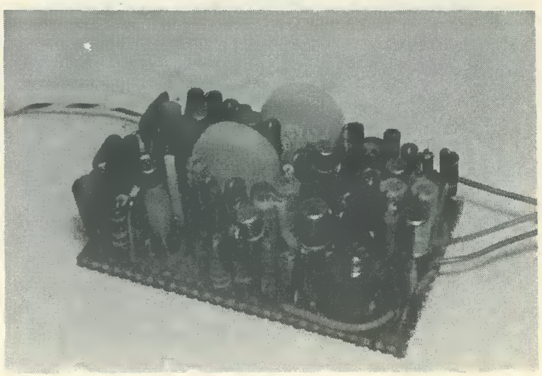
output circuits, so that the complete device closely simulates the action of a normal i.f. transformer.

The TO type of transfilter may be used in the type of circuit shown in Fig. 3 (*b*). Here, TR_1 and TR_2 are wired as conventional common emitter amplifiers, with the transfilter interposed between TR_1 collector and TR_2 base. At its resonant frequency the input of the transfilter presents a low impedance, so that a substantial amount of power is absorbed from TR_1 and transferred to the base of TR_2, thereby enabling a high degree of overall gain to be achieved. At other frequencies the transfilter presents a high impedance, so that very little power is absorbed from TR_1 and passed to TR_2, and the overall gain is low.

There is only one major snag in using the TO type of transfilter, and that arises in the following manner. For entirely practical reasons the physical dimensions of the ceramic disc must be kept reasonably small, although not so small that it becomes difficult to handle during the manufacturing process or in use. It is found that the size requirements are such that the disc must in practice operate on a fundamental frequency of only one or two hundred kc/s, so that for operation in the normal i.f. range the transfilter must be operated on its first overtone frequency. Thus, a TO transfilter, such as the TO-O2B, which is used in the SCT/RS1 receiver and is intended for operation at 465 kc/s, also responds to signals on its fundamental frequency of approximately 180 kc/s; hence, in a practical circuit, additional measures must be taken to suppress signals at the fundamental frequency. This can be achieved quite simply by either incorporating a simple L-C tuned circuit in some part of a multi-stage design, or by using a TF transfilter in conjunction with a TO type. It is this second solution that is adopted in the SCT/RS1 receiver.

The SCT/RS1 Circuit

The full circuit diagram of the SCT/RS1 single channel receiver is shown in Fig. 4. Here, the carrier signal is picked up by the antenna and fed to the r.f. tuned circuit L_1-C_2 and thence on to the base of the mixer transistor, TR_1. The local oscillator signal is developed in the crystal controlled stage, TR_2, and is fed, via C_4, to TR_1 emitter, so that mixing of the r.f. and local oscillator signals takes place, in this transistor producing a beat signal at TR_1 collector. The 180 kc/s and 465 kc/s products of this beat signal are accepted by transfilter TF_1 and passed on to the base of the first i.f. amplifier, TR_3, but the emitter of this transistor is by passed by transfilter TF_2 so that the amplifier tends to reject the unwanted 180 kc/s component and accept only the 465 kc/s signal, which then appears in amplified form at TR_3 collector. The 465 kc/s signal from TR_3 collector is next selected by transfilter TF_3 and passed on to the base of the second i.f. amplifier, TR_4, which



The other side of the receiver. The pot core assembly, L_3, is clearly visible on the right

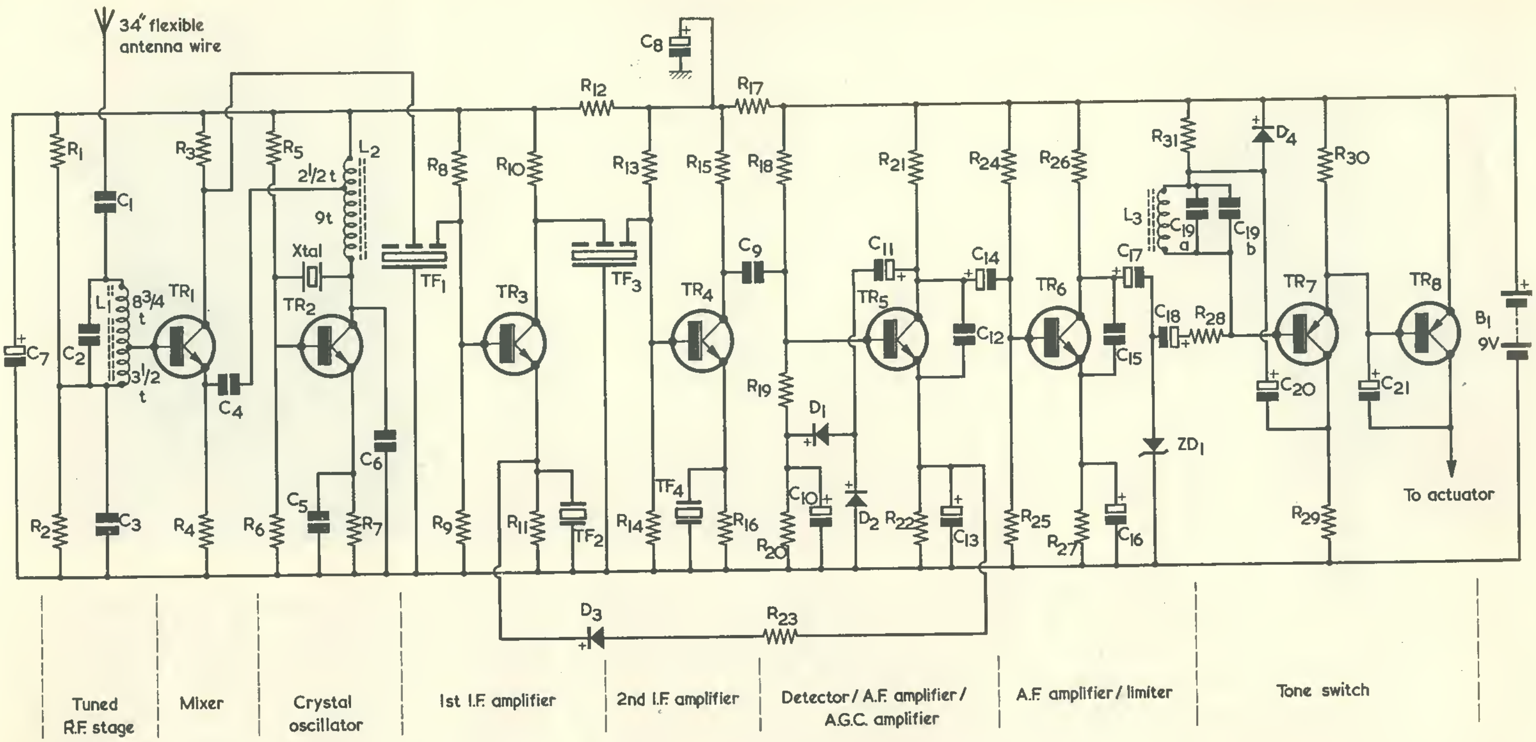


Fig. 4. The complete circuit of the SCT/RS1 single channel tone receiver

COMPONENTS

Resistors
(All resistors ¼ watt 10%)

R_1	10kΩ				
R_2	6.8kΩ	R_{12}	120Ω	R_{22}	4.7kΩ
R_3	10kΩ	R_{13}	27kΩ	R_{23}	470Ω
R_4	10kΩ	R_{14}	18kΩ	R_{24}	56kΩ
R_5	47kΩ	R_{15}	4.7kΩ	R_{25}	12kΩ
R_6	6.8kΩ	R_{16}	2.7kΩ	R_{26}	5.6kΩ
R_7	390Ω	R_{17}	180Ω	R_{27}	1kΩ
R_8	47kΩ	R_{18}	100kΩ	R_{28}	22kΩ
R_9	12kΩ	R_{19}	6.8kΩ	R_{29}	330kΩ
R_{10}	4.7kΩ	R_{20}	5.6kΩ	R_{30}	1kΩ
R_{11}	2.7kΩ	R_{21}	8.2kΩ	R_{31}	10kΩ

Capacitors
(All capacitors sub-miniature types)

C_1	12pF polystyrene
C_2	33pF silver mica
C_3	0.002μF Mylar
C_4	0.005μF Mylar
C_5	0.002μF Mylar
C_6	56pF silver mica
C_7	16μF electrolytic, 10V wkg.
C_8	16μF electrolytic, 10Vwkg.
C_9	0.01μF Mylar
C_{10}	8μF electrolytic, 6V wkg.
C_{11}	2μF electrolytic, 10V wkg.
C_{12}	0.005μF Mylar
C_{13}	8μF electrolytic, 6V wkg.
C_{14}	1μF electrolytic, 10V wkg.
C_{15}	0.005μF Mylar
C_{16}	16μF electrolytic, 10V wkg.
C_{17}	1μF electrolytic, 10V wkg.
C_{18}	1μF electrolytic, 10V wkg.
C_{19} (*a*)	0.02μF Mylar
C_{19} (*b*)	0.01μF Mylar
C_{20}	0.5μF electrolytic, 10V wkg.
C_{21}	1μF electrolytic, 10V wkg.

further rejects any unwanted 180 kc/s components via TF_4 and accepts the 465 kc/s signal. The 465 kc/s signal then appears in its final amplified form at TR_4 collector and is passed on to the following circuit via C_9.

The i.f. signal from C_9 is fed to the base of TR_5, and this stage provides a total of three functions, these being detection, a.f. amplification, and a.g.c. amplification. It is this TR_5 stage which is largely responsible for the high performance that is obtained from the complete receiver, and it is therefore worth-while considering its operation in some detail.

Basically, TR_5 is wired as a common emitter amplifier, with collector load R_{21}, base-bias resistors R_{18}, R_{19} and R_{20}, and emitter bias resistor R_{22} bypassed by C_{13}. The values of these bias components are so chosen that TR_5 operates with a collector current of only a few tens of microamps, so that the emitter-base junction of the transistor is operated on a non-linear part of its characteristics, near cut-off. Thus, when the i.f. signal from C_9 is fed to TR_5 base, the transistor is driven on by positive-going parts of the signal and off by negative-going parts, and detection takes place. This type of detector has two distinct advantages over the conventional diode detector, the first being that it is far more sensitive to signals of very small amplitude, and the second being that the transistor type has an input impedance some 50 times greater than the diode version, so that negligible loading of the i.f. stages takes place and an effective increase in the i.f. gain is therefore made available.

The detected signal that appears in the TR_5 base-emitter junction is subjected to normal amplification in the transistor, but the collector load R_{21} is decoupled to high frequency components by C_{12}, so that the basic 465 kc/s components of the signal are rejected. At the same time, the modulation signal is subjected to considerable amplification and appears as an a.f. signal at TR_5 collector, to be fed to the following stage, TR_6, via C_{14}.

Part of the a.f. signal at TR_5 collector is also fed, via C_{11}, to rectifiers D_1 and D_2, which convert the a.f. to a d.c. signal of positive polarity. This is then smoothed by C_{10} and applied to the base of TR_5 via R_{19}, so that the actual base bias of TR_5 varies with the strength of the i.f. signal from C_9. TR_5 functions as an emitter follower to the d.c. voltage applied to its base, with impedance transformation taking place in the transistor, so that the emitter potential, which varies between about 350mV under no-signal conditions and 1.5V on receipt of powerful signals, is at a low impedance level and is suitable for use as an a.g.c. voltage. This a.g.c. voltage is fed, via R_{23} and D_3, to the emitter of TR_3. On receipt of a powerful signal the a.g.c. line raises the potential of TR_3 emitter, thereby reducing the base bias and the gain of that transistor, with the result that the magnitude of the a.f. signal at TR_5 collector remains fairly constant over a wide range of r.f. input signal strengths. Diode D_3 ensures that no a.g.c. potential is applied to TR_3 until the magnitude of the r.f. signal exceeds $100\mu V$, so that the maximum possible gain is available to signals below this level.

