THE
RADIO CONSTRUCTOR
RADIO · TELEVISION · ELECTRONICS · AUDIO

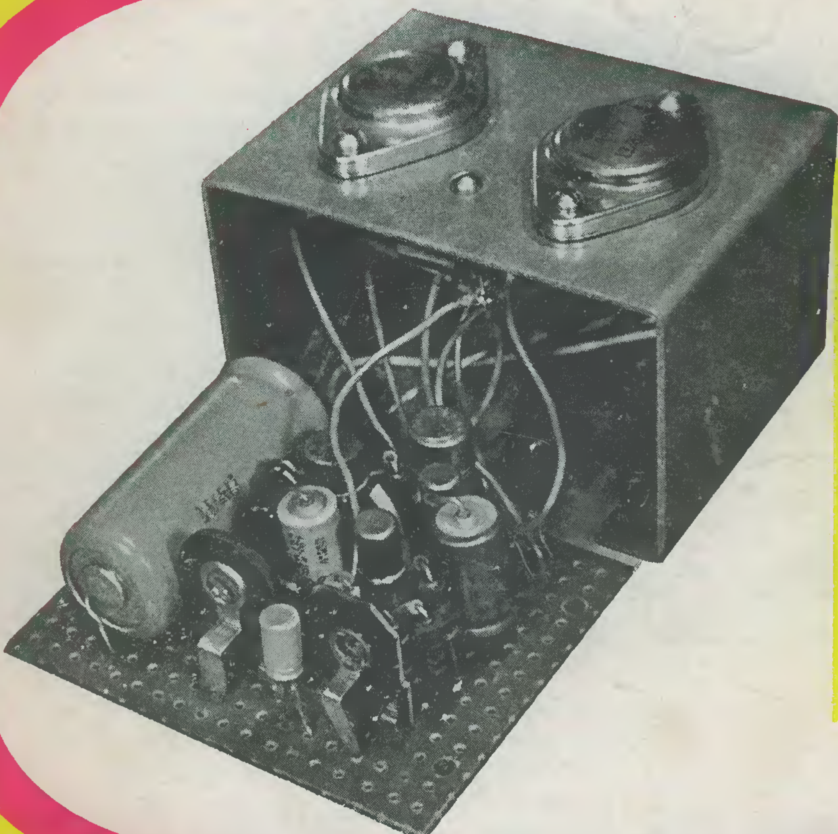
Vol. 21 No. 11

JUNE 1968

3/-

A DATA PUBLICATION

2/-



Miniature 5-Watt Hi-Fi Amplifier

Also featured

"Jupiter" 10 Watt 80/160M Transmitter * Photographer's Metronome * I.C. Booster for Luxembourg

Scottish Insurance Corporation Ltd

66–67 CORNHILL · LONDON · EC3

TELEVISION SETS, RECEIVERS AND TRANSMITTERS

Television Sets, Receivers and Short Wave Transmitters are expensive to acquire and you no doubt highly prize your installation. Apart from the value of your Set, you might be held responsible should injury be caused by a fault in the Set, or injury or damage by your Aerial collapsing.

A "Scottish" special policy for Television Sets, Receivers and Short Wave Transmitters provides the following cover:

(*a*) Loss or damage to installation (including in the case of Television Sets the Cathode Ray Tube) by Fire, Explosion, Lightning, Theft or Accidental External Means at any private dwelling-house.

(*b*) (i) Legal Liability for bodily injury to Third Parties or damage to their property arising out of the breakage or collapse of the Aerial Fittings or Mast, or through any defect in the Set. Indemnity £10,000 any one accident.

(ii) Damage to your property or that of your landlord arising out of the breakage or collapse of the Aerial Fittings or Mast, but not exceeding £500.

The cost of Cover (*a*) is 5/– a year for Sets worth £50 or less, and for Sets valued at more than £50 the cost is in proportion. Cover (*b*) (i) and (ii) costs only 2/6 a year if taken with Cover (*a*), or 5/– if taken alone.

Why not BE PRUDENT AND INSURE your installation—it is well worthwhile AT THE VERY LOW COST INVOLVED. If you write to the Corporation's Office a proposal will be submitted for completion.

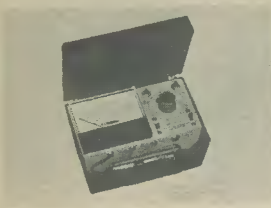
Write for full details, quoting reference 5304, to:—

THE MANAGER

SCOTTISH INSURANCE CORPORATION LTD.,

66–67 CORNHILL, LONDON E.C.3

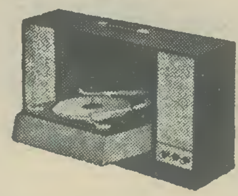
NEW! PORTABLE SOLID-STATE VOM
A thousand and one uses . . . plus lowest cost
IM–17 **Kit £12.10.0** pp 4/6



Solid state circuitry FET input. 4 Silicon transistor, 1 diode. 4 A.C. voltage ranges. 4 d.c. voltage ranges. 4 ohm ranges. 11M ohm input d.c. 1M ohm input on a.c. 4½in. 200µA meter. Battery powered. Rugged Polypropylene case, self cover and handle. Space for storage of test leads. Easy circuit board construction.

Just right for the householder, hobbyist, boaters, model builders. Amateur radio den, sophisticated enough for the radio and TV service engineer. Does hundreds of everyday measurements at low cost. Battery powered so will work anywhere.

***LATEST!* PORTABLE STEREO RECORD PLAYER, SRP-1** **Kit £28.6.0 incl. P.T.** p.p. 10/6
Ready-to-Use **£35.4.0** incl. P.T. p.p. 10/6



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$\frac{7}{16}$ x 3¾ x 10½in.

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.

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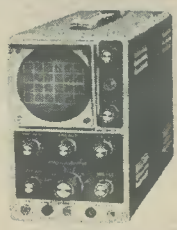
INSTRUMENTS

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" x 7¾" x 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** Ready-to-Use **£31.18.0** p.p. 9/-



OS-2

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.
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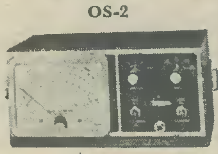

IM-13U

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.
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V-7A

VALVE VOLTMETER. Model V-7AU. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.c. input resistance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery. Kit **£13.18.6** Ready-to-Use **£19.18.6** p.p. 4/6

MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V a.c. and d.c.; 150µA to 15A d.c.; 0.2Ω to 20MΩ. 4½" 50µA meter.
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RF-1U

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** Rdy-to-Use **£20.8.0** p.p. 6/-

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Total Price Kit (excl. Loudspeaker) **£12.18.6** incl. P.T. p.p. 9/6. 8" x 5" Loudspeaker £1.16.1 incl. P.T.

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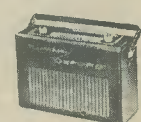
OXFORD LUXURY PORTABLE. Model UXR-2. Specially designed for use as a domestic or personal portable receiver. Covers L. and M. Wave bands. 7 transistor, 3 diode, circuit. 7" x 4" loudspeaker for big set sound. Heathkit now offer choice of Brown or Black real leather case. Excellent value at only **£15.10.0** Kit inc. P.T. p.p. 6/-



UXR-2

TRANSISTOR PORTABLE, Model UXR-1. Now available in modern colours or real leather case. 6 Transistor, 1 diode circuit for reliability. Pre-aligned I.F. transformers. Covers L.W. and M. Wave bands. 7" x 4" loudspeaker for generous sound. Case available in colours Navy Blue, Coral Pink, Lime Green or Brown Real Leather. Please state second choice. Kit **£12.8.0** Colour incl. P.T. p.p. 4/6.
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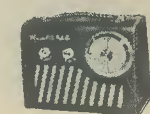

UXR-1

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.
TFM-IS Kit (Stereo **£25.2.6** incl. P.T. p.p. 6/-
TFM-IM Kit (Mono) **£21.3.6** incl. P.T. p.p. 6/-
Cabinet extra £2.5.0.

FM Tuner

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12 × 12 watts output.

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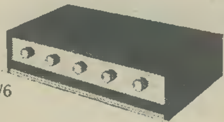

Cabinet £2.5.0 extra

Ready-to-Use **£38.0.0** incl. cabinet p.p. 10/6

FOR THIS SPECIFICATION

● 17 transistors, 6 diode circuit ● ±1dB, 16 to 50,000 Hz at 12 watts per channel into 8 ohms ● Output suitable for 8 or 15 ohm loudspeakers ● 3 stereo inputs for Gram, Radio and Aux. ● Modern low silhouette styling ● Attractive aluminium, golden anodised front panel ● Handsome assembled and finished walnut veneered cabinet available ● Matches Heathkit models TFM-1 and AFM-2 transistor tuners.

Full range power . . . over extremely wide frequency range. Special transformerless output circuitry. Adequately heat-sinked power transistors for cool operation—long life. 6 position source switch.

FULL SPECIFICATION SHEET AVAILABLE

LATEST! STEREO TAPE RECORDER, STR-1

Fully portable—own speakers

Kit £58.0.0 incl. P.T. p.p. 10/6

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FOR THIS SPECIFICATION

● ¼ track stereo or mono record and playback at 7½, 3¾ and 1⅞ ips ● Sound-on-sound and sound-with-sound capabilities ● Stereo record, stereo playback, mono record and playback on either channel ● 18 transistor circuit for cool, instant and dependable operation ● Moving coil record level indicator ● Digital counter with thumbwheel zero reset ● Stereo microphone and auxiliary inputs and controls, speaker/headphone and external amplifier outputs . . . front panel mounted for easy access ● Push-button controls for operational modes ● Built-in stereo power amplifier giving 4 watts rms per channel ● Two high efficiency 8″ x 5″ speakers ● Operates on 230V a.c. supply.

Versatile recording facilities. So easy to build—so easy to use.

FULL SPECIFICATION SHEET AVAILABLE

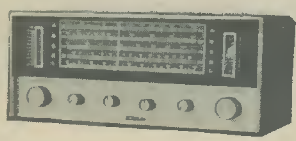
WORLD LEADER IN QUALITY KITSETS

The instruction manual shows you how to build the model.

Heathkit DAYSTROM

SHORTWAVE 4 BAND RECEIVER, GR-64E

Offers you the exciting world of Shortwave



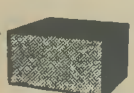
Covers 550 kH2 to 30 MH2 incl. broadcast plus 3 SW bands. 4 valve superhet circuit plus 2 silicon rectifiers. Own 5″ speaker. Illuminated 7″ slide-rule dial with logging scale. Signal strength indicator. Variable BFO control. Built in AM rod antenna. Circuit Board construction. Headphone jack. Attractive charcoal grey cabinet with black dial panel with green/white markings. Assemble in a few hours. Hear live broadcasts from around the Globe.

Kit **£22.9.0** pp 9/–. Ready to use **£29.9.0** pp 9/–.

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 £12.14.6**, p.p. 7/6 without legs, **KIT £12.0.0** incl. P.T. p.p. 7/6



AVON MINI SPEAKER SYSTEM
6½″ Bass, 3¾″ Treble speakers and crossover unit. Kit **£5.2.0** incl. P.T. Beautiful Walnut veneered fully-finished cabinet, **£8.18.0**, Total price Kit **£14.0.0** incl. P.T. p.p. 10/6

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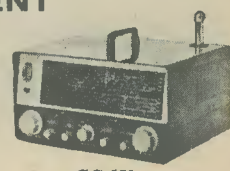

GC-1U

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.
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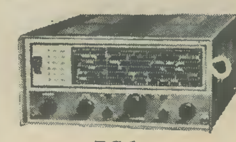
AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage.
Kit **£39.6.6** Ready-to-Use **£52.10.0** p.p. 9/–



RG-1

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained.
Kit **£81.10.0** Ready-to-Use **£106.15.0** p.p. 19/6

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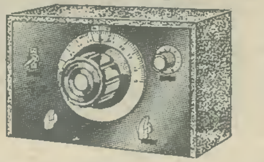
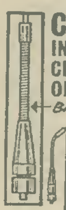
COMMUNICATION RECEIVER TYPE GDX

G.D.X. 25/C.



Brand new fully transistorised Communications Receiver Specifications: 4, complete ranges 550 Kc/s. to 30 Mc/s., covering all amateur bands, shipping and trawler bands, and broadcast band. A highly efficient double tuned superhet, comprising R/F aerial tuning section, A.V.C. and built-in tunable B.F.O. for C.W. or SSB reception. Operates from internal 9v. batteries provided. Ideal for Fixed or Mobile reception. With speaker and headphone output. Hammer finished robust steel case of pleasing modern design. Size approx. 9" x 7" x 7". British manufacture. Due to huge purchase we can offer these excellent receivers at such a low price. Complete with handbook, £16 10s., carriage and insurance 15/-. Headphones if required 15/- extra, p.p. 3/6. Fitted S. Meter 2 guineas extra. Miniature Battery Eliminator 39/6, p.p. 3/6. De-Luxe Loudspeaker in Cabinet £2 15 0., carriage 5/-.



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Miniature Two-Voltage Supply (Feb). Mains trans., 11/–; rect., 4/–.