The a.f. "tone" signal from TR_5 collector is fed, via C_{14}, to the base of TR_6, which is wired as a common emitter amplifier with its collector decoupled to high frequency signals by C_{15}. TR_6 further amplifies the a.f. signal, and passes it on, via C_{17}, to zener diode ZD_1, which clips the signal and converts it to a rectangular form with an amplitude of 4.7 volts. The magnitude of this final a.f. signal is constant within 3dB over r.f. input signal levels in the range $5\mu V$ to 200mV.

Inductors
(Formers, dust cores and pot core are available from Teleradio Electronics)
L_1 3½T + 8¾T of 28 s.w.g. enamel wire on 5mm former with dust core
L_2 9T + 2½T of 28 s.w.g. enamel wire on 5mm former with dust core
L_3 FX2236 pot core with Teleradio wound bobbin

Semiconductors
TR_1 ST141 (Sinclair)
TR_2 ST141 (Sinclair)
TR_3 ST140 (Sinclair)
TR_4 ST141 (Sinclair)
TR_5 ST141 (Sinclair)
TR_6 ST140 (Sinclair)
TR_7 2G381 (Texas) or NKT218 (Newmarket)
TR_8 2G381 (Texas) or NKT218 (Newmarket)
ZD_1 4.7V ⅛ watt zener diode (Z4.7 or similar)
D_1-D_4 OA90 or similar

Transfilters
TF_1, TF_3 TO-O2B (Brush Clevite)
TF_2, TF_4 TF-O1B (Brush Clevite)

Miscellaneous
Veroboard panel with 0.1in hole matrix, 2¾ × 1⅝in. (16 strips by 27 holes)
Midget radio control crystal (one of matched pair, 465 kc/s i.f.)
3-pin transistor holder
34in flexible antenna wire
Wire, insulated sleeving, etc.

All components are available from Teleradio Electronics, 325/7 Fore Street, London, N.9, who supply a complete kit of parts.

(N.B. The values given for R_{28}, C_{19} (*a*) and C_{19} (*b*) are those used in the prototype and may need adjusting. Also required for testing (as described next month) are a 6V 0.1A bulb (cycle dynamo type), a crystal earphone, an OA90 diode and a $0.002\mu F$ capacitor.)

The a.f. signal from ZD_1 is fed, via C_{18} and R_{28}, to the tone-operated "switch" given by TR_7 and TR_8. This circuit was fully described in the last part of this series and it will be remembered that, in the absence of the correct tone signal, TR_8 is cut off, so that an actuator connected in its collector circuit will be inoperative under this condition. On receipt of a correct tone signal of suitable amplitude, TR_8 is driven hard on, thereby operating the external actuator. The operating frequency of the tone switch can be adjusted by C_{19}, and the sensitivity of the switch can be adjusted by R_{28}. With correct selection of the value of R_{28} the overall sensitivity of the receiver can be made such that actuator operation is achieved with r.f. input signals of less than 2μV, although the tone switch is immune to operation by harmonics of tone signals other than the designed ones.

The manner in which adjustments are made, if necessary, to C_{19} and R_{28} are described in the next part of this series, which will appear next month. The next article will also give full details of construction and final testing of the receiver.

(To be concluded)

A LOGICAL APPROACH TO LOGIC

by S. J. Houghton, B.Sc.

Boolean algebra, logic circuits and truth tables tend to be a little awesome to the uninitiated. But they provide a useful means of solving some knotty switching problems, as the example in this article illustrates

Editor's Note

In this article conventional logic symbols are used. A + sign indicates OR, and can appear in an expression such as A + B. A multiplication sign (a full-stop is used here) indicates AND, as in A.B. A line drawn over a term means NOT; thus $\bar{A}$ means NOT-A and is the exact inverse of A. Remember that all processes are carried out under binary conditions, where each quantity can only exist in one of two states: viz, 0 or 1; or, again, A or $\bar{A}$.

Astute readers will note that an unnecessary complication appears in the truth table for the worked example, and that this complication is eliminated very quickly by the application of Boolean algebra principles, resulting in the simplest possible solution.

Circuit Operation

In order to understand the operation of a radio receiver, almost all that is required is an understanding of the operation of each circuit. The knowledge of the order in which the circuits are connected may be deduced from the action of each particular circuit.

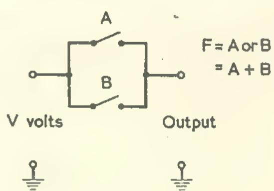
As systems increase in complexity the understanding is based, in general, more and more on the method of interconnection of the circuits, less emphasis being put on the finer details of circuit operation.

Digital (logic) systems represent a class of systems where the organisation of circuitry is far more important than an understanding of each detailed circuit; that is to say, a complete study of the operation of each "black box" gives virtually no clue to the operation of the system. In this short article, the "black boxes" we shall use are merely switches.

Switch Logic

Consider the switch arrangement of Fig. 1 (*a*). If switches A or B or both are closed then the output will be the input voltage V; that is, at least one switch must be closed to obtain the output F. The corresponding logic element is the OR gate, which may be synthesised in many other ways.

Since a switch has only two possible conditions, closed or open, we may represent these conditions by 1 and 0 respectively. The use of



(a)

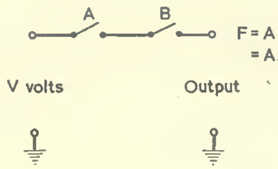
A	B	F
open	open	O volts
closed	open	V volts
open	closed	V volts
closed	closed	V volts

(b)

A	B	F
O	O	O
I	O	I
O	I	I
I	I	I

(c)

Fig. 1 (a). Two switches connected as shown are representative of an OR gate (b). A truth table covering all the possible combinations of A and B (c). The corresponding truth table in which 1 represents the presence, and 0 the absence, of a conducting path



(a)

A	B	F
0	0	0
1	0	0
0	1	0
1	1	1

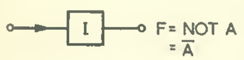
(b)

Fig. 2 (a). Two switches in series represent an AND gate (b). The truth table for an AND gate

the 1 and the 0 is different from their use in normal arithmetic, and it must be borne in mind that they do not directly represent numbers. In this example, they merely represent the pressure or absence of a conducting path. Similarly, we represent F by 1 or 0 depending on the presence or absence of a conducting path through the element and finally we represent OR by "+" which, again, must not be confused with the arithmetical plus sign.

These ideas may be clearly seen by an examination of the "truth table" of Fig. 1 (*b*), which is made up by trying all possible combinations of the variables. The corresponding truth table using 1 and 0 is shown in Fig. 1 (*c*). The 1 and 0 may be taken to represent the "true" and "false" of symbolic logic, i.e. Boolean Algebra. Hence, $F=A+B$ would be interpreted as "F is true if either condition A or condition B or both is true".

A similar consideration of the switching arrangement in Fig. 2 (*a*), which represents a logic AND element, gives the truth table of Fig. 2 (*b*). In this case there is a conducting path ($F=1$) only when both A and B are closed. The symbol "." is used to indicate AND and must not, once again, be confused with the sign corresponding to algebraic multiplication. Hence $F=A.B$ is interpreted as "F is true if and only if condition A is true and condition B is true".



(a)

A	F
0	1
1	0

(b)

Fig. 3 (a). Symbolic representation for an inverter or NOT element (b). The truth table for the inverter

A further element to be considered is the inverter or NOT element of Fig. 3 (*a*), which could in practice be given by a device such as a common emitter transistor where an input 0 gives an output 1 and vice versa. This element is represented by $F=\bar{A}$ (where, since A may only have the values 1 and 0, $\bar{A}$ corresponds to 0 and 1 respectively). This is interpreted as "F is true if and only if A is not true".

Simple relations		Laws	Simplification rules
0 + 0 = 0 (1)	A + A = A (9)	Commutation	A + A.B = A (22)
0 . 0 = 0 (2)	A . A = A (10)	A + B = B + A (17)	$A+\bar{A}.B = A+B$ (23)
1 + 1 = 1 (3)	$\bar{A}.A=0$ (11)	A . B = B . A (18)	A.(A+B) = A (24)
1 . 1 = 1 (4)	$\bar{A}+A=1$ (12)	Association	De Morgan's Theorem
0 . 1 = 0 (5)	0 + A = A (13)	(A+B)+C = A+(B+C) (19)	$\overline{A.B}=\bar{A}+\bar{B}$ (NAND)
0 + 1 = 1 (6)	0 . A = 0 (14)	(A . B) . C = A . (B . C) (20)	$\overline{A+B}=\bar{A}.\bar{B}$ (NOR)
$\bar{0}=1$ (7)	1 + A = 1 (15)	Distribution	
$\bar{1}=0$ (8)	1 . A = A (16)	A.(B+C) = A.B + A.C (21)	

Fig. 4. Useful relationships in symbolic logic

Some useful relationships are shown in Fig. 4. Here we encounter such equations as $1+1=1$, which is not, of course, at all like the sort of thing we encounter in ordinary arithmetic. This particular relationship is, however, an OR relationship such as that of Fig. 1 (*a*) where 1 may stand for a conducting path. Reading it as "a conducting path or a conducting path is a conducting path", the statement is meaningful and logical.

The last two simplification rules (known in symbolic logic as De-Morgan's Theorem) refer to NAND and NOR circuits. NAND is equivalent to NOT(A AND B) and NOR to NOT(A OR B). These should be noted as they are very useful in more advanced logic work.

Example

Let us now see how logic principles may be used to solve a switching problem.

Consider a simple example of the use of logic in a factory, in the form of a control for a hot-air heating system where it is desirable to control a fan for circulating the air and a motor ignition for turning on a furnace (oil heating) automatically.

We are presented with three conditions.

(*a*). The furnace must be turned on whenever the building temperature is below a given value. Hence a thermostat remote from the furnace supplies a variable "T" which is 0 when the temperature is too low and 1 when it is higher than the required temperature.

(*b*). The fan should not operate until the furnace is warm enough to heat the air. Thus a thermostat in the furnace supplies a variable "L" which is 1 when the temperature is sufficiently high and 0 otherwise.

(*c*). To prevent overheating the furnace must be switched off above a certain temperature defined by a third thermostat. This supplies a variable "H" which is 0 if the temperature is not excessive but 1 otherwise.

We approach this problem by drawing up a truth table (Fig. 5) which takes into account all the possible variations of T, L and H, with the corresponding values of the functions F (fan) and M (motor ignition). Note that the first three columns present all the combinations that can be offered by T, L and H. Impossible conditions are ignored, such as are given in the second and sixth lines of the table, where the furnace has an excessively high temperature ($H=1$) but is not hot enough to actuate the fan ($L=0$).

To examine this truth table in more detail, we may start with the conditions which affect M. Over the first four lines of the table, T at 0 indicates that the room temperature is too low and this is one of the requirements for switching on the furnace motor. The other requirement is that the motor must switch off when H is at 1 (i.e. the third

T	L	H	F	M
0	0	0	0	1
0	0	1	Not possible	
0	1	0	1	1
0	1	1	1	0
1	0	0	0	0
1	0	1	Not possible	
1	1	0	1	0
1	1	1	1	0

Fig. 5. Truth table covering all the possibilities in the example described in the text

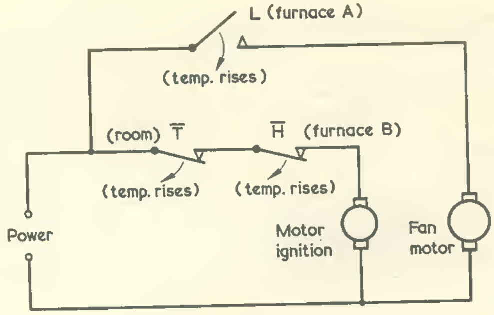


Fig. 6. The final switch logic worked out in the example

thermostat indicates excessive temperature). In the first and third lines both T and H are at 0 and these allow M to become 1 (i.e. the motor switches on).

The truth table similarly indicates the conditions which allow the fan to operate, i.e. F to become 1.

This truth table now shows all the possible circumstances controlling M and F. Dealing first with M, we know that M is 1 when T, L and H are 0 (first line) or when T is 0, L is 1 and H is 0 (third line). So we may say:

$M=\overline{T}.\overline{L}.\overline{H}+\overline{T}.L.\overline{H}$

$=\overline{T}.\overline{H}.(\overline{L}+L)$ (from relation 21)

$=\overline{T}.\overline{H}.1$ (from relation 12)

$=\overline{T}.\overline{H}$ (from relation 16)

Let us repeat the process for F. F is 1 for the conditions of T, L and H shown in the third line or the fourth line or the seventh line or the eighth line. Following the same procedure as with M we may say:

$F=\overline{T}.L.\overline{H}+\overline{T}.L.H+T.L.\overline{H}+T.L.H$

$=\overline{T}.L.(\overline{H}+H)+T.L.(\overline{H}+H)$ (from relation 21)

$=\overline{T}.L.1+T.L.1$ (from relation 12)

$=\overline{T}.L+T.L$ (from relation 16)

$=L.(\overline{T}+T)$

$=L$

The resultant switching arrangement is shown in Fig. 6. Since we have found that F=L, it is merely necessary for the first furnace thermostat to control F. When L is 1 the thermostat switch closes and switches on the fan.

We have also found that $M=\overline{T}.\overline{H}$. This is the AND condition given by the two switches of Fig. 2 (*a*) and so we may similarly have two switches in series to control the furnace motor. However, since we are dealing with $\overline{T}$ and $\overline{H}$, the thermostat switches are *open* for the 1 condition (temperature too high) and *closed* for the 0 condition (temperature too low), which is the inverse of the switch logic conditions of Fig. 2 (*a*).

The circuit of Fig. 6 meets all the control requirements originally stated and does so in the simplest possible form. ✱

Silicon Glass Rectifiers with 50A Surge Current Capability

The SGR100 and IN4384-6 silicon glass rectifiers comprise a new series of subminiature glass (DO-29) hermetically sealed units capable of conducting 1A average forward current at 100°C ambient and withstanding non-repetitive single cycle surge currents of up to 50A, announce Transitron Electronic Ltd., Gardner Road, Maidenhead, Berks.

Constructed with double diffused junctions rated at d.c. blocking voltages of up to 1,000V, and exhibiting specified maximum forward voltage drops as low as 1V at 1A, these units are especially suited for military, industrial and consumer applications where space is at a premium and robustness in the face of overload surge current transients is required. Typical applications are for bridge rectifiers with heavy capacitance smoothing, relay slugging and d.c. motor surge suppression. In effect, the series fills the gap between existing subminiature glass diodes which are unable to handle high currents and metal case stud or axial lead rectifiers with all their attendant mounting and heat sinking problems.

New Society

A Flint and District Radio Society was inaugurated at a well-attended meeting held at the Central Library, Flint on Friday, 30th June.

The Society intends to promote all aspects of amateur radio, including construction of equipment, operation of a Flint transmitter and preparation of members for the Radio Amateur Examination and the Post Office morse tests.

Lectures are to be held at the Central Library, Church Street, Flint and the Society also has accommodation available for its varied programme of practical activities.

A debate on "valves or transistors in amateur radio" is to be held on Friday, 14th July at 7.30 p.m.

The Society is affiliated to the Flint Association for the Arts and joins the highly-successful Flint Photographic Society and the Flint and District Art Society, which were also formed in association with Flint Public Libraries.

UNDERSTANDING RADIO

Classes of Amplification

$f = \frac{1}{2\pi\sqrt{LC}}$

by W. G. Morley

LAST MONTH WE DISCUSSED THE USE OF A.F. output valves in parallel or push-pull under Class A_1 conditions (in which no grid current flows) and Class A_2 conditions (in which grid current flows during part of the input cycle). We noted that push-pull operation is preferable because, when the valves work in Class A, the even harmonics introduced by distortion in the valves are cancelled out, no d.c. magnetising force is exerted on the output transformer core, and negligible current at signal frequencies is drawn from the h.t. supply.

We shall now turn our attention to other classes of amplification.

Class B Operation

In Class A_1 and A_2 operation, as we saw last month, the input signal is applied to the most linear part of the I_aV_g curve of the valve. This ensures that only a low amount of distortion is introduced by the valve itself.

An alternative method of operating a valve is shown in Fig. 1. Here we have the same I_aV_g curve as we had when we previously considered Class A_1 and A_2 operation, but the bias point is now at, or very near, the grid cut-off voltage. We apply our input signal as before and we produce, graphically, the corresponding anode current. As may be seen, no anode current flows during the negative input half-cycle (or nearly all of the negative input half-cycle) and all we obtain at the anode is a series of half-cycles resulting from the positive half-cycles at the grid.

This method of working is known as Class B_1 operation when no grid current flows during the input cycle, or Class B_2 operation when grid current flows during part of the positive input half-cycle.

It is possible to operate a single valve in Class B_1 or B_2 as an r.f. amplifier if a parallel tuned circuit resonant at the frequency being handled forms the anode load. Although only half-cycles of the signal frequency appear at the anode, the tuned circuit between the anode and the h.t. positive rail oscillates at its resonant frequency and provides the missing half-cycles itself. At the same time, a single valve cannot be operated as an audio frequency amplifier in Class B_1 or B_2 because the signal voltage at the anode would be an excessively distorted version of the input signal voltage.

Two valves in push-pull can, on the other hand, be operated in Class B_1 or B_2 to provide an a.f. output stage, as is shown in Fig. 2. In Fig. 3 (*a*) we see the anode currents for each valve over several cycles of the input signal. As is to be expected from Fig. 1, each anode draws current during alternate half-cycles. These anode currents flow in opposing directions through each half of the output transformer primary, whereupon they recombine to produce the original signal, as illustrated in Fig. 3 (*b*). It is worth examining this process in a little more detail, as it is quite different from that occurring with the Class A push-pull amplifier we discussed last month. If, during one half-cycle of the input signal, the grid of the upper valve of Fig. 2 is negative, then this valve is cut off and draws no current. The grid of the lower valve has a positive half-cycle applied to it and its anode current varies to provide an amplified half-cycle. When the next half-cycle commences, the grid of the lower valve goes negative and the grid of the upper valve goes positive. This time it is the lower valve which is cut off and the upper valve which provides the amplified half-cycle. Thus, on one half-cycle the upper valve is cut off and no current flows in the upper half of the output transformer primary, and on the next half-cycle the lower valve is cut off and no current flows in the lower half of the output transformer primary.

Push-pull Class B_1 and B_2 operation does not, in consequence, offer the automatic distortion-cancelling advantage which is given by Class A push-pull operation. Also, the current drawn from the h.t. supply is not constant, but varies considerably with input signal amplitude. If no input signal is applied both valves are cut off, or very nearly cut off, and the h.t. current drawn is at a minimum. When an input signal is applied, the valves draw h.t. current on alternate half-cycles, the current increasing with signal amplitude. In consequence,

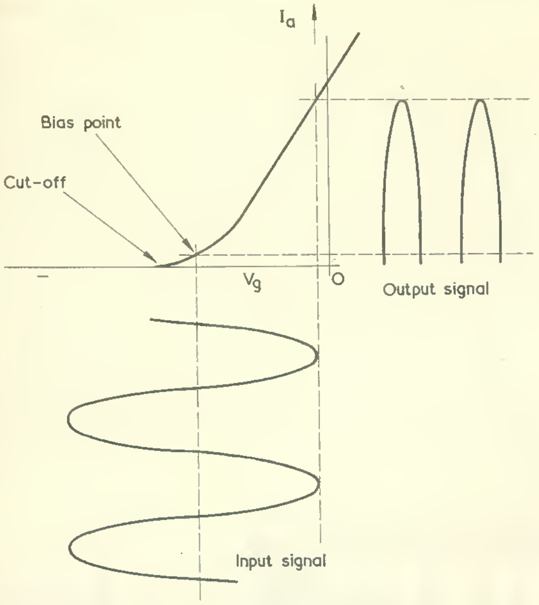


Fig. 1. When a valve is operated in Class B, the bias point is at, or very near, its cut-off voltage, so that only amplified half-cycles appear in the anode circuit

it is necessary for the h.t. supply fed to a Class B_1 or B_2 push-pull stage to be well regulated.

Since the point along the I_aV_g curve at which the valves are biased will normally be non-linear, a form of distortion can be introduced by the output stage which is shown, in exaggerated form, in Fig. 4. In this diagram sine wave half-cycles at each anode are distorted over the range where the anode current is low, with a consequent distortion in the combined waveform as illustrated below. It is interesting to note that the percentage distortion due to this effect increases as signal amplitude decreases. If the valves handle a large signal, the distorted section is only a small fraction of the overall waveform whereas, if the valves handle a small signal, the distorted section becomes a very large fraction of the overall waveform.

The main advantage of a Class B_1 or B_2 push-pull a.f. output stage is that it has a very high efficiency in terms of the ratio of h.t. power consumption to a.f. power output. Also, it is possible to obtain a much higher power output from two valves in a Class B push-pull output stage (especially when Class B_2 working is used) than would be given by the same two valves in a Class A push-pull output stage. Class B_2 working is, therefore, attractive for public address amplifiers and similar applications where a high output power is required, and particularly where batteries are used for the power supply.

Because the main reason for using a Class B push-pull a.f. output stage is to obtain a high power, such stages are almost always operated in Class B_2, in which grid current flows during part of the positive input half-cycles applied to the grids. The output stage has, in consequence, to be driven by a preceding power stage. Since operation in Class B_2 is much more common than operation in Class B_1, it can normally be assumed that reference to a Class B push-pull amplifier infers the Class B_2 condition.

It will be noted that, in Fig. 2, grid bias is provided by an external source, shown in the diagram as a battery. Cathode bias cannot be used for Class B stages because of the wide variations in anode and, hence, cathode current for different input signal amplitudes.

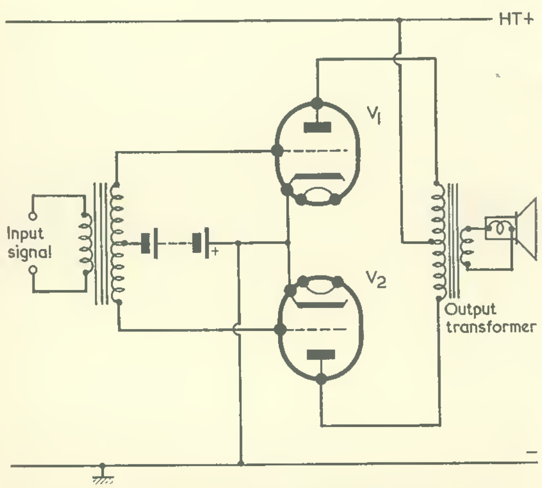


Fig. 2. A Class B push-pull output stage. Due to varying anode currents, cathode bias cannot be used and an external source of grid bias (shown here as a battery) has to be provided

Class C Operation

A third method of working is described as Class C operation, and this is illustrated in Fig. 5. As may be seen, the grid bias point in this diagram is negative of cut-off so that the valve only passes anode current during *part* of the input positive half-cycles.

Because of the high degree of distortion introduced by Class C operation, this mode of working cannot be employed for a.f. amplification. On the other hand, it is very useful for r.f. amplification when a parallel tuned circuit forms the anode load, since it offers a high efficiency in terms of output power. Oscillatory effect in the anode tuned circuit ensures that the missing sections of the cycles appear across it, even though the valve does not itself pass anode current during these periods.

Due to the high efficiency of r.f. power amplifiers in Class C, this mode of operation is very frequently used for the output valve or valves of transmitters. Class C output valves are employed singly or in push-pull; in the latter case the two anodes may be coupled to the two ends of a tuned winding having a centre-tap which connects to the h.t. positive supply.