CA3020 I.C. Amp. (Feb)., 33/–. Cooler, 1/–.

Transistor Bargains! Prices Down!

NOT 'seconds', NOT 'equivalents', NOT 'unmarked' rubbish, but BRAND NEW, FIRST GRADE. DISCOUNT PRICES (in brackets) for 5 OR MORE OF SAME TYPE.

AD161/2,	15/6	(12/8)	Complementary power pair.
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BC107	3/11	(3/1)	Npn silicon driver (hfe=250–500)
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BC168	2/6	(2/–)	Npn silicon universal (hfe=250–500)
2N706	3/4	(2/7)	Npn Si. Similar to ST140, ST141.
2N2926G	3/–	(2/6)	Npn Si. universal (hfe=235–470)
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AC128	4/–	BYZ10	11/–	OC203	8/–
AC176	6/–	BYZ12	7/6	OC204	11/–
AD140	12/–	BYZ13	5/–	OC205	10/6
AD149	11/–	GET102	5/4	ORP12	9/–
AD161	7/6	GET103	4/4	ORP60	8/–
AD162	7/6	GET111	10/–	OA5	3/–
ACY17	5/–	GET573	10/–	OA10	4/–
ACY20	3/6	OA73	1/6	OA47	1/6
ACY21	4/–	OC19	5/–	OA70	1/6
ACY22	2/6	OC20	33/–	OA79	1/6
AFZ11	10/–	OC22	13/–	OA81	1/6
AFZ12	11/9	OC23	25/–	OA85	1/6
AF114	4/9	OC24	19/–	OA90	1/6
AF115	4/9	OC25	7/–	OA91	1/6
AF116	4/9	OC26	12/–	OA95	1/6
AF117	4/9	OC28	12/–	OA200	2/–
AF186	12/–	OC29	15/–	OA202	2/–
AF239	12/–	OC35	9/6	2N3819	11/–
ASY26	5/–	OC36	13/–	2N3826	6/–
ASY28	5/–	OC41	3/6	1B40K10	19/–
ASZ21	4/–	OC42	4/–	ADT140	12/6
ASY29	6/6	OC43	4/–	ST140	3/–
BA115	2/6	OC44	3/–	ST141	5/–
BC107	4/3	OC45	3/–	MAT100	7/9
BC108	4/3	OC71	3/–	MAT101	8/6
BC109	4/3	OC72	4/6	MAT120	7/9
BCY10	20/–	OC73	3/–	MAT121	8/6
BCY12	22/–	OC75	5/–	TAA263	29/9
BCY30	7/–	OC76	3/–	2N3528	19/–
BCY31	9/–	OC81	3/–	2N2926	3/–
BCY32	8/–	OC81D	3/–	2N2646	10/–
BCY33	6/–	OC82	4/6	2N2160	14/9
BCY34	8/–	OC82D	4/3	2N1302	5/–
BCY38	19/–	OC83	3/6	2N1303	5/–
BCY40	16/–	OC123	7/–	2N1304	6/–
BCZ11	10/–	OC139	12/–	2N1305	6/–
BFY50	6/–	OC140	12/–	2N1306	8/–
BFY51	5/–	OC169	6/–	2N1307	8/–
BFY52	6/–	OC170	4/–	2N1308	10/6
BSX76	3/–	OC171	6/–	2N1309	10/6
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Fet Circuits. By R. P. Turner. **25s.** *Postage 1s.*

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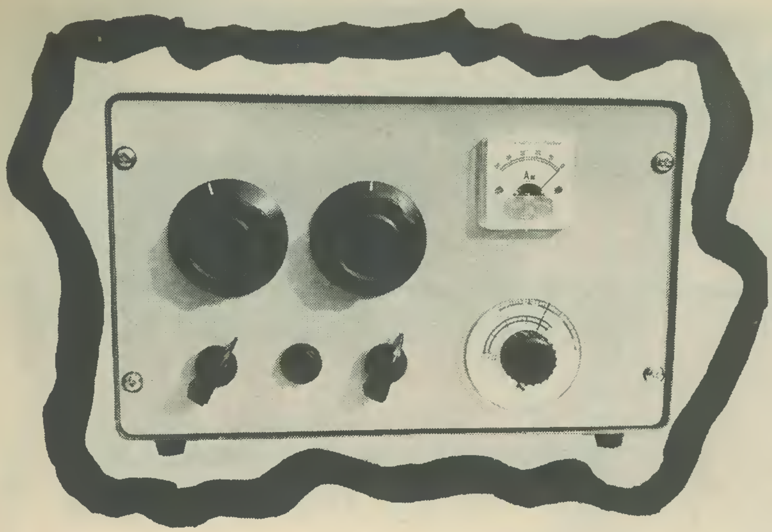


A 10 WATT 80/160 METRE BANDS TRANSMITTER

by

F. G. RAYER G3OGR

THE "JUPITER"

This neat and readily assembled transmitter gives c.w. and phone operation on 160m or 80m and can be easily adapted for 2-band operation on both these bands. Efficiency is high and power requirements are modest. This transmitter must not, of course, be operated without the appropriate Post Office licence

This transmitter is intended for speech and c.w. and has an efficiency and finished appearance equal to commercially made equipment. In addition to the satisfaction of using a home-built transmitter, the reader can easily incorporate one or two small modifications to suit personal needs.

If equipment covering 80m and higher frequencies is already available the "Jupiter" is an excellent Top Band transmitter which can be used with the full permitted 10 watts input. But, if required, the transmitter can be operated on 80m as well as 160m, with very little modification. Because a centre-fed dipole for 160m is extremely long an end-fed wire is generally employed, and this can be relied upon to give good results on 80m. So if this is the only transmitter, both bands can be worked with minimum trouble.

The reader may have an aerial relay or other favourite method of changing from Transmit to Receive. If not, the modified switching described later has much to commend it. This takes care of aerial, h.t. and receiver circuits, giving instant and complete changeover from Transmit to Receive by a single knob on the transmitter. The arrangement has worked without trouble for thousands of operations.

The constructional details in this article mainly apply to the transmitter being used either on 160m or on 80m. Suggested 2-band switching circuits, together with the modified Transmit-Receive switching circuit, are then given afterwards.

The transmitter runs from an external power supply, and a suitable unit may already be to hand. A receiver-type supply is possible, although output power will be reduced.

Very often coil-winding and correct band coverage can become something of a nuisance, so the Variable Frequency Oscillator (v.f.o.) incorporates a ready-made coil and three 1% capacitors, and this gives satisfactory coverage with no more trouble than that of adjusting the coil core. The buffer stage also has one (or two if both bands are to be covered) ready-made coil.

The transmitter was designed to offer immediate satisfaction with a minimum of difficulty and circuit complication, and it is a very straightforward and reliable project.

CIRCUIT NOTES

Fig. 1 gives the circuit of the complete transmitter. V_1 is the v.f.o., receiving h.t. from the OA2 regulator. The relatively large capacitors, C_2, C_3 and C_4 swamp slight changes in valve capacitance. VC_1, with L_1, C_1, C_2 and C_3 give coverage from 1.75–2.0 Mc/s (with a trifle to spare at the extremes of VC_1).

For Top Band, the v.f.o. tunes over 1.8 to 2.0 Mc/s, and V_2 acts as a buffer/amplifier. For 80m the v.f.o. is tuned from 1.75 to 1.9 Mc/s and V_2 performs as a doubler, giving an output over 3.5 to 3.8 Mc/s.

Grid current through R_6 develops about 40 to 60

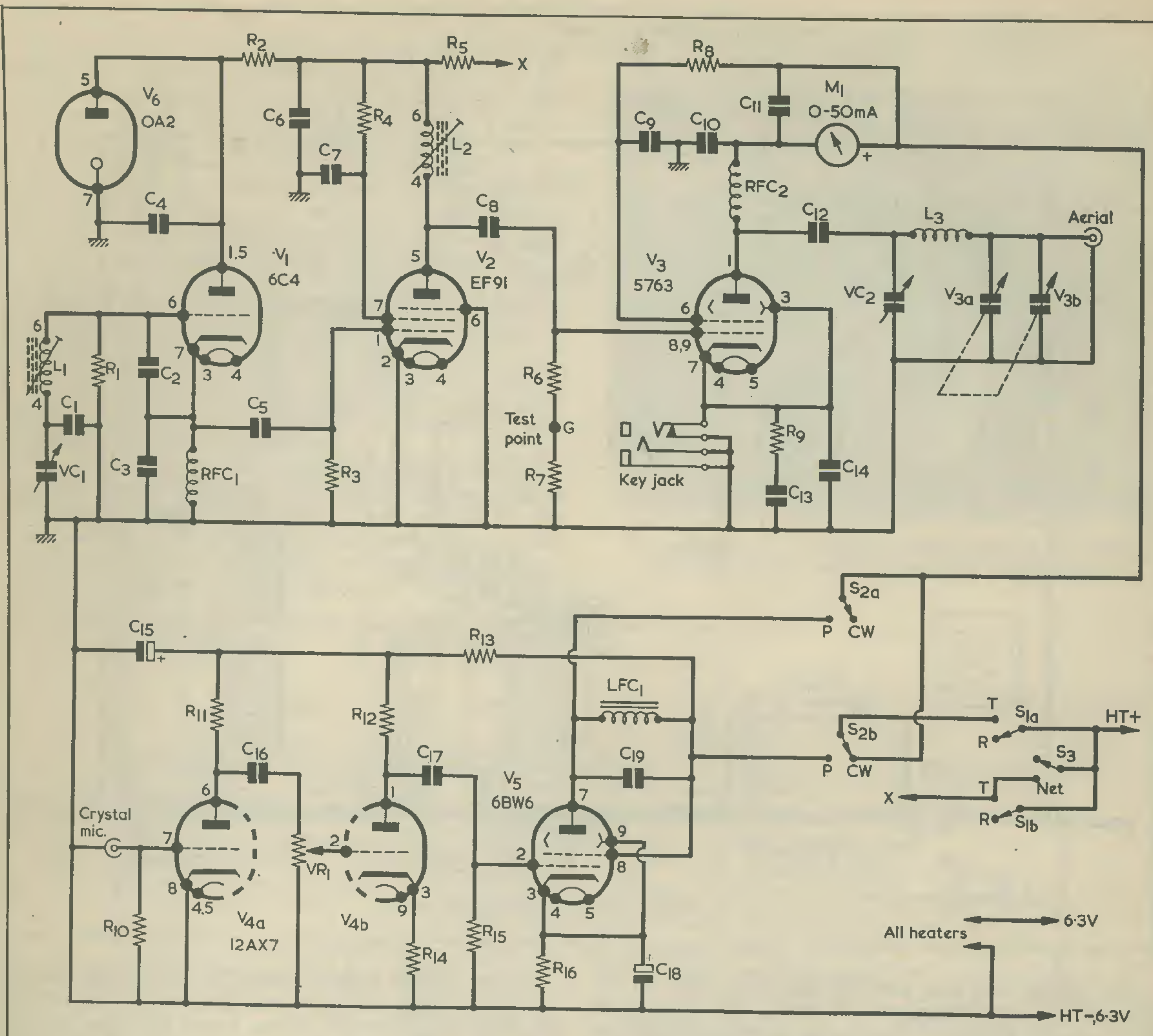


Fig. 1. The circuit of the "Jupiter" transmitter

volts bias for V_3. The series resistor, R_7, makes no difference to operation, but allows a test meter to be clipped between chassis and point "G" to check grid current. This is only necessary for an initial test.

L_3, with VC_2 and $VC_{3(a),(b)}$, forms a pi output circuit which allows loading into most ordinary aerials. The 0–50mA meter indicates anode current, and V_3 is cathode keyed for c.w., with a click filter provided by R_9, C_{13} and C_{14}.

The modulator consists of a high gain double-triode followed by V_5, and is choke coupled to the anode and screen-grid of V_3. With a Class A modulator of this type, incorrect operation such as loud talking near a sensitive microphone with VR_1 at maximum gain will cause bad audio quality instead of over-modulation, and is easily checked with one's own receiver, or by contacts with other stations.

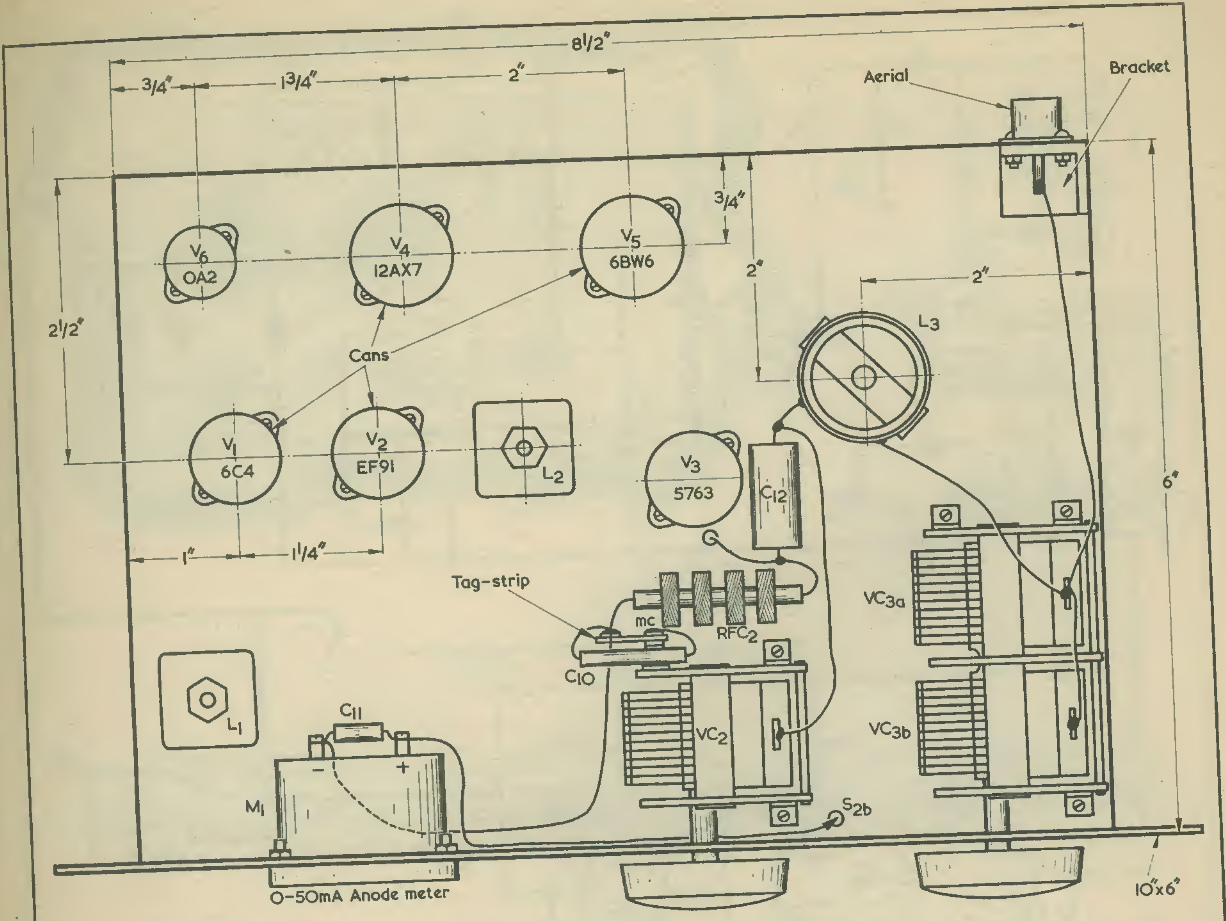
$S_{1(a)}$ and $S_{1(b)}$ switch on the transmitter by applying h.t. power. The "Net" switch, S_3, applies h.t. to V_1 and V_2 only. This provides a carrier which can be picked up by the receiver, allowing the transmitter to be tuned to any wanted frequency without actually radiating a signal.

With $S_{2(a)}$ and $S_{2(b)}$ moved from the "Phone" to the "c.w." position, the modulator is out of action and the r.f. section is operated directly from the h.t. supply. Switch S_2 and VR_1 (microphone gain) are mounted on the rear chassis runner.

CHASSIS AND PANEL

The positions of valveholders and other components can be found from Figs. 2 and 3. A chassis punch giving $\frac{5}{8}$in and $\frac{3}{4}$in holes for B7G and B9A holders is extremely useful here. It is best to do all the metal working before mounting any components.

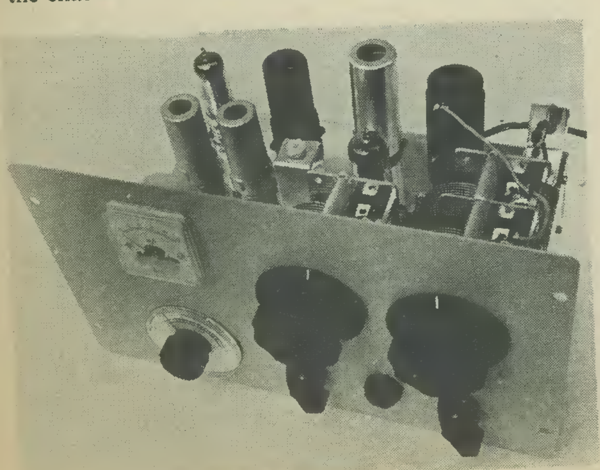
The 10 x 6 x 6in "Dinkicase" has a 10 x 6in front panel supplied. Note that the bottom of the chassis and the bottom of the panel are *not* flush, and that the chassis is raised $\frac{1}{4}$in to clear the flange in the case. VC_2 and $VC_{3(a),(b)}$ are bolted to the chassis, with spindles passing through clearance holes. The lower panel-mounted items hold the panel and chassis together.



mc = chassis connection

Fig. 2. The components above the chassis

The fitting of a rear panel to the case is left to the decision of the constructor. If fitted, the rear panel will require adequate ventilating apertures together with holes for component spindles, etc. It will be found that there is about ⅛in clearance between the back of the chassis and the back of the rear flange in the case.



How the transmitter appears from the top front

A few further points should be noted with respect to Fig. 2. First, solder an insulated lead to the bottom fixed plates tag of VC_2 before fitting this item. A strip with one insulated tag supports C_{10} and RFC_2. A lead passes from C_{12} to pin 1 of V_3, the hole in the chassis being drilled immediately adjacent to pin 1. This keeps V_3 anode circuits above the chassis.

The actual variable capacitor sections need not be 532pF as specified in the Components List 500pF is satisfactory. Capacitors with sections under about 350pF are not much recommended, and can in some cases cause tuning and loading difficulties.

Should a 0–5mA., 0–10mA or other sensitive meter be to hand, it can be shunted for a 0–50mA range and used in the M_1 position. A 0–75mA or other meter giving a sensible reading at about 20 to 40mA would also be satisfactory.

A coaxial output socket is mounted on a bracket at the rear of the chassis, as shown in Fig. 2. This is for the aerial or aerial tuner. The bracket may be made up from an odd piece of metal sheet.

The transmitter can be wired completely, then tested. Or it can be wired and tested in sections. In the latter instance, checks can be made as described in the following stage-by-stage data, which should be of particular use for anyone building their first transmitter.

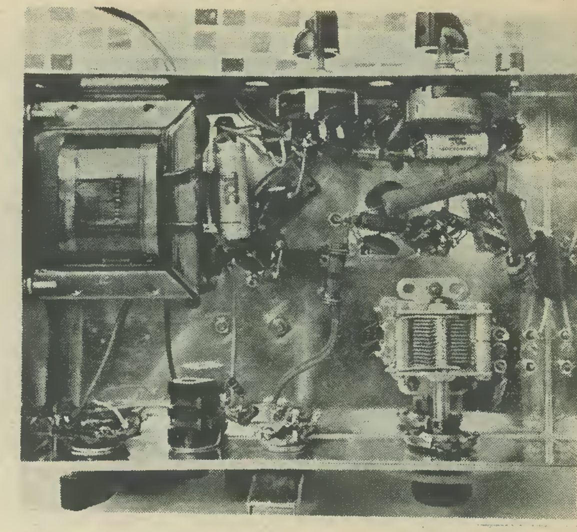
THE V.F.O.

In the v.f.o., VC_1 is under the chassis as shown in Fig. 3. The ball drive lies flat against the front of the chassis, in a ⅞in diameter hole, a countersunk 6BA bolt securing the drive lug. Ensure that the position of the hole agrees with VC_1 spindle.

Wiring to V_1 needs to be short and direct. C_1, C_2 and C_3 should be silver-mica types. The use of 1% capacitors (and these are easily obtained) allows suitable coverage without experiment. An alternative approach, which allows more latitude in values consists of reducing C_1 to about 125pF, and connecting a 50pF or similar air-spaced trimmer in parallel. Adjusting this trimmer and L_1 then modifies band coverage as required.

Coil L_1 is clear of sources of heat and the particular v.f.o. arrangement used here has been found satisfactory over a long period, including/A working after hundreds of miles of road travel.

The v.f.o. tuning drive was fitted with a disc of thin Perspex 2⅛in in diameter (cut with an adjustable tank or chassis type cutter) having a line scribed on the back and filled in black. This line moves over a thin card frequency scale cemented to the panel. An ordinary pointer would serve a similar purpose.



The underside of the chassis. Layout is neat, and given short r.f. wiring without crowding of components

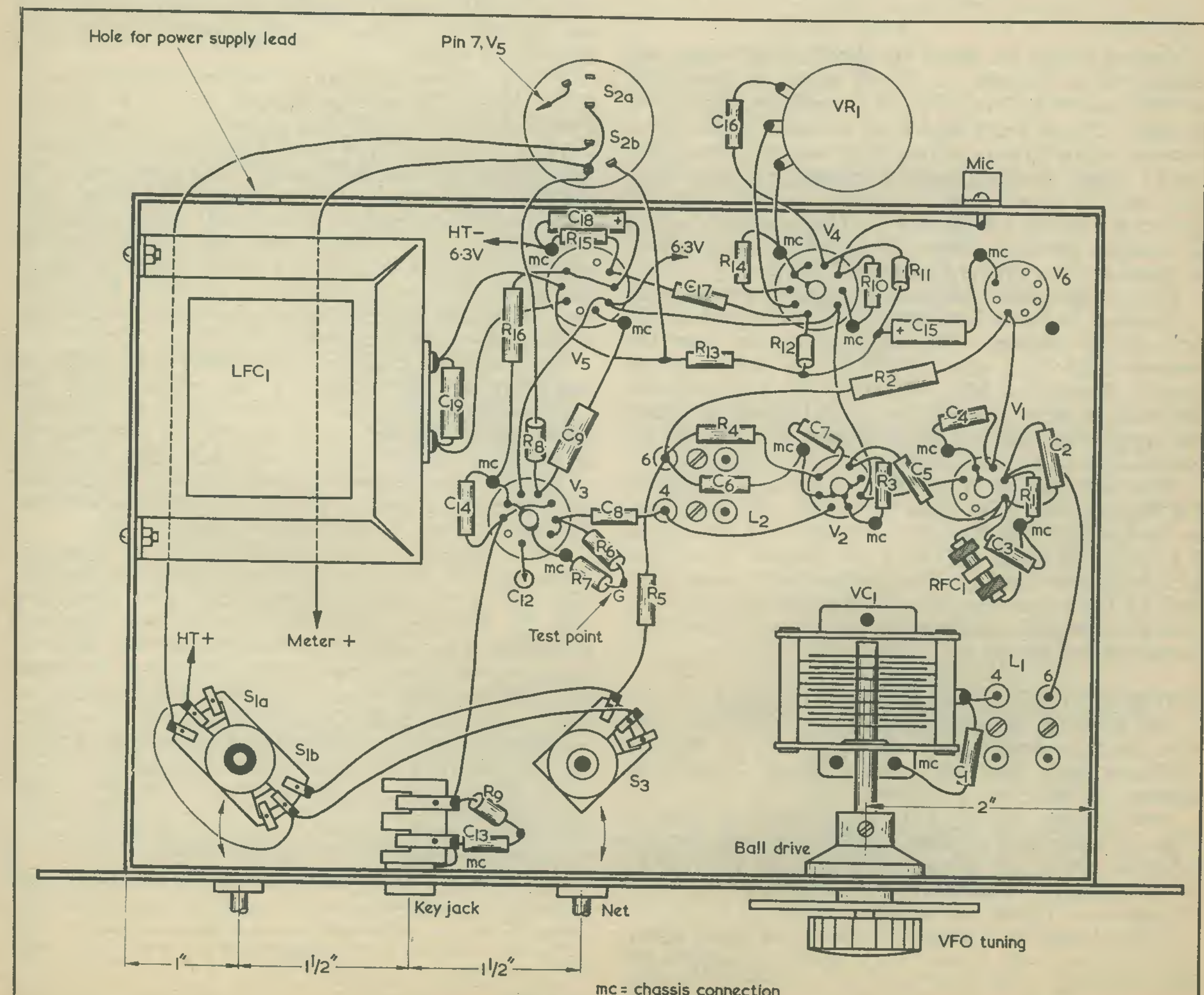


Fig. 3. Components and wiring below the chassis

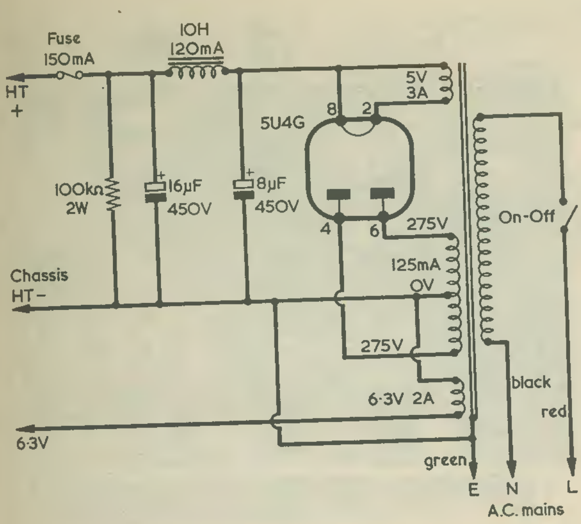


Fig. 4. Supply requirements are not critical. The circuit of a suitable power unit is given here

The v.f.o. can be tested by applying 6.3 volts and about 100 to 150 volts h.t. to V_1 anode, or about 150 to 300V to the h.t. end of R_2 if the voltage regulator is present. Bring a short lead from the aerial socket of a receiver with a b.f.o. or tuning meter near V_1, whereupon the r.f. signal should be easily located. For Top Band only, set VC_1 half open and rotate L_1 core until the carrier appears at 1.9 Mc/s. For 160m and 80m, adjust L_1 core for coverage from 1.75 to 2 Mc/s, with a little to spare at the extreme positions of VC_1.