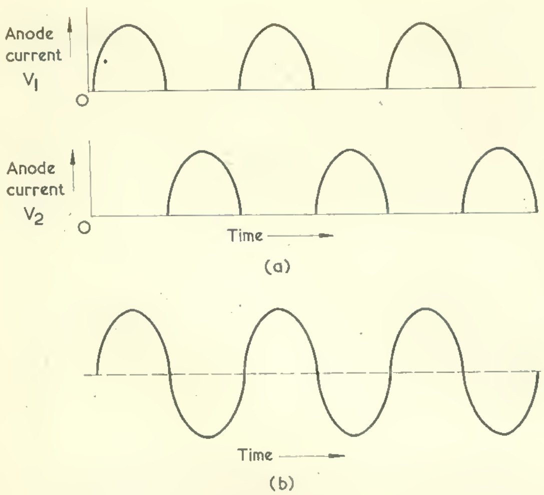


Fig. 3 (a). With a sine wave input signal applied in Fig. 2, anode current in the two valves flows on alternate half-cycles
(b). Since the anodes are connected to the opposite ends of a centre-tapped transformer primary, the two anode currents combine to reproduce the original signal

Greatest efficiency is obtained when the input drive to the grid of a Class C amplifier is sufficiently high to allow grid current to flow during the more positive parts of the positive half-cycles. This is the method of working most commonly used and can be referred to as Class C_2. If grid current does not flow, the mode of operation may be described as Class C_1. References to r.f. power amplifiers normally state "Class C", whereupon Class C_2 operation can usually be assumed.

As is to be expected from a consideration of the manner in which it works, the h.t. current drawn by a Class C amplifier varies with input signal amplitude. At very low signal amplitudes (too low for correct operation) the valve is cut off all the time and it draws no anode current. When the signal input amplitude is sufficient for positive half-cycle peaks to pass beyond cut-off the valve commences to draw anode current, this current increasing as input amplitude increases.

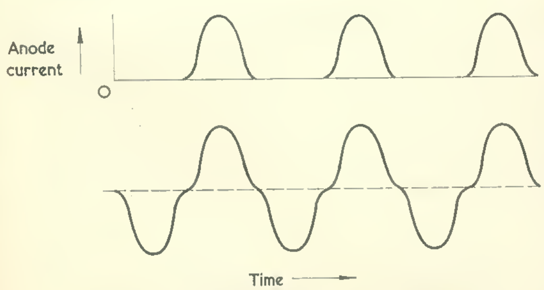


Fig. 4. Showing in exaggerated form a type of distortion which can be introduced by a Class B output stage. The half-cycles at each anode may have the shape shown in the upper section, whereupon the combined waveform has the distortion shown below

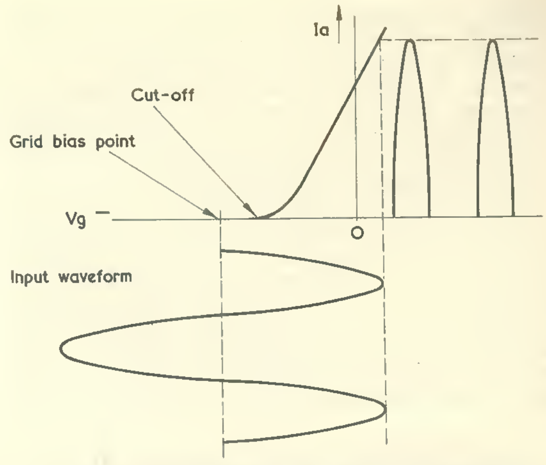


Fig. 5. In Class C the bias point is negative of cut-off, with the result that the valve passes current only during part of the positive input half-cycles. It is usual for the positive input peaks to pass into the grid current region, as is shown here

Class AB Operation

We have seen that, in Class A, the input signal is applied over the most linear part of the I_aV_g characteristic. In Class B the valve is biased at (or very slightly positive of) the cut-off point so that it only amplifies the positive input half-cycles. And, in Class C, the valve is biased negative of cut-off so that it only amplifies *part* of the positive input half-cycles. Of these three classes, Class A and Class B can be used for a.f. output circuits.

A fourth mode of working is known as Class AB. As the name infers, Class AB relates to the case where the grid bias point lies between those which apply for Class A and Class B operation. Class AB working can be used with two valves in an a.f. push-pull output circuit, and it enables a higher power output to be achieved than would be given by the same valves in Class A.

A Class AB amplifier functions in the same manner as a Class A amplifier for small signal inputs, because the input waveform is still applied to a linear part of the I_aV_g characteristic. As input signal amplitude increases, the negative parts of the grid waveform become applied to the more non-linear section of the I_aV_g characteristic, and the distortion offered by each valve increases. However, the ability to cancel out even harmonics which is given by a Class A amplifier tends to apply here also, and this distortion is reduced. At yet higher input signal amplitudes each valve may be cut off during negative input peaks, whereupon one valve only passes anode current during these periods.

Since two valves in Class AB offer a greater power than the same valves in Class A, Class AB operation is attractive for applications where an increased distortion at high output powers is acceptable. With reasonably careful design, Class AB operation can also be used for the output stages of domestic high quality amplifiers.

Class AB stages may be divided into Class AB_1 (where no grid current flows) and Class AB_2 (where grid current flows during part of the positive input half-cycle). It is normal practice for the Class AB_2 grid bias point to be closer to cut-off than occurs in Class AB_1, and Class AB_2 gives a greater power output. One sometimes encounters the statement that "Class AB_2 is intermediate between Class AB_1 and Class B". For domestic amplifiers, Class AB_1 is preferred because the output stage can be preceded by a simple voltage amplifier circuit, instead of by a power amplifier as would be required with Class AB_2. Also, the distortion introduced by the output stage will be lower with Class AB_1.

Unlike a Class A push-pull output stage, a Class AB push-pull stage draws an increased h.t. current as input signal amplitude increases. The increase in h.t current is not as marked as with Class B operation, and does not preclude the use of cathode bias for Class AB_1 working. An external source of grid is, however, required for Class AB_2.

Next Month

In next month's issue we shall consider the various types of valve which are employed in a.f. output stages.

★

Combined AF/RF Signal Generator

Tracer! (JBJ)

by W. Kemp

A neat item of test equipment which can be used as a probe for both r.f. and a.f. signals without switching. Although intended primarily for testing transistorised equipment, it may also be employed with valve equipment by adding an input isolating capacitor

THIS SIMPLE LITTLE UNIT, WHICH USES ONLY TWO transistors, makes a useful combined a.f. and r.f. signal tracer, and is unique in that no external r.f. probe is required. The circuit works from a 9 volt battery and draws a total current of only 2mA, giving a working battery life of hundreds of hours with most small batteries.

The output of the unit, which measures $2\frac{1}{2}$ x $1\frac{1}{8}$ x 1in and includes a built-in volume control, is taken to a crystal earpiece. The complete and independent piece of test equipment can be built for less than 25s.

The Circuit

The full circuit diagram of the unit is shown in Fig. 1, and consists basically of a simple 2-stage direct coupled audio amplifier designed around v.h.f. transistors.

As far as a.f. signals are concerned, the circuit operates in the following manner.

The a.f. input signal is connected to the input terminals and fed, via C_1, to the variable resistor RV_1. A proportion of this signal is then tapped off at RV_1 slider and fed via C_2 to the base of TR_1, which is connected as a common emitter amplifier with collector load R_1. An amplified version of the input signal is thus made available at TR_1 collector, and this signal is fed directly to the base of TR_2, which is also wired in the common emitter mode with collector load R_2, so that further signal amplification takes place and a final large amplitude a.f. signal appears at TR_2 collector. This is fed directly to the crystal earpiece. C_3 bypasses high frequency signals and restricts the bandwidth of the amplifier to the a.f. range.

A standing bias voltage is set up at TR_2 emitter via R_3, which is decoupled to a.c. by C_4. The magnitude of this bias voltage is approximately equal to the d.c. potential at TR_2 base, which, in turn, is at the same potential as TR_1 collector. The bias potential

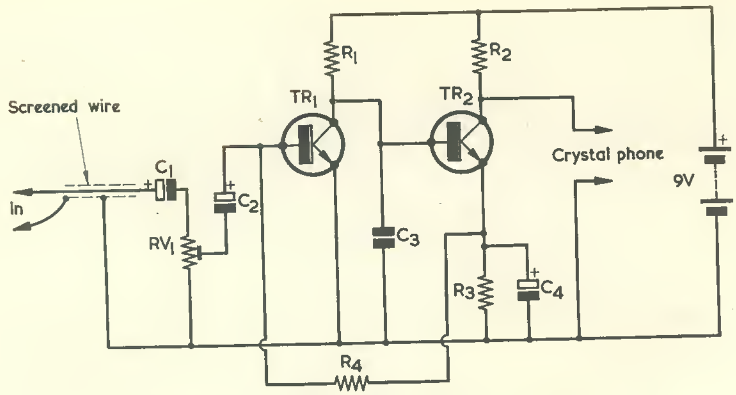


Fig. 1. The circuit of the combined a.f.—r.f. signal tracer

at TR_2 emitter is then used to provide the base-bias to TR_1 via R_4.

A d.c. negative feedback loop is thus set up in the transistor biasing network, and a large degree of self-compensation against shifts in the biasing levels, due to variations in transistor characteristics and supply line potentials, is obtained. Suppose, for example, that for some reason the standing current of TR_1 tends to increase above the design level, causing the potential at TR_1 collector to fall. If this occurs, the potential at TR_2 base, and thus at TR_2 emitter, will also fall. Since TR_1 base-bias is derived from TR_2 emitter, the base current (and hence the collector current) of TR_1 will automatically be reduced, thereby countering the original change in TR_1 collector current. A high degree of d.c. stabilisation is therefore obtained.

This completes the description of the d.c. and a.f. working of the circuit, and we can now consider the r.f. operation of the unit.

In "conventional" practice, an external r.f. probe is used in conjunction with an a.f. amplifier when tracing modulated r.f. signals, the probe circuit being similar to that shown in Fig. 2 (*a*). The simple explanation usually given for the action of such a probe is that the r.f. signal is applied across diode D via blocking capacitor C, and that the diode then rectifies or demodulates the r.f. signal, making the demodulated a.f. signal available at the output terminals of the probe. In fact, the action is a little more complex than is implied by this explanation, and to understand this we must first look at the typical forward characteristic curve of a normal diode, as shown in Fig. 2 (*b*).

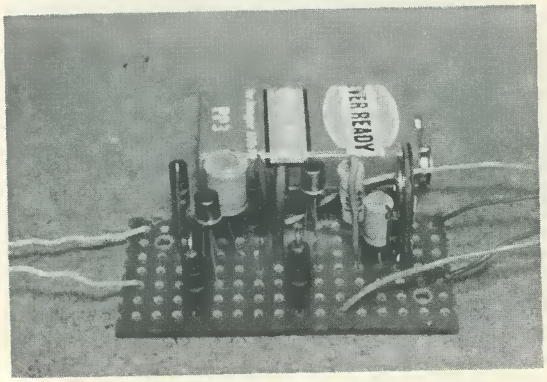
COMPONENTS

Resistors
(All fixed values ½ watt)
- R_1 5.6kΩ 10%
- R_2 5.6kΩ10%
- R_3 1.8kΩ 10%
- R_4 27kΩ 10%
- RV_1 10kΩ skeleton potentiometer

Capacitors
(All miniature types)
- C_1 8μF, 15V wkg. electrolytic
- C_2 16μF, 15V wkg. electrolytic
- C_3 0.05μF, ceramic
- C_4 50μF, 6V wkg. electrolytic

Semiconductors
- TR_1 ST140 (Sinclair)
- TR_2 ST141 (Sinclair)

Miscellaneous
- Veroboard with 0.15in hole spacing, 2½ by 1⅛in (7 strips by 16 holes)
- Crystal earpiece
- Wire, insulated sleeving, screened wire, 9 volt battery and battery terminals, etc.