Exact calibration is left until transmitter construction is finished, and can be readily carried out with a 100 kc/s crystal marker. The procedure is to tune the receiver (with b.f.o. on) to 1,800 kc/s as shown by the crystal. Switch the b.f.o. off and v.f.o. on, and tune the v.f.o. to zero beat with the crystal harmonic. Mark the transmitter dial 1.8 Mc/s. Repeat for 1.9 and 2.0 Mc/s.

Tune the receiver to 3.6 Mc/s by the crystal. This is 1.8 Mc/s on the v.f.o. scale for 160m, and twice this, or 3.6 Mc/s, for the 80m scale. Repeat for 3.5 Mc/s and 3.7 Mc/s. Of these, 3.7 Mc/s corresponds to 3.7/2= 1.85 Mc/s for the Top Band scale. In the same way, find 3.9 Mc/s (not wanted on 80m scale) for 1.95 Mc/s. This gives enough markings for the 10 kcs/ points to be estimated and drawn in.

BUFFER STAGE AND GRID CURRENT

The V_2 stage is wired with L_2 for Top Band. Also wire the grid, heater and cathode circuits of V_3. Clip voltmeter leads from test point G (Figs. 1 and 3) to chassis, the latter being positive.

With around 250 to 300 volts applied at point X (Fig. 1) some grid current should be found. Set the v.f.o. to about 1.9 Mc/s and rotate the core of L_2 for maximum grid current, which will be around 3mA (indicated as 3 volts across R_7).

Grid current falls slightly towards the band edges. It is also nearer 2mA when V_2 is used as a doubler for 80m working. But tests with an r.f. power output meter will show that V_3 delivers the same output with anything from about 1.5mA to 4mA grid current, when loaded to the same d.c. input. So permanent metering of grid current is not required, and no adjustment is needed for working over either one or both bands.

Should a 200 volt, or other rather low h.t. supply be used for the whole transmitter, reduce R_4 and R_5 if necessary for at least 1.5mA grid current.

POWER AMPLIFIER

Most of the remaining V_3 circuits are above the chassis, as in Fig. 2. The switches may also be mounted and wired at this stage. Below the chassis, switches $S_{1(a)(b)}$ and S_3, mounted on the front panel, are shown out of position in Fig. 3 to clarify connections. Switch $S_{2(a)(b)}$ and potentiometer VR_1 are mounted on the rear chassis runner, adjacent to V_5 and V_4 valveholders respectively. These are similarly shown out of position in Fig. 3.

The p.a. coil L_3 has 68 turns of 22 s.w.g. enamelled wire wound side by side on a 1in diameter Paxolin tube 3¼in long. The wire ends are secured in the usual manner by passing them through pairs of small holes. For 80m, a loop is twisted, scraped and tinned at the centre (34 turns) to provide a centre-tap. The coil is mounted vertically with a bracket, or with a strip through slots in the tube, or by pushing it on a disc bolted to the chassis. Commence winding near the top end so that the bottom of the winding is about 1in clear of the chassis.

If only phone operation is intended the key jack, C_{13}, C_{14}, and R_9 may be omitted, as well as $S_{2(a)(b)}$. Pins 3 and 7 of V_3 are then connected to chassis.

The r.f. section (V_1, V_2 and V_3) can be tested alone, after wiring. An "artificial aerial" load is required. The simplest is perhaps a 15 watt household lamp, connected to a coaxial plug to fit the aerial outlet, or clipped from $VC_{3(a)(b)}$ to chassis. However, whilst such an artificial aerial is suitable for phone tests, or steady carrier conditions, it should not be used for keyed c.w. conditions because the filament resistance changes considerably with temperature.

For phone or c.w., carbon resistors able to take a few watts may be employed as an artificial aerial. An r.f. (thermocouple) meter in series will show actual watts output. Smaller rating resistors can be connected in series/parallel, as necessary and according to value.

The p.a. can be loaded by a wide range of impedances, and the method with an aerial is the same as with the 15 watt lamp or other artificial aerial.

When testing, initially close VC_2 and $VC_{3(a)(b)}$. Tune the v.f.o. to the required frequency. (In practice, this will be that upon which a call is to be made.) Put S_3, the Net switch, off (its normal position). Switch on with $S_{1(a)(b)}$. The panel meter will show an excessive, off-tune current. Open VC_2 until the meter dips. Current may be only 10mA or so, according to h.t. voltage and load. Open $VC_{3(a)(b)}$ with one hand, meanwhile slightly adjusting VC_2 for *minimum* current. As this continues minimum current rises until, with 10 watts or so input, a 15 watt lamp will light quite brightly.*

INPUT/OUTPUT

For operating, the transmitter input is Anode Voltage x Anode Current, the result being in watts. For Top

*For safety reasons, it is desirable to add an r.f. choke between the aerial output terminal and chassis, in order to guard against the risk of shock due to breakdown in C_{12} and to prevent the formation of static voltages in the tank coil circuit. This choke may be a 2·6mH component, such as the Denco RFC.5, and may be mounted at the output socket bracket. This choke is *not* shown in the circuit and wiring diagrams.—Editor.

Band; do not exceed 10 watts. Anode voltage is best measured from the meter end of RFC_2 to chassis, while meter M_1 will, itself, show the current.

Assume 250V at 40mA, whereupon $250 \times 0.04 = 10$ watts input. Or forget the "0"s and do it mentally. Similarly, 250V at 30mA $= 7\frac{1}{2}$W, 300V at 30mA $=$ 9W, and so on.

Radio frequency output can be found from I^2Z, where I^2 is the current shown by the r.f. meter, and Z the impedance or resistance of the load. Suppose the r.f. meter indicates 200mA, or 0.2A, and the load is 100Ω. $I^2Z = I \times I \times Z = 0.2 \times 0.2 \times 100 = 4$ watts. Again, assume 0.3A through 75Ω, whereupon the r.f. power is 6.75W.

To explain why we do not leave V_3 detuned, the power dissipated, or wasted, at V_3 anode is Input minus Output. Suppose we have 10W input and 6W output. The power dissipated at V_3 anode is then 4W.

The % anode efficiency of the p.a. $\frac{\text{Output}}{\text{Input}}$. Suppose 10W input and 6W output. This gives an efficiency of 60%, which is an average figure.

AUDIO SECTION

The modulator section is straightforward, with enough gain for an average crystal microphone. As mentioned earlier, VR_1 is on the rear chassis runner. Using short direct leads, and with the lead to pin 7 of V_4 run against the chassis underside, no screening was necessary. The external microphone lead must, however, be screened in the usual way, the outer braiding being the return to chassis.

If desired, and assuming that an appropriate component is to hand, LFC_1 can be generously rated (100mA) speaker transformer primary instead of the choke specified in the Components List. In this case it becomes possible to test the modulator circuit by temporarily removing h.t. from the r.f. section and connecting a speaker to the transformer secondary. The microphone and speaker must be well separated to prevent acoustic feedback, and the modulator output should sound crisp and clear. The test with a speaker could also be carried out with the choke specified by connecting the primary of any valve output transformer across the tags of LFC_1, with a speaker across the secondary. The values of C_{16}, C_{17} and C_{19} are chosen to provide a strong middle register, as is required here.

When the P3142 choke specified is employed for LFC_1, care should be taken to ensure that there is no risk of possible contact between its tags and the case bottom when the chassis is fitted in the case. The choke dimensions are such that adequate clearance can be obtained, provided attention is paid to this requirement.

To check audio results when modulating, load V_3 to about 8 to 10 watts input, with a 15 watt lamp connected as artificial aerial. With no receiver aerial, or only a few inches of aerial, tune in the signal. The receiver r.f. and i.f. gain controls need to be well towards minimum, so that volume is average with the receiver audio gain at its usual setting. Overloading the receiver will cause distortion. Also acoustic feedback from the receiver speaker to the microphone will cause howling if these are not well separated. Advance VR_1 until audio distortion commences due to too much gain, then back off slightly.

POWER SUPPLIES

Many contacts have been made using a receiver-type power supply offering 80mA at 250 volts. But a 275 volt or 300 volt supply able to give 120mA is much better. H.T. voltages above 300 should not be used.

A reduced h.t. voltage causes p.a. efficiency to fall off. For example, 50mA at 200 volts corresponds to 10 watts input, but this will give less r.f. output than 30mA at 300 volts (9 watts input).

The heater drain is just under 2 amps, and is easily met by a 2 amp 6.3 volt secondary. Fig. 4 gives the circuit of the power pack most often used. It has no particular advantage over other circuits, but it also has no snags. The 100kΩ resistor is merely a safety bleeder.

TWO-BAND WORKING

The transmitter gives good results on 80m. Longer range working is more usual here than on 160m, though 160m has its own advantages, especially during dark evenings.

A few watts can be obtained on 80m by doing nothing more than turning VC_2 to a dip near minimum capacitance, and thereby doubling in the p.a. stage. However, this is not really recommended.

To operate V_2 on 80m, the lower inductance coil L_4 (see Components List) is connected in circuit in place of L_2. For 2-band operation, the switch shown in Fig. 5 (*a*) may be added. To keep r.f. connections reasonably short, this 2-way switch is mounted in the S_3 position, S_3 replacing the key jack and the latter fitted to the chassis rear runner. L_4 may be positioned on the chassis between L_2 and the added 2-way switch.

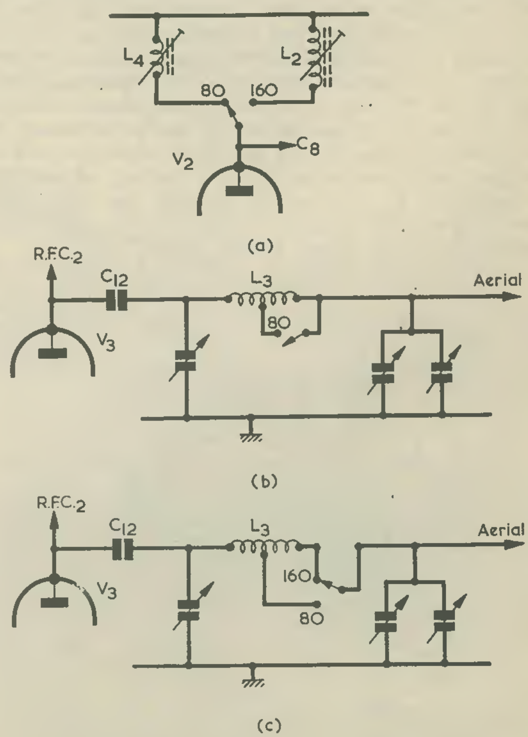


Fig. 5 (a). Adding a switched 80m coil to the anode circuit of V_2
(b). Half the p.a. tank coil may be switched in for loading on 80m
(c). An alternative method of switching the p.a. coil

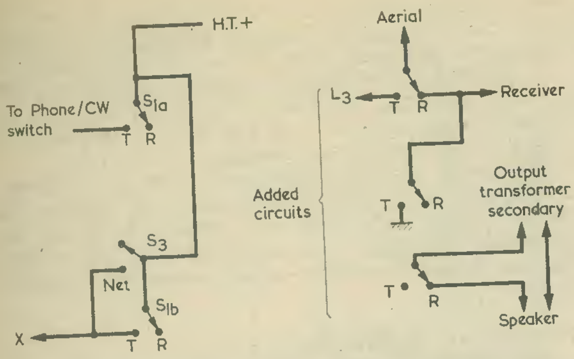
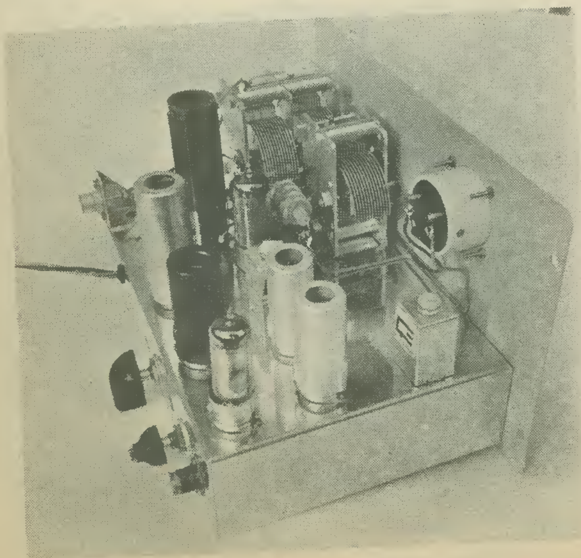


Fig. 6. A comprehensive Transmit-Receive control may be obtained by replacing $S_{1(a)(b)}$ with a 5-pole 2-way switch

Peak the core of L_4 for maximum grid current at some frequency between about 3.6 and 3.7 Mc/s.

With L_3 wound as described, 80m output can be obtained with VC_2 nearly open, as just mentioned. With doubling in V_2, the r.f. output is then satisfactory. But the range of impedances which can be matched is reduced and it is better to take advantage of the centre-tap in L_3 and use only half this coil.

A short-circuiting switch is added, as in Fig. 5 (*b*). A small switch can be accommodated fairly high between VC_2 and $VC_{3(a)(b)}$, allowing short leads and keeping output circuits above the chassis. Some readers may feel that short-circuiting half the p.a. coil in this manner could introduce losses, but the writer has checked this point by comparing the results obtained with the switching of Fig. 5 (*b*) and the alternative circuit shown in Fig. 5 (*c*). Results with the short-circuiting switch were poorer by only a minute margin than those given with the switching circuit of Fig. 5 (*c*). Since the Fig. 5 (*b*) circuit requires only an on-off switch which can be easily fitted and wired up, this method of switching is preferred by the writer. Should the constructor decide to use the circuit of Fig. 5 (*c*), a *small* 2-way switch has to be fitted to the panel.



A view of the completed transmitter from the side

INTEGRAL SEND-RECEIVE SWITCHING

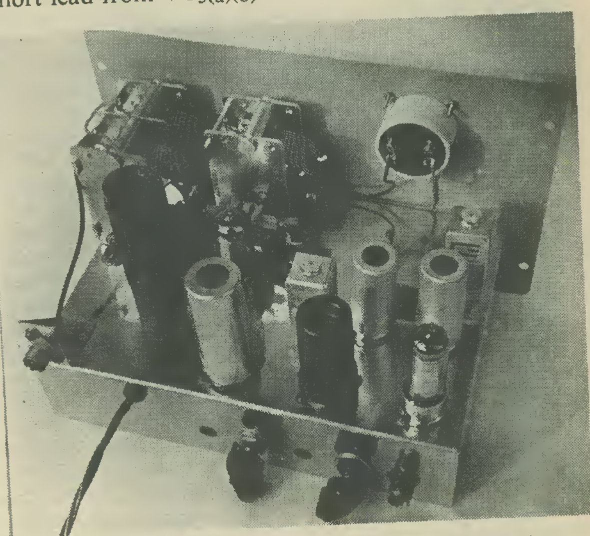
If desired, the single-knob send-receive switching circuit mentioned at the beginning of this article may be incorporated, whereupon $S_{1(a)(b)}$ is replaced by a switch having 5 poles. (Actually, a 2-wafer, 6-pole switch is more easily obtainable.) The $S_{1(a)}$ and $S_{1(b)}$ sections function as before, and the Net switch is still retained. As is shown in Fig. 6, three new switch sections (or poles) are added.

One new section transfers the aerial from the p.a. tank coil L_3 to a coaxial socket on the back below the chassis, from which a coaxial lead runs to the receiver. The second new section earths this lead on Transmit.

The third section opens the receiver speaker circuit on Transmit, though enough r.f. leaks through to the receiver to make a.g.c. reduce gain enormously, even with the earthed aerial connection.

To listen, leave the 5-pole switch at Receive. To tune the v.f.o., close the Net switch only. To send and receive, leave the Net switch open, and operate the 5-pole switch only.

To avoid unnecessary r.f. under the chassis, drop a short lead from $VC_{3(a)(b)}$ to the related switch section,



Rear view, showing the components above the chassis

and take the aerial connection straight back up through the chassis, then run it on top to the output coaxial socket, following the same route as for the aerial lead in Fig. 2.

AERIALS

Aerials are a subject in themselves, but a few notes may help. The simplest is an end-connected wire. For the bands under consideration, it should preferably be at least 100ft long, though numerous contacts have been made with 40ft and shorter wires. Something around about 125 to 130ft will be approximately a half-wave on 80m, and quarter-wave on 160m. The wire can be longer, if space permits.

The load which the end-fed wire presents to the transmitter depends on its length, the frequency, and other factors. Very many lengths will be suitable—that is, they will fall within the range of adjustment of VC_2 and $VC_{3(a)(b)}$.

Some lengths (including the very short) are unsuitable, as they may not load the transmitter to enough watts input. Alternatively, the input may be too high even

COMPONENTS

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

R_1 68kΩ
R_2 10kΩ 3 watts
R_3 100kΩ
R_4 22kΩ $\frac{1}{2}$ watt
R_5 3.3kΩ 1 watt
R_6 22kΩ $\frac{1}{2}$ watt
R_7 1kΩ
R_8 5.6kΩ 2 watts
R_9 470Ω (see text)
R_{10} 1MΩ
R_{11} 220kΩ
R_{12} 100kΩ
R_{13} 22kΩ
R_{14} 3.3kΩ
R_{15} 470kΩ
R_{16} 270Ω 1 watt
VR_1 250kΩ potentiometer, log track

Capacitors

C_1 150pF 1% silver-mica
C_2 680pF 1% silver-mica
C_3 680pF 1% silver-mica
C_4 2,000pF disc ceramic
C_5 100pF silver-mica
C_6 0.01μF disc ceramic
C_7 0.01μF disc ceramic
C_8 100pF silver-mica
C_9 1,000pF silver-mica
C_{10} 1,000pF silver-mica
C_{11} 0.01μF paper or Mylar, 150V wkg.
C_{12} 1,000pF silver-mica
C_{13} 5,000pF disc ceramic (see text)
C_{14} 5,000pF disc ceramic (see text)
C_{15} 2μF electrolytic, 350V wkg.
C_{16} 2,000pF disc ceramic
C_{17} 2,000pF disc ceramic
C_{18} 25μF electrolytic, 25V wkg.
C_{19} 0.01μF paper or Mylar, 450V wkg.
VC_1 100pF variable, type JB/U101/7/100 (Electroniques)
VC_2 532pF variable, type JB/4507/1/532 (Electroniques)
$VC_{3(a)(b)}$ 532pF + 532pF 2-gang variable, type JB4507/2/532 (Electroniques)

Inductors

L_1 Screened coil type SL/T (Electroniques)
L_2 Screened coil (for 160m) type SL/Y (Electroniques)
L_3 68 turns close-wound, 22 s.w.g. enam., 1in diameter former
L_4 Screened coil (for 80m—see text) type SL/U (Electroniques)

RFC_1 4.7mH choke type FCC-7 (Electroniques)
RFC_2 2.6mH choke type RFC.5 (Denco)
LFC_1 10H 120mA l.f. choke (see text) type P3142 (Electroniques)
(N.B. For safety reasons, it is preferable to connect a further 2.6mH r.f. choke across the transmitter output. Details are given in the footnote.)

Valves

V_1 6C4
V_2 EF91
V_3 5763
V_4 12AX7
V_5 6BW6
V_6 OA2

Meter

M_1 0–50mA moving-coil meter type MR38P (Electroniques)

Switches

$S_{1(a)(b)}$ 2-pole 2-way rotary (see text)
$S_{2(a)(b)}$ 2-pole 2-way rotary (see text)
S_3 s.p.s.t. rotary
(N.B. Additional switches are required for 2-band operation. See text.)

Sockets, Etc.

2 B7G skirted valveholders with centre spigots
1 plain B7G valveholder
2 B9A skirted valveholders with centre spigots
1 plain B9A valveholder with centre spigot
2 B7G screening cans 2in high (for V_1 and V_2)
1 B9A screening can 2in high (for V_4)
1 B9A screening can $2\frac{1}{2}$in high (for V_5)
2 Coaxial sockets
1 Closed-circuit jack (see text)

Metalwork

1 Datum "Dinkicase" 10 x 6 x 6in type DD6106 (Electroniques)
1 chassis 6 x 2 x $8\frac{1}{2}$in (H. L. Smith & Co. Ltd.)
1 bracket (home-built) for aerial coaxial socket

Miscellaneous

1 6:1 epicyclic ball drive with flange, type 4511/F (Jackson Bros.)
2 $1\frac{1}{2}$in dia. (or similar) knobs
1 1in dia. (or similar) knob (v.f.o. drive)
4 small pointer knobs
1 tagstrip, 1 tag insulated
1 crystal microphone
Connecting wire, nuts, bolts, etc.

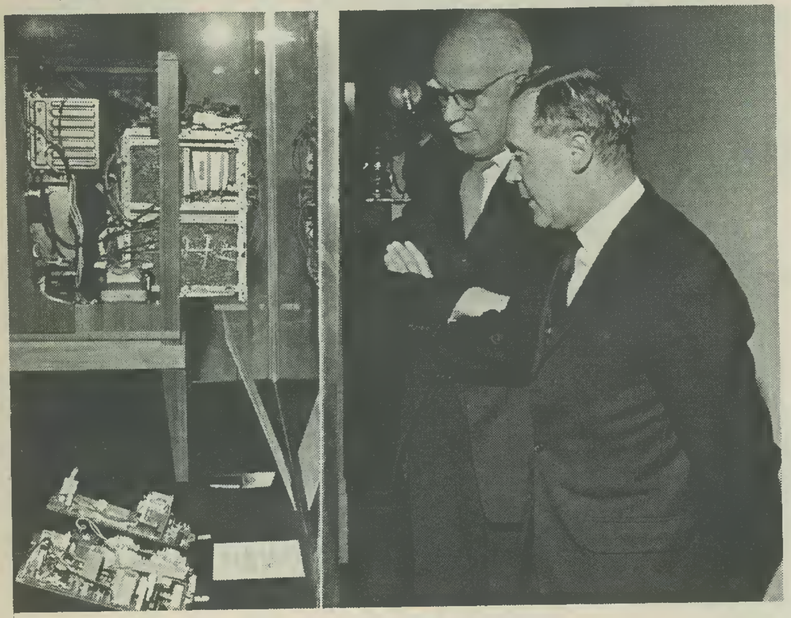
with $VC_{3(a)(b)}$ fully closed and VC_2 "dipped". The simplest cure, if the aerial length cannot be changed, is to place a loading coil between transmitter and aerial. A fairly large diameter tapped coil, wound with 18 s.w.g. enamelled wire is ideal. But even a scramble-wound coil of flex or connecting wire may solve the problem. Find a number of turns which allows normal loading. The maximum inductance likely to be required is similar to that of the tank coil.

The advantage of an end-fed aerial lies in the ease with which it can be erected, the fact that many lengths do well, and also the convenience of working both bands with one wire. Results are usually good when the aerial and downlead (which forms part of the total length) are mostly high and clear of earthed objects. A good earth helps enormously with lengths near a quarter-wave, but with lengths near a half-wave the earth can sometimes be removed with no change in signal strength reports.

A centre-fed dipole must be cut for the band, and it has 75Ω or similar co-axial cable (or twin feeder) from its centre to the transmitter. Its operation does not depend on an earth circuit. About 126–128ft will usually cope for 80m.

NEWS . . . AND .

PRESENTATION OF WORLD'S FIRST TRANSISTOR COLOUR TV TO SCIENCE MUSEUM



Mr. Dennis Neill (right), Director of Thorn Electrical Industries Ltd. and Managing Director of British Radio Corporation Ltd., discusses the BRC all-transistor colour TV receiver with Mr. D. Chilton, Keeper of the Department of Electrical Engineering and Communications at the London Science Museum, at the recent presentation by British Radio Corporation.

Recently, Mr. Dennis Neill, Director of Thorn Electrical Industries Ltd. and Managing Director of British Radio Corporation Ltd., presented the London Science Museum with a model of the world's first all transistor colour television receiver.

The presentation was received for the Science Museum by Mr. D. Chilton, Keeper of the Department of Electrical Engineering and Communications. The model will be displayed in the Radio Section.

The first of its kind, the British Radio Corporation all-transistor colour TV receiver also breaks with tradition with its computer-type chassis construction. The circuit is made up of ten printed circuit modules all of which are 'plug-in' and may be removed and replaced in seconds.

The use of transistors and modules in the BRC colour receiver result in an extremely reliable set that is simple to service.

DO IT YOURSELF

RADIO

An unexpected side-effect of the success of Radio Leicester, the BBC's pioneer in local broadcasting in England, has been the popularity of night classes in radio technique. Hundreds of people are attending courses – top businessmen, parsons interested in producing religious magazines, teachers, and the man-in-the-street who has always wanted a chance to get on the air.

"This is one of the big assets of local radio – its nearness to the people, the immediacy of their reactions; not so much broadcasting as conversation". This is the view of Donald Edwards, General Manager of BBC Local Radio Development, as he described it recently to a lunch-time audience in Broadcasting House, London. "There is no shortage of material" he emphasised. "Indeed there is more than a station's small staff can handle, but a community can do much of the broadcasting itself. It is their station. We give a helping hand, but it is the people's radio. All sorts of ordinary citizens who have never broadcast before are revealing charm and wisdom at the microphone. They walk into their local station, or meet the radio car in the street, and talk. If it is interesting, it is broadcast."

WAKE UP – YOU'RE DEAD!