The completed signal tracer, shown alongside a PP3 battery to demonstrate its small size. This photograph was taken immediately after tests of the prototype, and screened wire is recommended for the input instead of the unscreened leads shown here

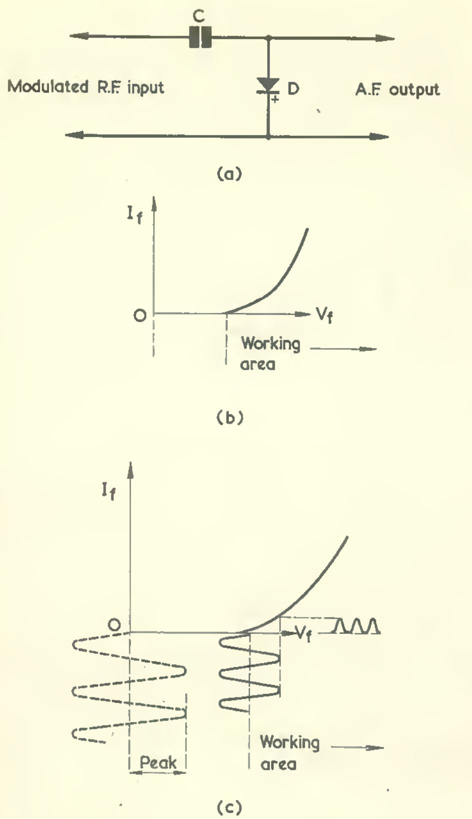


Fig. 2 (a). A typical signal tracer r.f. probe
(b). Simplified diagram showing the forward characteristic of a germanium diode
(c). The characteristic results in more efficient detection of low-level signals if the diode is given a slight forward bias

This diagram shows, in simplified form, the forward characteristic of a typical junction diode, I_f indicating the forward current obtained for a given forward voltage, V_f. The most important points to notice about this diagram are that little forward current flows until the forward potential reaches the start of what is shown in the diagram as the "working area", and that I_f then increases sharply and in a non-linear fashion as V_f increases. Typically, the "working area" of a germanium diode starts at 200mV. Since the curve represents voltage against current, an impedance is also implied, so that we can say that the forward impedance of the diode varies with forward voltage, the impedance being relatively high below the "working area" voltage and low and very non-linear after the "working area" is reached.

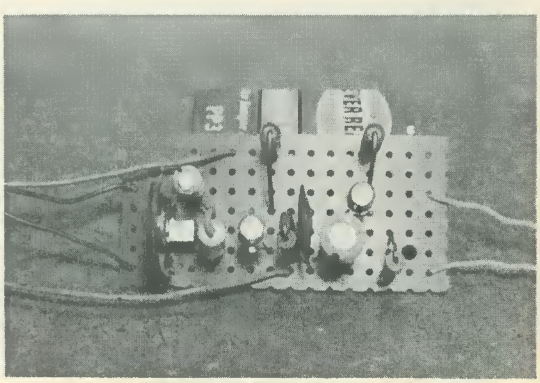
Now, if an a.c. signal is applied across the diode, as in the case of the r.f. probe, the input signal will swing about the zero volts line, as shown by the dotted waveform in Fig. 2 (*c*), and if the peak value of this waveform does not reach the "working area" of the diode very little forward current will flow on any part of the waveform. Thus, a germanium junction diode may offer little demodulation action to input signals with peak-to-peak amplitudes of less than 400mV. If the peak amplitude of the input signal enters the "working area" of the diode, efficient demodulation commences to take place.

Suppose, now, that we manage to find some way of applying a bias potential to the diode, so that with no input signal applied the diode is biased to the start of its "working area" voltage. If we now apply an alternating input signal across the diode, the signal will swing about the voltage to which the semiconductor is biased, as shown by the full line waveform of Fig. 2 (*c*), and signal amplitudes of only tens of millivolts will be sufficient to cause efficient detection to occur.

The simplified characteristics shown in Figs. 2 (*b*) and (*c*) refer to forward currents of the order of 50 to 100μA and above. A forward current can still flow in a germanium diode before the start of the "working area" shown in the diagrams, but this will be relatively low. The function of Fig. 2 (*c*) is to show that detection of low-level signals is much more efficient when the diode is suitably biased in the forward direction.

The normal demodulator probe, of course, has no bias potential applied, and thus suffers from the disadvantage of being inefficient when fed by small amplitude signals. If, however, we look at a transistor, we find that a junction diode is naturally formed between the base and emitter, this "diode" passing a current I_e when biased by a voltage V_{be}. It follows that, if we use the transistor correctly, we can obtain efficient detection by suitably biasing the base-emitter junction, while at the same time obtaining gain by normal transistor action, and this is the technique used in Fig. 1.

Returning now to the circuit diagram of Fig. 1, the r.f. action of the unit may now be described. The r.f. input signal is applied to TR_1 base via C_1, RV_1, and C_2, and appears across the base-emitter junction of the transistor. If the amplitude



A top view of the prototype signal tracer

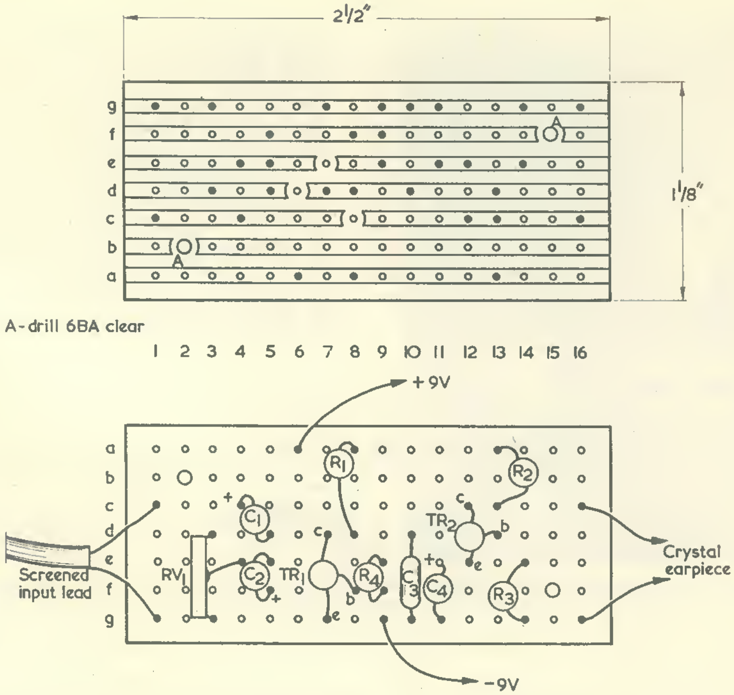


Fig. 3. The copper and component sides of the Veroboard after assembly

of this signal is greater than, say, 20mV, substantial distortion of the signal will be obtained, since the transistor is biased into its operating region, and detection will be obtained. This detected signal is then amplified by the transistor and appears at TR_1 collector, where C_3 bypasses any remaining r.f. components to the negative supply line, leaving the demodulated a.f. part of the signal to be fed on to TR_2. Here it is further amplified and finally fed to the crystal earpiece.

Note that, for efficient detection to take place in the TR_1 stage, the internal base-emitter capacitance of the transistor must be very low, and this condition is only met on v.h.f. transistor types. The capacitance on the Sinclair ST140 transistor specified is a mere 2.5pF, and is thus ideally suited to this application.

When the circuit is used purely as an a.f. amplifier, the signal applied to TR_1 base has an amplitude of less than 20mV, so that appreciable distortion of the signal does not then take place.

Construction

The unit is wired up on a small piece of Veroboard panel with 0.15in hole spacing, and construction should be started by cutting this panel to size and drilling the two small mounting holes to clear 6BA screws, as shown in Fig. 3. Next, break the copper strips, with the aid of a small drill or the special cutting tool that is available, where indicated.

The components and leads can now be soldered in place on the panel, as illustrated in the diagram. Note that all components are mounted vertically, and that insulated sleeving should be used where there is any danger of components short-circuiting against one another. The mounting tags of RV_1 should be reduced in diameter with the aid of a file, so that they fit in the holes in the panel, before attempting to solder this component in place.

The screened input lead should be kept fairly short, a length of 18in or less being adequate for signal tracing in transistorised equipment. The centre lead ends in a test prod, or probe, whilst the outer conductor may be terminated by a short flexible lead fitted with a crocodile clip.

When construction is complete, the unit can be given a functional check by connecting a 9 volt battery in place and checking that a signal is heard in the earpiece when a test signal is connected to the input of the unit.

Using The Unit

When using the unit for signal tracing, the earthy input terminal should be made common to the negative supply line of the equipment under test, and the remaining probe terminal should be connected to appropriate test points. When testing defective equipment, initial tests should, generally, be made at the "front end" of the equipment, and successive tests should work backwards towards the rear of the circuitry until the faulty part of the circuit is located. If, for example, tests are being made on a faulty superhet receiver, the first test should be made by setting RV_1 for maximum sensitivity and connecting the probe to the r.f. stage of the receiver, checking that some kind of signal is heard in the earpiece. If that test is satisfactory, move the probe to the first i.f. stage, slowly working through the circuit towards the loudspeaker until a point is reached at which no signal is heard in the earpiece, the faulty part of the circuit then being that which is under test. It will be helpful to gain experience by using the tracer with a serviceable receiver before employing it for fault-finding.

All electrolytic capacitors, including C_1 and C_2, exhibit a small amount of inductance, so that their impedances actually increase above certain frequencies. Because of this, it is recommended that, if the unit is to be used for signal tracing at frequencies *above* about 7 Mc/s, small 1,000pF bypass capacitors be wired in parallel with C_1 and C_2.

Note that the signal tracer is primarily intended for testing transistorised equipment. If it is to be used on valve equipment, a 0.5μF capacitor, with a working voltage of 500, should be inserted in series with the probe lead.

25th GERMAN RADIO EXHIBITION 1967 — BERLIN

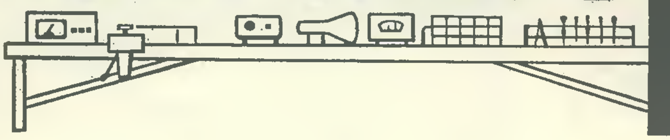
There are only three more weeks till the Great German Radio Exhibition in Berlin. For the twenty-fifth time the public will be made acquainted with a great achievements show of technical progress in the field of Radio and Television. The grand attraction of this Anniversary-exhibition is that of coloured television, the official commencement of which will be the telecasting of the opening celebration on 25th August, 1967. The programme will be simultaneously telecast on both stations (ARD and ZDF).

During the Exhibition a joint coloured programme will be produced by both television stations, which will be receptable on channel 39 in Berlin from 10.00 a.m. till 7.00 p.m. daily. The Exhibition's black and white television programmes of the ARD and ZDF stations will also be telecast over channels 7 (ARD) and 33 (ZDF) from 10.00 a.m. till 7.00 p.m.

The industry will display its newest products, special shows being presented by the German Federal Post, the Electric Handicraft Trade, the German Amateur Radio Club, Lufthansa Airlines and the German Red Cross. A special exhibition concerning the themes "Parallel Ways" (black and white and coloured television), "Stereophony—Hifi" and "Portables" will also be offered. The ARD station and the ZDF station are setting up their studios in the R (Sachsen) and A (Berlin) halls.

In addition, the visitors to the Radio and Television Exhibition will be offered an extensive programme. In the summer garden of the fair grounds, athletic events, variety shows and concerts will be held daily; in the "Palais am Funkturm" fashion shows may be viewed. Theatregoers will be interested to know that the Berlin theatres, in spite of the summer holidays, will be presenting a complete programme; and for those interested in sports, there are also a few events in store. The social highlight of the Exhibition is the ball, which is completely in line with the TV colour theme—A Dance under the Rainbow.

In your workshop



"AH," SAID SMITHY WITH satisfaction as he mopped his brow, "here's the place."

Tearing his attention from a garish display of seaside postcards featuring ladies of immense and improbable proportions, Dick looked doubtfully at the two doors, flanked by flyblown windows, to which Smithy was now pointing.