"It seems to me that our scientists may have got their priorities slightly wrong. You may ask yourself which you would rather have – the scientific suppression of rheumatism, the common cold, malnutrition and the warfaring instinct . . . or a fluorescent iodine alarm clock to get you up, right on time, 500 years after you're dead."

Basil Boothroyd in the BBC World Service – talking about scientists at Massachusetts Institute of Technology who are developing a clock which will lose only one second in 600 years.

"Look Dad he's riding a megacycle!"

. . . COMMENT

VTS DRILL WHICH CAN BE LOCKED AT ANY SPEED

There is a continual development in the technical improvement of portable electric drills. Initially there were only single speed drills, then two- and even multi-speed models. About two years ago SKIL introduced their revolutionary Variable Trigger Speed (VTS) system, an electronic speed control which theoretically gives as many speeds as the maximum r.p.m. of the tool. This type of speed control has been obtained by building a silicon controlled rectifier in the electrical circuit.

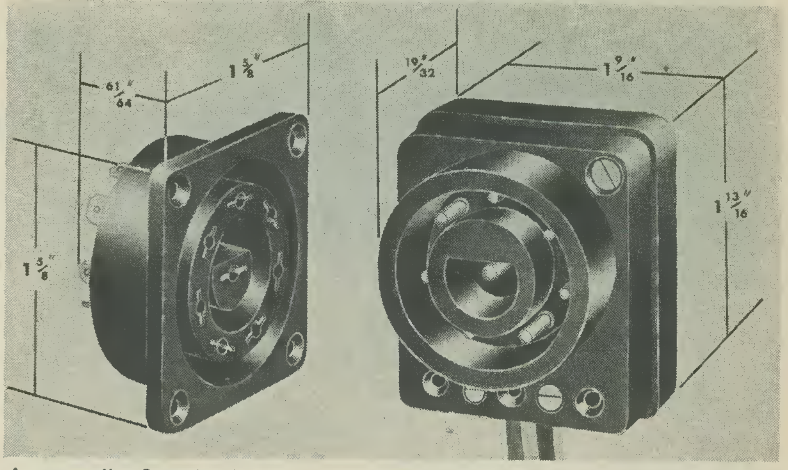
In industrial as well as in do-it-yourself circles the advantages of the Variable Trigger Speed system were instantly recognised. In practice this stepless speed control proved to be invaluable, because the operator can always select the appropriate speed for drilling in many different types of material.

When such a VTS-drill is mounted in a vertical or horizontal stand, it is advantageous to be able to set the speed at any stage between zero and maximum r.p.m. Now SKIL announce their new model 1435B do-it-yourself drill with stepless speed control plus an adjusting screw which—in conjunction with the lock button—allows the operator to select and maintain any desired speed. Yet another important step in the perfection of electric drills!

Some other details: Pistol grip design and extra side handle for maximum handling ease: drill capacity in steel 5/16"; dependable 300 input Watts motor: excellent for driving all SKIL Snap/Lock attachments at the appropriate speed; speed adjustable from 0–2500 r.p.m. Price £11 10s. 0d.

Enquiries to SKIL (Great Britain) Ltd., 59 High Street, Hounslow, Middlesex.

BULGIN 8— POLE CONNECTOR



A versatile 8 pole (7 EARTH) connector of 6A. 250V. a.c. 'mains' rating. Both plug and socket members are so designed that when un-mated, live parts are shrouded and safe to handle. Thus it may be used for both mains 'INLET' or 'OUTLET' applications. Of robust shock resisting plastic construction with positive polarity keying to prevent reversed insertion. Plug member has generous terminal screw connectors, and efficient cable grip facility connection terminals are clearly coded for 'mains' and auxiliary lines.

THE KEY TO THE DOOR

Some farm animals eat more than their fair share of food because they are greedier, heavier, push more, or are more important animals within the herd. To end this one-upmanship on the farm, Denny Desoutter, in one of his 'Science in Action' newsletters in the BBC World Service, described how an electronic key, by opening a door to its own food store could control a beast pushing to get at food.

The device, developed by a Scottish firm in association with the National Research Development Council, is a tuned coil embedded in a plastic disc attached to the animal's collar. A beast would be able to push a door open only if it was wearing the coil tuned to the particular oscillator in its own food cupboard. Only if the two matched would the bolt to the cupboard be automatically pulled back.

Designed to ensure that each animal received one portion of food, the mechanism would cost about £15 for each door. Savings would be made by relieving farmhands of the time-wasting chore of having to lead each animal to a stall and tether it there.

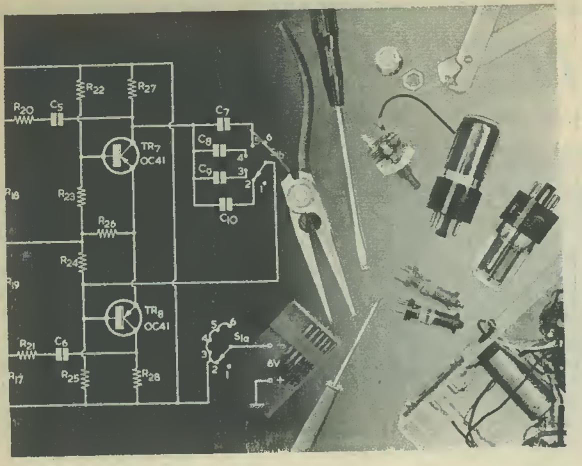
NEW WIRELESS MUSEUM

Members of the Peterborough & District Amateur Radio Society are establishing a "Wireless Museum" of radio equipment used in the 1920's and early 1930's. If any reader knows of the whereabouts of an ancient crystal receiver, bright-emitter valve type set, horn loud-speaker, or old wireless book or magazine, would they please drop a postcard to the hon. secretary – D. Byrne, G3KPO, Jersey House, Eye, Peterborough.

FREE – IN NEXT MONTH'S ISSUE

We shall be adding some extra pages to the "Constructor" next month so that we can supply all readers with our ANNUAL INDEX – FREE. There will be a considerable demand for the issue as the free index represents a bonus of 1s. 6d. to each reader.

To avoid disappointment, as we no longer publish the index separately from the magazine, place an order with your newsagent now.



SUGGESTED CIRCUIT No. 211

INTEGRATED CIRCUIT BOOSTER FOR LUXEMBOURG

by G. A. FRENCH

Despite the fact that, following the recent demise of the "pirate" radio stations, there is nowadays a virtually continual pop music programme on the B.B.C. Radio 1 channel, many of the younger radio listeners still prefer to tune in, for at least part of the time, to Radio Luxembourg on 208 metres. During the hours of darkness Radio Luxembourg can normally be received at good strength on an average superhet, but reception conditions early in the evening and around dusk are very often quite poor.

This month's Suggested Circuit is devoted to a Radio Luxembourg signal booster unit whose output can be applied to the aerial and earth sockets of a conventional medium wave superhet and which can give improved reception of the Luxembourg signal. An unusual feature of the booster unit is that it works with an aerial which is only 7in long, and yet it provides an output signal which is considerably greater than that offered by an aerial wire having a length of 20ft! The prototype was checked with a standard mains superhet receiver having aerial input coils (as opposed to a ferrite rod aerial) and it was found that, under conditions when Radio Luxembourg was barely audible with the 20ft aerial, the signal was received at full strength when this aerial was replaced by the booster with its 7in aerial wire.

It has to be pointed out at this stage that the aerial input impedance and coupling arrangements in medium wave receivers will vary from model to model, and that these differences could qualify the performance offered by the booster unit. In this respect, therefore, the circuit has to be considered as being in the experimental category.

The booster unit also enables the writer to introduce an interesting integrated circuit which has now become available on the home-constructor market. This integrated circuit is primarily intended to function as an i.f. amplifier in f.m. receivers, but it is employed in the present application because of the exceptionally high r.f. gain it provides. Since the application is other than that intended by the manufacturer of the integrated circuit some limitations have to be accepted, and these are discussed later.

The experienced experimenter, on seeing the possibilities inherent in the simple unit described here, should have little difficulty in adapting the basic principle for other purposes. The outstanding advantage given by the circuit is its ability to provide a relatively high r.f. output from a signal which is picked up on an extremely short length of aerial wire.

INTEGRATED CIRCUIT

The integrated circuit is the R.C.A. CA3011 (currently available from Amatronix Ltd., 396 Selsdon Road, Croydon, Surrey) and its internal circuitry appears in Fig. 1.

In this diagram terminal 8 is the "ground" connection and is normally at chassis potential. The positive supply, which may vary between 6 and 9 volts (with an absolute maximum limit at 10 volts) is applied to terminal 10. This positive supply is fed, via R_{10}, to the groups of voltage regulating diodes designated D_1 and D_2, the individual diodes in each group consisting of silicon junctions passing current in the forward direction. Assuming some 0.6 volts per junction, about 2.4 volts relative to terminal 8 appears at the upper end of the group D_2, and about 4.2 volts at the upper end of the group D_1. The regulated voltage at the upper end of D_2 is applied to emitter-follower Q_{10}, whose emitter feeds the base circuits of Q_8 and Q_5. Similarly, the regulated voltage at the upper end of D_1 is applied to the base of Q_9, whose emitter supplies the collector circuits of Q_1 to Q_5.

The input signal is applied across terminals 1 and 2, the latter being held at chassis potential for r.f. by an external 0.1μF capacitor. Q_1 and Q_2 form an emitter-coupled differential amplifier pair, the base of Q_2 being bypassed to chassis, via terminal 3, by a second 0.1μF capacitor. The signal at Q_2 collector is passed to the base of emitter-follower Q_3, whose emitter feeds into the differential amplifier Q_4, Q_5. The signal from Q_5 is next applied to the further emitter-follower Q_6 and, thence, to the output differential amplifier pair Q_7, Q_8. Terminal 4 is bypassed externally to chassis via a third 0.1μF capacitor, thereby earthing the bases of both Q_5 and Q_8 for r.f. The output load is connected between terminals 5 and 10.

D.C. stabilising loops are provided internally by way of R_{14} and R_{15}, whilst a fourth 0.1μF capacitor, connected externally between terminal 10 and chassis, bypasses the supply potential. The complete device is encapsulated within a TO-5 metal can, this being connected internally to terminal 8. Input impedance between terminals 1 and 2 is typically 3kΩ.

Fig. 1 is taken from the CA3011 circuit issued by R.C.A., and employs the same component numbering. In the R.C.A. circuit there are no resistors designated R_6 or R_{11} to R_{13}.

As is to be expected from the large number of transistors which appear in the signal amplification chain, the overall gain offered by the i.c. is exceptionally high. The manufacturers specify the CA3011 as an f.m. i.f. amplifier offering a useful frequency range from 100 kc/s to greater than 20 Mc/s. Quoted voltage gain is of the order of 70db (3,000 times) up to 2 Mc/s, dropping to some 60db (1,000 times) around 12.5 Mc/s. These figures are very high indeed for a single device no larger than a standard transistor, and the convenience afforded by the use of the CA3011 becomes even more apparent when it is remembered that the only external components it requires are four 0.1μF capacitors.

Fig. 2 shows the layout of the CA3011 lead-outs, with the leads pointing towards the reader. Terminals 6, 7 and 9, it should be noted, are internal connections. *No external connections must be made to these leads.*

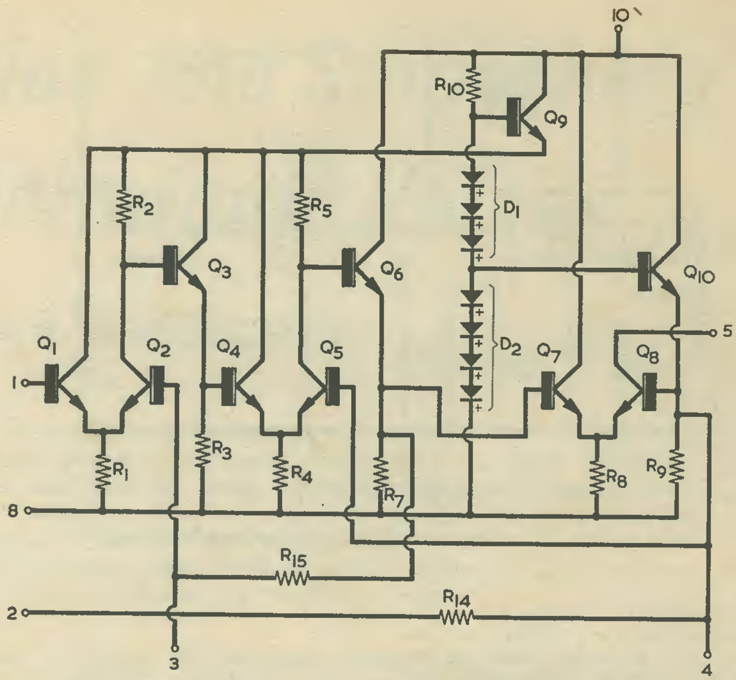


Fig. 1. The internal circuitry of the R.C.A. CA3011 integrated circuit

BOOSTER CIRCUIT

The Luxembourg booster circuit using the CA3011 appears in Fig. 3. In this diagram the 7in aerial is connected direct to the tuned circuit given by coil winding L_2 and trimmer C_1. L_3 is a coupling winding and it connects to terminals 1 and 2 of the CA3011 integrated circuit. The coil employed is a Denco Transistor Dual Purpose Blue type Range 2T, which is normally intended for aerial coupling purposes on the medium wave band. In this instance, however, the aerial coupling winding, L_1, is unused, and merely has one end connected to chassis. The Denco coil may be plugged into a B9A valveholder, and the numbers alongside the windings in Fig. 3 indicate the corresponding valve pins. Resistor R_1 is included merely to maintain d.c. continuity between terminals 1 and 2 of the integrated circuit if the coil happens to be removed from the valveholder for experimental purposes, and this resistor may be omitted if the coil is wired permanently into circuit.

Returning to the integrated circuit in Fig. 3, terminal 8 of the device connects to chassis and to the negative pole of a 9 volt battery, the positive pole of which connects, via on-off switch S_1, to terminal 10. Terminals 2, 3, 4 and 10 are bypassed to chassis via the 0.1μF capacitors C_2 to C_5. The 150Ω resistor R_2 provides the output load for the integrated circuit, and appears between terminals 5 and 10. The output passes via C_6 to a screened cable, and thence to the aerial and earth terminals of the associated receiver. For reasons of stability, all the r.f. components and wiring after terminal 5 are screened from the remainder of the circuit.

As is at once evident from the diagram, the booster circuitry external to the CA3011 is extremely simple indeed.

To set up the booster unit after it has been assembled, the receiver with which it is to be used is initially tuned to Radio Luxembourg with a normal aerial plugged in. This aerial is then removed and the output lead from the booster unit coupled to the receiver aerial and earth terminals instead. The booster is next switched on, after which trimmer C_1 is adjusted for best reception of the Luxembourg signal. The unit is then ready for use, no further adjustments being required.

LIMITATIONS

From the foregoing it might be assumed that the i.c., in a basic circuit similar to that shown in Fig. 3 but with a larger aerial applied, could be usefully employed as a signal booster at all frequencies at which it offers useful gain. This application is feasible, but it is only practicable if tuned circuits capable of providing sufficient selectivity to isolate the desired signal appear between the aerial and the CA3011 input terminals. If, for instance, a large aerial were connected to the coupling winding L_1 of Fig. 3, the single tuned circuit L_2 C_1 would not present sufficient selectivity to isolate the desired signal from those adjacent to it. Cross-modulation would then result, and the desired signal would carry a background of modulation from transmissions on neighbouring frequencies together with noise picked up by the aerial over a relatively broad band of frequencies.

The simple tuned circuit and very short aerial of Fig. 3 provides sufficient selectivity for reception of the Luxembourg transmission, and hence enables the booster unit to offer a performance which is both useful and attractive. L_2 and C_1 offer a relatively high Q at the high frequency end of the medium wave band, and the unit can be used for boosting other signals around the Radio Luxembourg frequency. Some difficulty may be experienced if the booster unit is used in districts where the B.B.C. West Radio 4 transmission on 206 metres is received at high strength, and it could be found that the simple tuned circuit employed may not be sufficient to prevent a Radio 4 background being present on the boosted Luxembourg signal. No trouble on this score was experienced with the prototype, which was checked in an area where the West transmission appears at good strength, but it is a point which should nevertheless be borne in mind.

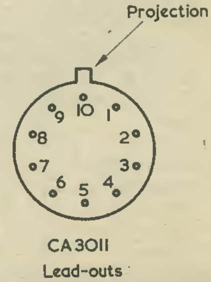


Fig. 2. The lead-out numbering of the CA3011

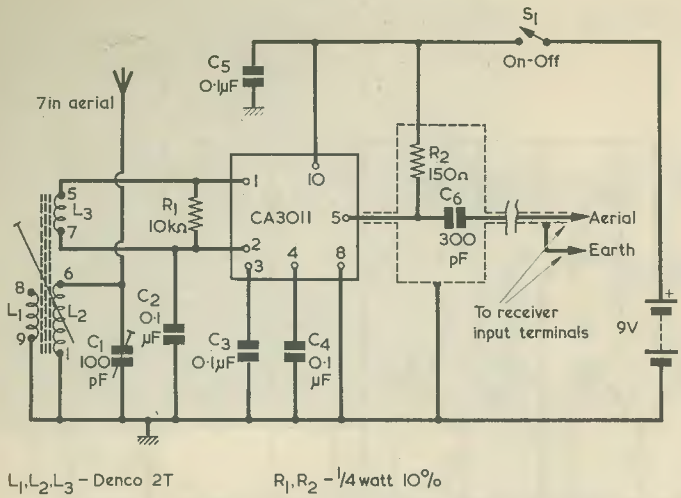


Fig. 3. The CA3011 employed in the Radio Luxembourg booster unit

wire was initially soldered to the integrated circuit lead-out, after which a length of sleeving was passed over both wires, this extending right up to the CA3011 can. Braiding taken from a length of thin screened cable was then passed over this sleeving and nearly up to the can, taking care to avoid short-circuits to leads 4 and 6. It is possibly unnecessary to take the screening as close to the can as this but, bearing in mind the exceptionally high gain offered by the integrated circuit, the writer felt it would be desirable to err on the cautious side here.

FINAL POINTS

The prototype circuit offered the performance which has already been described, and there was no evidence of instability using the 150Ω load shown in Fig. 3. Should instability occur with any unit built up to the circuit it could be cleared by reducing the value of this resistor. It is much more probable, however, that the instability would be caused by excessively long leads in the bypass capacitor circuits or by inadequate screening.

If the booster unit is used in conjunction with a mains-driven receiver whose chassis is common to one side of the mains, the requisite isolating capacitors *must* be present in both the receiver aerial and earth input circuits.

The current drawn by the prototype unit from the 9 volt battery was 24mA.

As a matter of interest it may be mentioned that the prototype booster unit, with its 7in aerial, offered results at least as good as a 20ft aerial over all the medium wave band when C_1 was replaced by a standard 310pF tuning capacitor. This capacitor was, of course, adjusted for optimum strength with each signal it was desired to receive. At the low frequency end of the medium wave band the booster gave the same signal strength as did the 20ft aerial. At frequencies above 1 kc/s (300 metres) signal strength using the booster was greater than with the 20ft aerial, this increase in strength becoming markedly more pronounced as the frequency of reception increased. On long waves, the booster unit offered the same signal strength as the 20ft aerial at all points of the band, the medium wave coil in the booster being replaced, for the purpose of this experiment, by a Blue Range 1T coil (750 to 2,000 metres) from the same Denco series. On the short wave bands, using a Blue Range 4T coil (20 to 60 metres), cross-modulation proved troublesome, and the 20ft aerial gave better results.

In consequence, the booster unit could, if desired, be employed alternatively as a "compressed aerial" on medium and long waves. The tuning capacitor which is then required should be fitted with a simple epicyclic slow-motion drive as adjustments, even with the single tuned circuit, are fairly critical.

CONSTRUCTION

A suitable basic layout for the booster unit is illustrated in Fig. 4. It will be seen that the coil, together with its trimmer and the integrated circuit, appear on the upper surface of a small metal box which forms the chassis. It is preferable to have the coil unscreened. The four 0.1µF bypass capacitors connecting to the integrated circuit should have their leads as short as possible. Small paper or plastic foil capacitors will be suitable here.

A screened lead from terminal 5 of the integrated circuit travels through the metal box surface to R_2 and C_6. These components are completely enclosed within the metal case, which then provides the requisite screening. The on-off switch, S_1, can be positioned at any convenient point.

To prevent instability, the screening on the lead to terminal 5 should closely approach the metal can of the integrated circuit. In the prototype the writer used the following approach. A short length of thin tinned copper

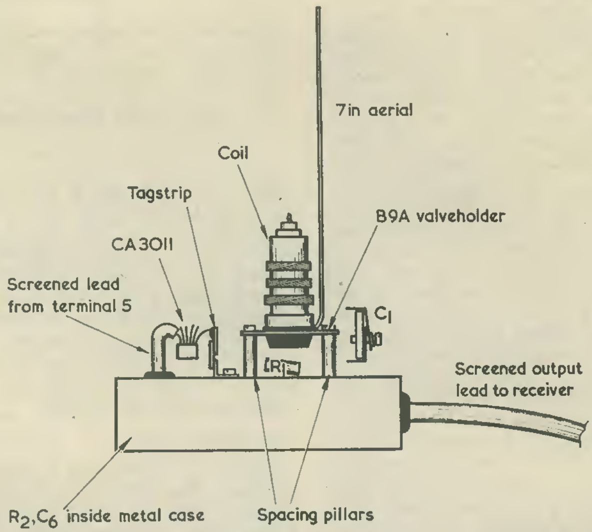


Fig. 4. A suggested layout for the major components of the booster unit. C_2 to C_5 are not shown, and these should be on the upper surface of the metal case, connecting to the integrated circuit by way of very short leads

Stabilisation and Smoothing with Thermionic Valves

by J.B. DANCE, M.Sc.

A common reaction, when considering a stabilised power supply employing either valves or transistors, is to think in terms of the series circuit. But the shunt stabiliser can offer similar performance and can, in many cases, be cheaper than a series stabiliser. Our contributor devotes most of this article to the shunt circuit as applicable to valve power supplies. Mathematical analyses are given to support the description of operation, and it is shown that the end results of the calculations are simple equations which can be readily applied

VOLTAGE STABILISERS USING THERMIONIC TUBES can be divided into two main types, namely series and shunt stabilisers. In series stabilisers all of the stabilised current passes through a series valve, the potential drop across this valve being controlled by the applied grid potential. Several valves are usually required in this type of circuit. In shunt stabilisers, the controlling valve appears across the power supply output.

Shunt valve stabilisers will be considered in some detail since they are simple and some types can be constructed using only a single valve.

ELECTRONIC SMOOTHING

If a power supply circuit is required which will provide an output that is almost completely free from hum or other ripple, the type of circuit shown in Fig. 1 may be used. This circuit will also remove any hum harmonics and any transient voltage pulses which may be present in the mains supply due to random changes in the loading. The smoothed output is taken from point B and should be used to supply only the circuits which really do need a well smoothed supply. All other parts of the equipment should be fed from point A in order to ensure that the current passing through resistor R_2 is kept as small as possible.

PRINCIPLE OF OPERATION

If the potential across C_2 in Fig. 1 increases slightly for any reason (for example, during a peak of the hum derived from the mains supply), this voltage peak will be applied to the grid of the valve V_2 via capacitor C_3. The anode current passing through the valve thus increases and this tends to reduce the voltage at point B due to the increased voltage drop in R_2.

If the component values are suitably chosen, the increased voltage drop across R_2 can be made equal to the initial rise in potential, so that the potential at point B remains constant. One can think of the valve as being a phase inverter producing an output of opposite polarity to the instantaneous voltage and (in this circuit) having a gain of unity. All of the alternating current (due to hum, etc.) passing through R_2 also passes through the valve. The resistor R_4 serves to protect the valve against excessive grid current during any positive voltage transients of the potential at point A.

This circuit has an input time constant of approximately C_3R_1 and will be effective at frequencies greater than approximately $1/C_3R_1$.

CIRCUIT ANALYSIS

The resistor R_3 provides a suitable bias for the valve. The value of this resistor may be calculated from the equation

$$R_3 = \frac{V_g}{I_a} \ldots \text{Equation 1}$$

where V_g is the grid bias recommended by the valve manufacturers and I_a is the anode current at this bias. This sets the d.c. conditions.

(*continued on page* 679)

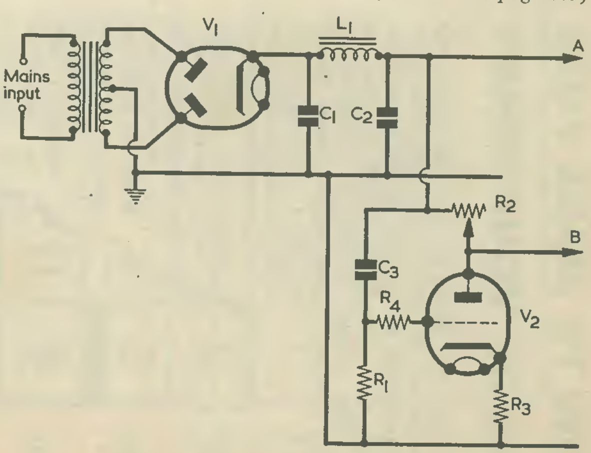
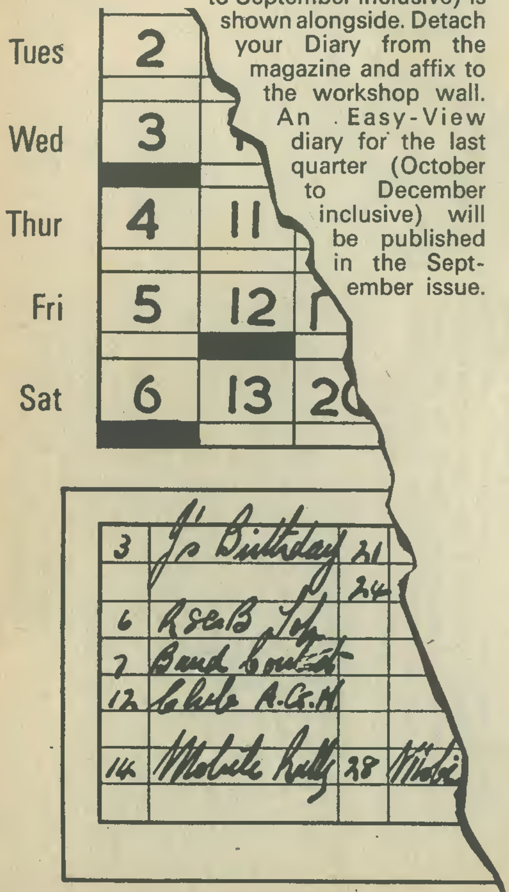


Fig. 1. An electronic smoothing circuit

HOW TO MAKE FULL USE OF YOUR DIARY

Underline the dates of both personal and radio events in which you are interested or concerned, as shown in the illustration below, and enter brief details of these in the Diary Notes. A list of forthcoming events of radio interest taking place during the third quarter (July to September inclusive) is shown alongside. Detach your Diary from the magazine and affix to the workshop wall. An Easy-View diary for the last quarter (October to December inclusive) will be published in the September issue.