The brilliant August afternoon sun shone down and harshly illuminated the pair as they stood on the pavement amongst the cheerful gaily-clad crowds, some intent on going to the beach and others just returning. Resolutely, Smithy pushed open one of the two doors and entered, to be followed by his dubious assistant. Dick blinked for some moments until his eyes, previously attuned to the sunlight glare of the street, became accustomed to the gloom inside. Glancing round he saw about a dozen square tables, each covered with a stained greyish-white cloth and each adorned with a large bottle of chop sauce together with a second sauce dispenser in the shape of a plastic orange. An all-pervasive odour of stale onions hung in the air.

Smithy's Treat

"Cor love us," breathed Dick eventually. "What's *this* dump?"

"Dump?" repeated Smithy, shocked. "I would have you know that this is the place I was telling you about—where a mate of mine and I came two years ago. We had a good old technical chin-wag together, and an excellent meal in the bargain."

"Trust you," commented Dick bitterly, "to pick a crummy joint like this. When you suggested we should take a day off down at the sea, I was all for it. And when you also said that you'd stand me a meal I was beginning to look forward to something *really* groovy. I certainly didn't expect I'd have to eat in a clapped-out nosher like this."

"Nonsense," replied Smithy briskly.

He walked over to a table, pulled out a chair, sat down and looked about him.

"I see we're nice and early," he remarked. "Which means we've got the whole place to ourselves."

"I'm not surprised," grumbled Dick, sitting down and repressing a shudder as he glanced at the flaking plaster on the walls. "I should imagine that all the people who've eaten here in the past are now down with cholera or bubonic plague."

The scent of stale onions suddenly increased in strength as a door opened. A large lady of forbidding mien, and with a physique reminiscent of the sumo wrestlers of Japan, glared at them.

"Yerse?"

"Two teas, please," called out Smithy firmly.

The lady withdrew.

"Hell's teeth," snorted Dick. "Is that to be the meal, then? Two teas?"

"Don't be silly," replied Smithy shortly. "I'm just getting the essentials sorted out first."

"If all you're going to do here," complained Dick, "is swill tea all the time, we might as well have stayed back in the Workshop."

A suddent thought crossed his mind and he brightened.

"Talking about the Workshop," he continued, "reminds me about something you were saying a couple of days ago. About these new integrated circuit things."

"Oh, those," replied Smithy absently. "If I remember correctly, I said that integrated circuits are quite likely to replace many of the standard circuits and components we've got used to in present-day radios and TV's. They're already doing so in computers."

"Yes, that's what you did say," remarked Dick impatiently, "but what you didn't do was explain just exactly what integrated circuits are."

"Integrated circuits," said Smithy in reply, "are devices which comprise an actual circuit, with its circuit elements incorporated in the device itself. These elements can be resistors or capacitors and, in some cases, transistors and diodes as well, and everything is interconnected together within the device to form a working circuit. Integrated circuits have terminations to which you can connect any further external circuits. Most integrated circuits are fantastically tiny, and the manufacture and use of these is usually referred to as 'microelectronics'. But the main point of an integrated circuit is that it is a unit which consists of a *circuit* on its own. You can't break it down into separate circuit elements like you can with a circuit which consists of components assembled on a printed board."

"What are the advantages of integrated circuits?"

"The big advantages," replied Smithy, "are reliability and a potential very low cost. Plus, with certain types, exceptionally small size. One of the reasons for reliability is that, since all the component parts of an integrated circuit are connected together within the integrated circuit itself, the number of electrical joints between them is considerably reduced. To explain this, let's take an example. We'll suppose that, using conventional components mounted on a printed circuit board, we connect, say, the collector of a silicon transistor to one end of a resistor. Let's now see how many joints there are between the transistor collector and the resistor. Starting at the collector itself, we go from the silicon of the collector to its metallising, and from the metallising to the wire inside the transistor can. The next joint is the one between the wire from the collector to the lead-out wire. That's three joints before we've even left the can. After this you get the following joints: lead-out wire to solder, solder to printed board copper foil, copper foil to solder, solder to resistor lead-out wire, and resistor lead-out wire to resistor composition. That last joint at the resistor will, in practice, probably consist of more than one actual junction but, even assuming that it's a single joint, there are still no less than eight joints in that little lot. A connection between a transistor collector and a resistance element in an integrated circuit of the semiconductor type would involve only two joints."

"Well, that should certainly improve reliability," conceded Dick. "You don't have to be long in the servicing game to realise how many snags are caused by trouble at joints, where the circuit path changes from one conductor to the next. What about the cost and the very small size?"

"The cost," said Smithy, "is reducing all the time as manufacturers carry out further research and improve production methods. Don't forget that initial tooling and development costs for integrated circuits are high, and that this fact is liable to be reflected in the earlier designs. To get a low price for any mass-produced article you have, of course, to make it in large quantities, which means that you've got to find a market for it. Most of the present integrated circuits are going into computers, although a few are already finding their way into the entertainment market, in radios and in TV sets. Once integrated circuits really break the price barrier and become obviously cheaper than present-day circuits with their separate components and assembly costs, you and I, Dick, will be seeing stacks of them!"

Dick frowned.

"I used to think that that's what would happen with transistors replacing valves," he remarked. "But it's taking a dickens of a time for transistors to completely oust valves in TV sets, for instance."

"True enough," agreed Smithy. "Although TV does represent rather a special case, with its well-established valve circuits and techniques. However, the step from transistors to integrated circuits is not so big as that from valves to transistors. Current TV transistorised design lends itself well to the use of integrated circuits in the i.f., a.f. and timebase oscillator sections. But I'm getting ahead of myself now, because you don't really know what integrated circuits are, anyway."

Thin-Film Circuits

"I don't," agreed Dick. "As you may have gathered from what I've been saying, I haven't the vaguest idea about how they're made or what they do."

"Fair enough," said Smithy. "It looks as though I'll have to give you a bit of background on them, then. I'm not going to go into any great detail, but what I'll tell you should enable you to understand some of the terms that are used, and help you to follow the more detailed references you'll encounter in technical articles and things like that."

At that moment the door opened and the large lady appeared, bearing two cups of tea. She deposited them upon the table, then turned to another to pick up a card, which she also placed in front of Dick and Smithy.

During this brief period, Smithy, used to enormous quantities of tea in the Workshop, had already emptied his cup, and he handed it back to the lady.

"Let's have another cup," he said cheerfully. "We'll be ordering in a minute."

The woman frowned and cast a sudden quizzical glance at Smithy. However, she said nothing, picked up his cup and retired to her onion-saturated limbo behind the door.

"That's better," said Smithy, wiping his mouth. "Now, let's return to these integrated circuits. There are three main types of integrated circuit, these being the thin-film integrated circuit, the thick-film integrated circuit and the semiconductor integrated circuit. The last one is also known as the silicon integrated circuit. We'll do the thin-film and thick-film circuits first because these are the easiest. I won't be able to deal with the semiconductor integrated circuit this time, so I'll leave that for a later date."

Smithy paused for a moment to collect his thoughts.

"Now, the thin-film circuit," he went on, "consists of a substrate, which is usually ceramic, on to which the circuit elements are deposited."

"Hold on a minute!" interrupted Dick. "What's a 'substrate'?"

"It's the bottom layer of material on which the other bits of the circuit are built," explained Smithy, "and it provides the mechanical strength for the circuit. As a rough analogy you could say that, when you put butter on toast, the toast is the substrate. High conductivity

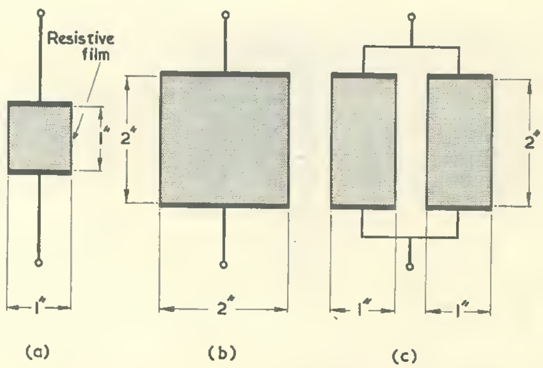


Fig. 1 (a). A square of resistive film measuring 1in by 1in. Connections are made to the entire length of opposite sides
(b). The same resistance is given if the size of the square is increased to 2in by 2in
(c). The larger square can be split into two 2in by 1in rectangles. Being twice as long as the 1in by 1in square each rectangle has twice its resistance. Since the rectangles are effectively in parallel in the larger square, its total resistance then becomes the same as for the 1in by 1in square

metals such as gold or aluminium, or resistance alloys such as nickel-chrome, are deposited on to the surface of the substrate to provide the interconnections between circuit points, or to provide resistors. This process has to be done in a vacuum and one way of depositing the metal consists of having the metal evaporate close to the substrate, the latter having a mask in front of it which acts like a stencil. Since the metal is evaporated in a vacuum, the molecules of metal which boil off travel in straight lines. Those that pass through the mask fall on to the substrate and cool there, whereupon you have a metal deposit, or film, on the substrate which follows the pattern of the mask. Obviously, the high conductivity metal and resistance alloy deposits have to be made at different times and with different masks."

"I see," said Dick. "This means, then, that you can produce thin-film integrated circuits by suitable masking and depositing processes, these circuits having patterns of conductive and resistive material on them which represent resistors and the interconnections between them."

"That's right," replied Smithy. "The account I've given of the process is simplified, but what I've told you is the basic idea."

"How," asked Dick, "do you get different values in the resistance bits? Do you use different types of alloy?"

"Not generally," replied Smithy. "The main approach with thin-film circuits is to use a standard alloy and thickness of deposited film, and to change the outline of the resistance section deposited on the substrate. This enables all resistor elements to be deposited in one operation. A nickel-chrome film can, for instance, be deposited at a thickness which gives, say, 250Ω per square."

"250Ω per square what?"

"Per square nothing," replied Smithy. "Just 250Ω per square."

"Dash it all, Smithy," protested Dick. "You can't just say '250Ω per square'. It's got to be 250Ω per square inch or square centimetre, or something like that!"

"No, it hasn't," said Smithy. "Just hang on a jiffy and I'll show you."

The Serviceman pulled out a ball-point pen and proceeded to apply it to the tablecloth in front of him.

"If," he continued, "you have a film of resistive material with a square outline and having the same thickness at all points, and you connect to the entire length at opposite edges, you will get the same resistance regardless of the size of the square. Say, for instance, you've got a square which is 1 inch by 1 inch. (Fig. 1 (*a*)). If you increase the size to 2 inches by 2 inches (Fig. 1 (*b*)) you'll still get the same resistance. The new square is equivalent to two rectangles measuring 1 inch by 2 inch connected in parallel. (Fig. 1 (*c*)). Each of the two rectangles has the same width and is twice as long as the original 1 inch by 1 inch square, and so it will have twice the resistance. But the two rectangles are in parallel in the larger square and so the total resistance is the same as for the original square. This analysis can be applied to any size of square, and it will always prove that you get the same resistance between two opposite edges. Fascinating, isn't it?"

"I'll say," agreed Dick. "So, to get different values of resistance, you start off with a fixed number of ohms per square and then use different shapes of rectangle."

"That's the idea," confirmed Smithy. "If you want a 500Ω resistor and the film you deposit gives 250Ω per square, you arrange the mask pattern so that the deposit is a rectangle which is twice as long as it's wide. (Fig. 2 (*a*)). This means that the resistor consists of two squares in series. Regardless of the actual dimensions, you'll always get 500Ω if the length is twice the width. For 1,000Ω the length must be four times the width, (Fig. 2 (*b*)), whereupon you've got four squares in series. For higher resistances you need a longer rectangle, whereupon you fold it around a bit, so that it doesn't take up too much space." (Fig. 2 (*c*)).

"Well, blow me," said Dick. "That's neat, isn't it? What about capacitors?"

"To get capacitors with the thin-film process," said Smithy, "the usual approach is to use a sandwich construction. One plate consists of metal deposited direct on to the substrate, after which a layer of insulating material is deposited on top of it. (Fig. 3). Silicon dioxide is a suitable material and this forms the dielectric of the capacitor. A further metal deposit on top of the silicon dioxide then gives the second plate, whereupon your capacitor is complete. This basic procedure can produce capacitors having values ranging from a few pF up to 0.03μF or so."

No Inductors Or Transistors

At this moment, Smithy's eye fell on the card which the lady of the establishment had placed on the table.

"Blimey, Dick," he said, "we'd better start ordering. What'll you have?"

Dick, brought forcibly back from the world of integrated circuits to his present surroundings, gazed with a marked lack of enthusiasm at the dog-eared card in front of them. This, under the brave heading of "The Commodore Restaurant",

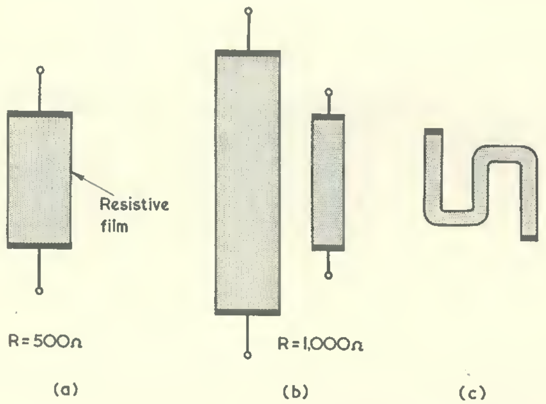


Fig. 2 (a). A rectangle whose length is twice its width. With a resistive film of 250Ω per square, the resistance of the rectangle is 500Ω
(b). Two rectangles, both having a length which is four times the width. Despite the difference in actual dimensions, both rectangles exhibit a resistance of 1,000Ω
(c). When a long rectangle of resistive material is required on a thin-film or thick-film circuit, the rectangle may be folded, in the manner shown here, to conserve space

outlined the delights of the establishment in an uneven typescript which, in places, was obscured by cigarette burns, blobs of solidified gravy and, in the lower right hand corner, an irregular contour of what appeared to be fossilised cabbage.

"Let's see now," said Smithy brightly, as he scanned the items listed on this noisome tablet. "Would you like sausage and chips, egg and chips, or bacon and chips? Or, again, you can have sausage, egg and chips, or bacon, egg and chips, or sausage, bacon and chips."

"That's a charming choice, I must say!"

"Oh, I don't know," replied Smithy. "I always feel there's nothing like a bit of variety in a menu. Lower down, now they've got the same things but with beans."

"Haven't they got any *food*?"

"Really," commented Smithy, profoundly offended, "that's hardly the attitude of a guest. You'd better look for yourself."

Dick took the menu from Smithy, and a look of increasing horror spread over his face as he examined the remainder of the items listed.

" 'Liver and chips' ", he read out. "Cor blimey, we've got 'liver, bacon and chips' next and then they go through the permutations all over again with 'liver, sausage and chips' and 'liver, egg and chips'. Below 'liver, egg and chips' they've got 'mixed grill and chips'. I suppose that's the bits listed above all laid out on one plate."

"That's right," said Smithy appreciatively. "Mixed grill and chips was what I had last time I was here. I got liver, bacon, egg, sausage, beans and chips all together. Smashing it was."

"Ye gods," broke in Dick. "What's this? *Chipatty* and chips?"

"I don't know what that's like," confessed Smithy. "I usually avoid the foreign dishes."

"I'm not surprised," said Dick, still studying the list. "Right at the bottom of the menu they've got what they call 'Speciality of the House'. It's 'Chipatty, shish-kebab, mixed grill and chips'. Blimey, that *would* be something!"

"Shall I order it for you?"

"No thanks," said Dick hurriedly. "Ask them if they'll do me a fried-egg sandwich."

"A fried-egg sandwich?" snorted Smithy. "What are you trying to do, show me up or something?"

The door opened and Smithy quickly moved the menu-card so that it covered the sketches he had scribbled on the tablecloth. Orders were placed. Smithy asked for his mixed grill and chips, whilst Dick eventually, and with very great reluctance, chose sausage and chips. The lady returned to her regions, once more carrying Smithy's empty cup for replenishment.

"Let's get back to those thin-film circuits," said Dick. "From what you've told me it's possible to make up circuits on them using resistors and capacitors."

Smithy nodded in agreement.

"What," asked Dick, "about inductors?"

"Inductors," replied Smithy, "*can* be made up by depositing spirals of metal on the substrate, these working in the same way as the spirals which make up the inductors in printed circuit biscuits for TV tuners. But the inductances obtained are too low to be of much use in practice and, inductors are normally avoided in the initial design of the circuit."

"What about transistors and things like that?"

"So far as I know," said Smithy, "it isn't possible as yet to produce truly integrated transistors in a thin-film assembly. Manufacturers haven't been able to build up practical transistors with deposits of material using basic thin-film processes, although it seems that research is still pressing on in this direction. But you can add a transistor to a thin-film circuit in the form of a flip-chip."

"A *what*?"

"A flip-chip."

"Corluvaduck," commented Dick. "Talk about chips with everything! We couldn't get away from chips in that menu and stap me if they don't now come up in integrated circuits!"

"Don't let it worry you," chuckled Smithy. "To start off with, a 'chip' is a flat tiny square of silicon in which a transistor, or other component, has been formed. You can even have a second integrated circuit in the chip, but how that is done I'll have to leave till our next gen-session together. All I'll say now is that a thin-film circuit can be laid out so that the terminations of a chip, laid face downwards on the substrate, can be soldered or otherwise connected into the thin-film circuit. A chip used in this manner is then called a 'flip-chip'. I should add that flip-chips can also consist of diodes, capacitors or any other device which can be built up on a chip. Sometimes, it is preferred to add capacitors as flip-chips instead of having them in the thin-film circuit itself."

Smithy took a large draught from his cup.

"And that," he said, "should give you a general basic idea of thin-film integrated circuits. They consist of a composite structure which is complete with resistors, *and* capacitors if desired, and to which you can add further components such as transistors by the flip-chip technique. When a thin-film circuit has been made up, it is covered in some sort of plastic resin to keep it protected. The sizes of thin-film integrated circuits vary quite a bit. Some may be quite large affairs having a side of about an inch or so, whilst others are a lot smaller. They are, of course, made in quantity. A large number of thin-film circuits, each with its own mask, will pass through each of the depositing processes together."

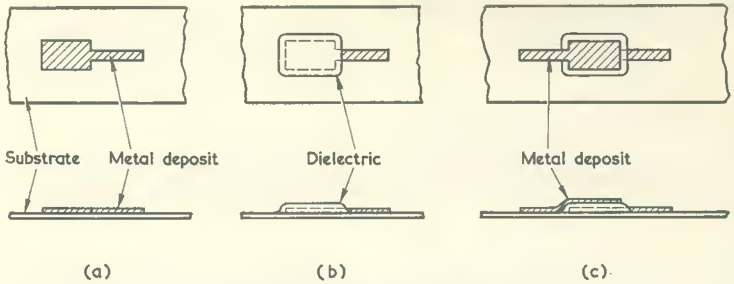


Fig. 3 Simplified diagram illustrating, by top and side views, the manner in which a capacitor may be formed on a thin-film or thick-film circuit. For purposes of illustration film and dielectric thicknesses are shown much greater than would occur in practice, and the dielectric outline may vary in actual circuits. In (a) the first metal deposit provides the bottom plate of the capacitor, whilst the dielectric is added in (b). The second plate is deposited in (c), giving the complete capacitor. The extensions on each metal deposit allow interconnection to other circuit elements

Thick-Film Circuits

"What," asked Dick, "about thick-film integrated circuits?"

"Apart from the way they're produced," replied Smithy, "thick-film circuits are basically similar to thin-film circuits. The film deposited on the substrate is thicker than with the thin-film circuit, hence the names given to the two different types. Thick-film integrated circuits have the great advantage that they don't need a vacuum for the conducting or resistive layers to be deposited on to the substrate. This makes the manufacturing process simpler and less expensive. It is also said that thick-film circuits are physically stronger than thin-film circuits."

"How are the film deposits made?"

"By a sort of screen printing process," replied Smithy. "Over the substrate you have a mask or screen which acts like a stencil and allows, to continue the printing analogy, specially prepared 'inks' to be printed on the surface of the substrate. The substrate is, once again, usually ceramic. The result of the printing process is that you get an 'ink' pattern on the substrate which corresponds to the pattern imposed by the mask. The substrate is then heated, whereupon the 'ink' changes to a conducting or resistive path, as required. To provide a conducting path the 'ink' could consist of gold or silver powder dispersed in a fluid which gives the mixture the liquid properties needed for application. When fired, the liquid evaporates and you have a deposit of metal left on the substrate. For resistance, the 'ink' can contain a resistive mixture instead of a highly conductive metal. Another advantage with the thick-film circuit is that, by varying the resistive mix, you can get a wider range of resistance values than with the thin-film process. With thick-films you can obtain resistances well in excess of 1MΩ."

"Any other differences?"

"Speaking," replied Smithy, "in the simple basic terms we've been using today, there aren't many more. As with the thin-film circuits, thick-film circuits are limited to conductors, resistors and capacitors in the integrated circuit proper. Alternatively, capacitors can be added as flip-chips. Transistors and other devices which can be made up on a chip can also be added as flip-chips."

Smithy Was Here

"I must say that all this seems very far removed from the sort of stuff we normally handle," commented Dick. "Still, I suppose that if you can get all the resistors you need for, say, a transistor stage into a thin-film or thick-film integrated circuit, after which you only have to add a few other components as flip-chips, you *must* have something which is, if nothing else, a lot smaller than the same thing using individual resistors, capacitors and semiconductors."

"True enough."

"How," asked Dick, "do you connect the integrated circuit into the main circuit into which it is incorporated?"

"In the same manner as any other small component," replied Smithy. "You have lead-outs which protrude through the protective covering of the circuit."

Smithy paused.

"Now don't forget," he went on, "that I've only given you half the story concerning integrated circuits. The most exciting types are the ones which use a semiconductor substrate, and you can actually build transistors *into* these! The two-joint connection between a transistor collector and a resistor which I mentioned at the beginning is typical of what you get with a semiconductor integrated circuit. But I'll have to leave semiconductor integrated circuits until the next time we have a gen-session together. Hallo, it looks as though our order's coming."

Again, the door opened. The large lady appeared with a tray bearing two plates and Smithy's teacup. Helpfully, Smithy moved the menu-card out of the way, whereupon she placed the tray on the table with a resounding crash. Surprised, Smithy looked up to find himself gazing at a censorious finger.

"I *knew* as 'ow it was you," said the woman accusingly. "As soon as you started to get me traipsing back and forth with cups of tea, I knew as 'ow it was you."

For once, Smithy was completely dumbfounded. His mouth opened and closed silently, like a goldfish after the ant-eggs have been dropped in.

"Two years ago," continued the woman aggressively, "you was in 'ere. Wasn't you?"

Dumbly, Smithy nodded.

"*I knew*," said the woman triumphantly. "Drinking tea like an 'orse you was then, just as you are now. And wot did I find after you'd gone?"

"I don't know," stammered Smithy. "What did you find?"

"The same as I've found now," snorted the woman pointing a scornful finger at the table and Smithy's diagrams. "Our best tablecloth all covered over with ink scribbles, like this one 'ere is. We 'ad to buy a new cloth last time to replace it and it looks like we'll 'ave to buy a new one again now. So, mate, when you pays yer bill, you can also fork out for two ruined tablecloths as well."

Outraged indignation caused her to rise to even higher standards of contumely as she glared at the hapless Serviceman.

"Dead common you day-trippers is," she pronounced with finality. "There's *walls* for the likes of you to scribble on!"

After which statement the lady stationed herself forbiddingly at the entrance, thereby barring any possible escape. Thus entrenched, she glowered at the now completely demoralised Smithy, as he floundered through his mixed grill without even the benefit of a fourth cup of tea.

When, later, the pair came blinking into the harsh sunlight of the street, with Smithy the poorer by the price of two meals and two tablecloths, Dick felt that his best approach under the circumstances would be to thank Smithy quickly and quietly for the food he had provided.

He decided, wisely, not to thank Smithy for the entertainment that had gone with it.

EMI TV FOR NEW ZEALAND

EMI Electronics have been awarded a contract for the supply of complete video equipment for the New Zealand Broadcasting Corporation's latest News Studio in Hamilton, North Island.

The installation includes two of the popular Vidicon Cameras type 201 fitted with Angenieux zoom lenses, a complete production vision mixer using the latest EMI solid-stage technique with vertical interval switching, telecine, pulse and video distribution systems, and EMI's newly developed solid-state monitors. Installation will be carried out by N.Z.B.C's own engineers and the Studio will be operational by late 1967.

Radio Topics

By Recorder

It's always the cobbler's child who is the worst-shod.

This adage is, of course, intended to emphasise the point that the only work that a tradesman can't find time for is that which exists in his own home. For instance, a self-employed painter and decorator friend of mine who alternates between indoor and outdoor work (you can always tell when he's on an outdoor session because that's when the rain starts) has been nagged by his wife for as long as I can remember to rè-decorate their front room. It's just human nature to put off any outstanding spare-time jobs which show no profit and which involve no change from normal work.

Cobbler's Confessions

Rather to my surprise, I find that I fall into the cobbler category with the precise fit of the proverbial square peg in its square hole. In my own den-cum-workshop, which is pretty well full to the brim these days with radio parts, chassis, books and publications, I rely for occasional sound radio broadcasts of background music or news bulletins on an f.m. tuner I knocked up way back in 1955. It's a completely home-built design using an r.f. pentode, double-triode oscillator and mixer, two i.f. pentodes and a ratio discriminator incorporating a couple of GEX34 diodes. That tuner was the apple of my eye after I'd made it but, as happens so often with these things, it became more and more neglected and forgotten as later projects captured my attention. For many years now, if no other radio has happened to be available I'd switch it on and see the heaters of its valves glowing through the dust. The a.f. amplifier which follows the tuner tells a tale of even more shameful abuse. This is a unit I made a long time before the tuner, and it now struggles away to give a travesty of its previous performance.

Nevertheless, these two Old Faithfuls have been pressing on, whenever called upon, to provide me with the odd radio programme. But the performance of the tuner has gradually been deteriorating and I suddenly realised a month ago that it couldn't raise sufficient output to provide even background music. Following the example of the cobbler I put off doing anything about it for several weeks, then I finally decided that I should at least give the tuner a quick look-over before I finally discarded it for something more modern with a few transistors in it.

As I shall now recount, the look-over and complete repair took exactly fifteen minutes! A very quick check with the testmeter showed that all the anodes and screen-grids were getting a reasonable h.t. voltage and so I coupled the signal genny up to the grid of the mixer. A little of its (supposed) a.m. modulation became audible from the speaker as I swung the generator around 10.7 Mc/s. It is pointless to attempt the alignment of an f.m. i.f. strip on results from the speaker and so I next coupled the testmeter across the discriminator stabilising electrolytic capacitor. By dint of screwing up the signal genny to full output and switching the testmeter to its lowest voltage range

I got a slight movement in the needle. All over the range from about 10.2 to 11.5 Mc/s!

Out came the insulated core adjuster and, with the generator set to the correct i.f. of 10.7 Mc/s, I tackled the i.f. transformers. One core needed about two turns, another needed about three turns and, almost before I realised what was happening, I had to start attenuating the signal generator to keep the testmeter needle from bashing away at its end-stop. A final quick run-through up to the primary of the discriminator transformer took hardly any time at all. The set has a balanced discriminator, so I next coupled the testmeter between chassis and the audio take-off point. The holes and electrons in those old GEX34's must have wondered what had hit them as the diodes started passing the first sizeable currents they'd experienced for years. But they proceeded to give of their very best, and a touch on the discriminator secondary core was all I needed to achieve the delightful situation where the voltmeter needle went nicely and linearly in one direction as I swung the signal generator frequency up, and just as nicely and linearly in the other direction as I swung the signal generator frequency down.

All that now remained was to disconnect the signal generator and hitch on the aerial. *And* hurriedly turn down the gain of the a.f. amplifier as the local signals came belting in.

Marvellous, isn't it? I had nearly been on the point of ditching that old tuner, when all it needed was an adjustment to six cores! I must confess that I'm at a loss to understand why the i.f. trimming had drifted off all that much. The i.f. coils were home-wound and, perhaps, the dope I had used fairly liberally to hold them in position had decided to change its electrical characteristics over the last decade or so.

Being now the proud owner of an f.m. tuner having an excellent performance I'm turning a questioning eye on the a.f. amplifier which follows it. This venerable piece of equipment once sported two 6V6's in push-pull in the output stage but it now runs on one only, the other valveholder remaining vacant. Once, the amplifier developed a crackle which cleared when one of the 6V6's was removed, and I left it "temporarily" with only half the output stage operative until I could find the time to look at it properly. That would be about five years ago now, so I suppose I'll get round to it one of these days.

One comforting thought arises from this shocking maltreatment of my own gear. If ever there's a dearth in electronics I've got all the qualifications to start up my own shoe repairing business.

Microelectronics Gag

As the silicon integrated circuit engineer remarked resignedly when, after a busy day's work on n-type diffusions, his wife asked him to change the baby: "Ah well, it is at least a different polarity."

Multiple Transistors

I note, from an article appearing in the July issue of our American contemporary *Electronics Illustrated**, that some of the importers of transistor radios into the U.S.A. aren't playing exactly fair. The radios in question are pocket types sold usually at low cost as "loss leaders", and are advertised as being 14-transistor, 15-transistor or 16-transistor models. The claimed multiplicity of transistors may cause an unwitting member of the public to make a purchase in the hope of obtaining superior performance but, in fact, the sets work no better than normal models using about 7 or 8 transistors.

Electronics Illustrated checked a number of the receivers in question. In some the additional transistors did appear in the receiver circuit, although any advantage given by their presence was problematic. Whenever a diode was required a transistor was fitted instead, one of its junctions functioning as the diode. Also, the a.f. and output stages of these radios had many more transistors than would appear in a normal set. In one receiver, for instance, a group of four diode-connected transistors in series-parallel operated presumably as a temperature dependent resistor for the control of output transistor bias.

Other receivers were worse. In these, about half the transistors fitted to the board were not in circuit at all. On the underside of the board their leads were merely soldered to each other and to nothing else.

In this country we don't seem to be suffering from this type of consumer exploitation. It is not unknown, incidentally, for a British manufacturer to use a transistor junction as a diode, but this approach is more probably intended to obtain a specific performance with relation to temperature or to

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*H. M. Gregory, "The Transistor Radio Scandal", *Electronics Illustrated*, July 1967 use up surplus transistor production than as an excuse for obtaining an increase of one in the transistor count.

Nevertheless, it is worth-while keeping a watchful eye open to ensure that radios which claim excessive quantities of transistors do not make their appearance here. Judging from the American experience, it will be imported radios which are advertised in this manner.

Negative Ions

Negative ions are good for you.

This is the view of a group of medical researchers who contend that people subjected to a field of negative ions in the air become very much invigorated as a result. Investigations into this effect have been carried on for many years, notably in Russia, and recent newspaper reports have referred to ionising devices for installation in offices or homes. So far as one can judge from the reports, these devices work by applying a high voltage, negative of earth, to a needle which then proceeds to ionise the air around it. In consequence, the inhabitants of the office or room become stimulated by the ions which are generated by the device.

Positive ions, on the other hand, are stated to have a depressing effect. Which, at long last, solves a problem which has baffled me for ages: why are regular television viewers so apathetic and lethargic? The answer is now, of course, quite obvious. The high voltage e.h.t supply to the TV receiver picture tube is positive with respect to earth, with the consequence that all the viewers around the set are being continually sprayed with excessive quantities of dejection-causing positive ions.

In oscilloscopes whose cathode ray tubes require a fairly high e.h.t. voltage, a conventional approach consists of having the final anode only slightly positive of chassis, the requisite e.h.t. being then applied, *negative* of earth, to the tube cathode. I now propose that this approach be employed for all future TV sets as soon as the necessary design work can be carried out. Following oscilloscope usage, these sets should have a negative e.h.t applied to the cathode group of components for the tube instead of a positive e.h.t to the final anode, whereupon viewers will not only obtain pleasure and entertainment from the programmes displayed but will also be bathed in an atmosphere rich in negative ions, with the result that a session of television viewing will leave them rejuvenated, revitalised and re-invigorated!

FURTHER TV TRANSMITTING STATIONS FOR BBC-2

The BBC welcomes the announcement by the Postmaster General that he has approved in principle the following further group of high power UHF transmitting stations for BBC-2.

Carmarthen, Blaen-Plwyf (Cardiganshire), Dorset, Rosemarkie (Inverness), Caldbeck (Cumberland), West Cornwall, Selkirk, Herefordshire, Ayrshire, North Kent, Stockland Hill (East Devon), Presely (Pembrokeshire), South Devon, Arfon (Caernarvonshire), West Sussex, and Dumbarton.

These 16 additional stations will serve some 2½ million people and together with the 28 high power stations already approved will make BBC-2 available to 90% of the population of the United Kingdom.

A number of low-power BBC-2 relay stations are being built to fill in the gaps in the coverage of the main stations caused by the screening effect of high ground. Four of these relay stations are already in operation in the London area, and a further three in the Midlands. Some twenty relay stations in the Midlands, the North of England and in South Wales have so far been approved, and the majority of these are under construction. Relay stations in the West of England and in Northern Ireland are also planned. It is hoped to bring most of them into service during 1967 and the first half of 1968.

All these BBC-2 stations will be capable of transmitting the colour programmes.

'BASIC OSCILLOSCOPE'—JULY issue

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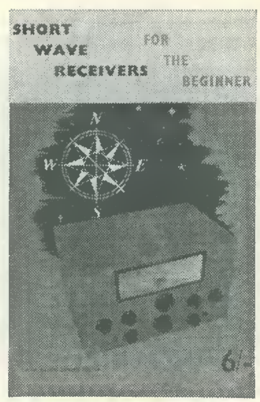

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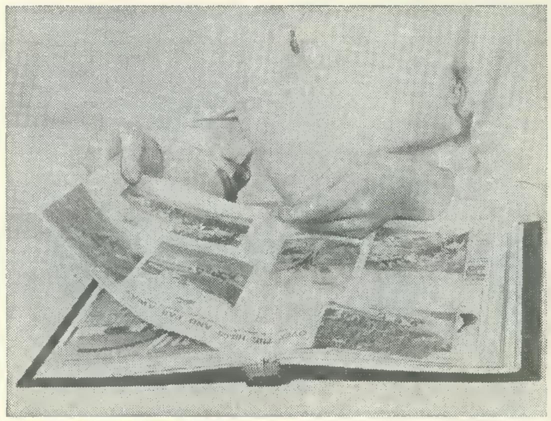

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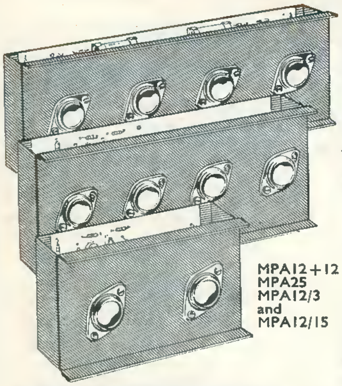

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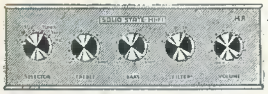

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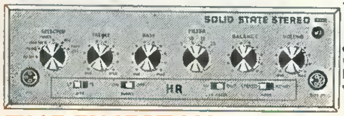

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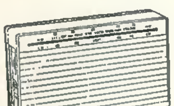

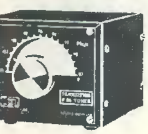

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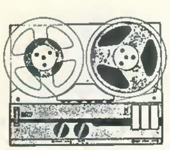

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