SUGGESTIONS FOR YOUR EASY-VIEW DIARY

JULY

6–7	Cheltenham Mobile Rally, Pittville Park, Cheltenham.
6–7	RSGB Summer Top Band Contest
7	South Shields Mobile Rally, details G3KZZ
7	Scottish National R/Control Contest, Leven, Fife
13–14	RSGB High Power H.F. Field Day
14	Worcester Mobile Rally
21	RSGB Third 70 Mc/s (Portable) Contest
21	Cornish Mobile Rally, Pentire Head, Newquay
28	S. Coast R/Control Rally, Golden Cross, Sussex
28	Saltash & District Mobile Rally, Saltash Grammar School

AUGUST

3–4	RSGB Sixth 144 Mc/s (Open) Contest
10–11	(DARC) 3·5 – 28 Mc/s CW Contest
18	R/Control Thermal Soaring Meeting, Golden Cross, Sussex
18	Torbay Mobile Rally, Dartmouth
18	RSGB National Mobile Rally, Woburn Abbey, Beds.
25	Swindon Mobile Rally, Lydiard Park, nr. Swindon
25	Sutton Coldfield R/Control Annual Rally

SEPTEMBER

2	Peterborough Mobile Rally, Riverbank, Peterborough
7–8	RSGB VHF National Field Day
7–8	(DARC) 3·5 – 28 Mc/s Phone Contest
14	British Amateur Television Club Annual Convention
15	RSGB 80 Metre Field Day
15	S. Midlands Area R/Control Rally, Cranfield, Beds.
16	ISWL 1968 2nd Broadcast Bands Listener Contest
21–22	(SSA) 3·5 – 28 mc/s CW Contest
28–29	(SSA) 3·5 – 28 mc/s Phone Contest

THE RADIO CONSTRUCTOR'S 'EASY VIEW' DIARY

THIRD QUARTER 1968

JULY

Sun		7	14	21	28
Mon	1	8	15	22	29
Tues	2	9	16	23	30
Wed	3	10	17	24	31
Thur	4	11	18	25	
Fri	5	12	19	26	
Sat	6	13	20	27	

AUGUST

Sun		4	11	18	25
Mon		5	12	19	26
Tues		6	13	20	27
Wed		7	14	21	28
Thur	1	8	15	22	29
Fri	2	9	16	23	30
Sat	3	10	17	24	31

SEPTEMBER

Sun	1	8	15	22	29
Mon	2	9	16	23	30
Tues	3	10	17	24	
Wed	4	11	18	25	
Thur	5	12	19	26	
Fri	6	13	20	27	
Sat	7	14	21	28	

DIARY NOTES

STABILISATION AND SMOOTHING WITH THERMIONIC VALVES

(continued from page 679)

The value of R_2 may be found from a consideration of the a.c. circuit conditions; it must be chosen so that the gain of the stage is unity. Let the a.c. input voltage applied between the grid and earth be V_{in}. The grid-to-cathode a.c. voltage, V_{gc}, is given by the equation

$$V_{in} = V_{gc} + V_{R3} \ldots \text{Equation 2}$$

where V_{R3} is the alternating potential across R_3. As far as alternating voltages and currents are concerned, the circuit may be represented by the constant voltage equivalent of Fig. 2. The components inside the dotted lines are equivalent to the valve. The valve effectively generates an alternating potential of $-\mu V_{gc}$ volts where μ is the amplification factor of the valve. The minus sign, which indicates that the output voltage is 180° out of phase with the input voltage, will be ignored in the following calculation.

The current flowing, I, is given by Ohm's Law as

$$I = \frac{\mu V_{gc}}{R_2 + R_3 + r_a}$$

The alternating voltage across R_2 is IR_2, so

$$V_{R2} = \frac{\mu V_{gc}}{R_2 + R_3 + r_a} R_2$$

Similarly, the alternating voltage across R_3 is given by

$$V_{R3} = \frac{\mu V_{gc}}{R_2 + R_3 + r_a} R_3$$

In order that the gain of the stage shall be unity, the value of the output voltage, V_{R2}, must satisfy the equation

$$V_{R2} = V_{gc} + V_{R3} \text{ (see equation 2)}$$

That is:

$$\frac{\mu V_{gc}}{R_2 + R_3 + r_a} R_2 = V_{gc} + \frac{\mu V_{gc}}{R_2 + R_3 + r_a} R_3$$

Dividing through by V_{gc} and multiplying by $(R_2 + R_3 + r_a)$, we obtain:

$$\mu R_2 = R_2 + R_3 + r_a + \mu R_3$$

$$\therefore (\mu - 1) R_2 = r_a + (\mu + 1) R_3$$

$$\text{Hence, } R_2 = \frac{r_a}{\mu - 1} + \frac{\mu + 1}{\mu - 1} R_3$$

As μ is much greater than unity, $\mu - 1$ and $\mu + 1$ are both approximately equal to μ. Thus

$$R_2 \simeq \frac{r_a}{\mu} + R_3$$

$$\text{or } R_2 \simeq \frac{1}{gm} + R_3 \text{ (since } \mu = gm\, r_a) \ldots \text{Equation 3}$$

In practice it is best to employ a variable resistor for R_2 in Fig. 1 and to adjust it until no hum is detectable at point B. For hum detection this point may be connected via a d.c. blocking capacitor to the input of a sensitive audio amplifier or to the input of an oscilloscope.

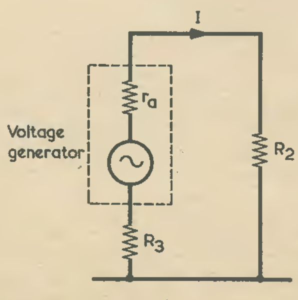


Fig. 2. Equivalent circuit for the V_2 stage in Fig. 1

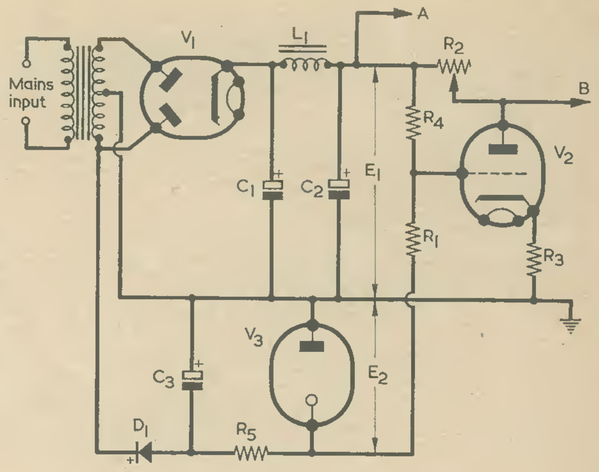


Fig. 3. A shunt stabiliser circuit

The capacitor C_3 of Fig. 1 must be a good quality paper component; an electrolytic capacitor is quite unsuitable owing to the fairly high leakage. The resistor R_1 provides a d.c. path between the grid and cathode of the valve and should not have a value above the maximum specified by the valve manufacturer.

PRACTICAL EXAMPLE

Let us design a circuit using half of an ECC81 (12AT7) double triode in the Fig. 1 circuit. The recommended grid bias voltage is -2.0 volts and the resulting anode current about 10mA. Hence,

$$R_3 = \frac{2.0}{10 \times 10^{-3}}$$

$$= 200\Omega \text{ (using equation 1).}$$

From valve data, gm for the ECC81 is 5.5 mA/volt. Using equation 3,

$$R_2 \simeq \frac{1}{gm} + R_3$$

$$\simeq \frac{1}{5.5 \times 10^{-3}} + 200$$

$$\simeq 182 + 200$$

$$\simeq 382\Omega$$

Hence a 500Ω variable resistor would be suitable for use as R_2. R_4 may be about 50kΩ to 100kΩ. In the case

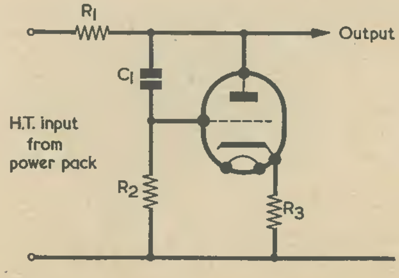


Fig. 4. A feedback shunt smoothing circuit

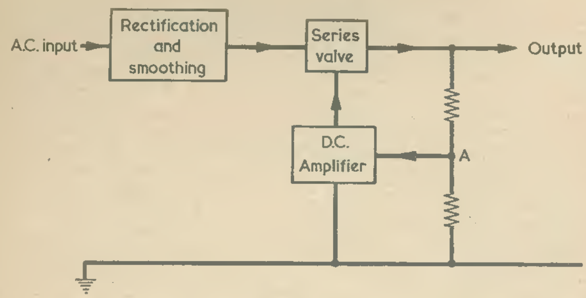


Fig. 5. Block diagram for a series stabiliser

of the ECC81, the maximum permissable resistance between grid and cathode when cathode bias is employed is 1MΩ. R_3 and R_4 are fairly small compared with this and therefore R_1 may be 1MΩ. The capacitor C_3 should be large if slow variations of the mains supply voltage are to be smoothed out. For most purposes, however, a 0.1μF paper capacitor is suitable for this position, since it will only be necessary to eliminate hum.

STABILISATION

The circuit of Fig. 1 will provide smoothing but not stabilisation, since capacitor C_3 will not pass zero frequency variations of potential to the grid of the valve. The type of circuit shown in Fig. 3 will provide both stabilisation and smoothing, but requires a negative stabilised h.t. supply in addition to the h.t. supply being smoothed. However, the negative h.t. current required is quite small and may be obtained by the method shown in the circuit. D_1 is a small power rectifier diode of suitable peak inverse voltage rating (not less than $2\sqrt{2}$ times the r.m.s. transformer secondary voltage). C_3 is the negative h.t. supply reservoir capacitor and V_3 is a gas filled voltage stabiliser tube such as the 90C1 which has a working voltage of, very approximately, 100 volts. The resistor R_5 is used to drop the voltage across C_3 to the voltage stabiliser operating voltage; if it is omitted, the voltage stabiliser will be damaged.

The coupling to the grid of V_2 is via resistors in order that the circuit is effective for very slow changes of the mains supply voltage. R_1 should not exceed the maximum grid-to-cathode resistance recommended by the manufacturers for valve V_2. R_4 is selected so that the ratio R_4/R_1 is approximately equal to the ratio of the steady potentials E_1/E_2. The mean grid potential of V_2 is then approximately equal to the earth potential. R_3 is calculated as in the Fig. 1 circuit to provide a suitable bias voltage for V_2.

CALCULATION OF R_2

The value of resistor R_2 may be calculated in a similar way to the value of the corresponding resistor in Fig. 1. In the case of Fig. 3, however, the value of the alternating potential between the grid and earth is less than the alternating voltage across the capacitor C_2, since the resistors R_4 and R_1 act as a potential divider to the a.c. component as well as the d.c. component. To take this into account, the value of R_2 has to be multiplied by the factor $\frac{R_1 + R_2}{R_1}$ or, since V_2 grid is virtually at earth potential, $\frac{E_2 + E_1}{E_2}$

Thus, in Fig. 3,

$$R_2 \simeq \left(\frac{1}{gm} + R_3\right)\left(1 + \frac{E_1}{E_2}\right)$$

This equation enables the approximate value of R to be found, but it is best to employ a variable resistor of a value somewhat higher than is given by the equation so that it can be adjusted for optimum stabilisation and hum removal.

It remains to find the value of R_5. First of all the current passing through R_1 must be found. This is equal to $E_1 + E_2$ divided by $R_4 + R_1$. The current through the stabiliser V_3 should be selected to be in the working range of this tube. For example, the 90C1 has a working current range of 1 to 40mA, so a current of 10mA may be selected. The total current passing through R_5 is the sum of this current and that passing through R_1. The value of the potential across R_5 is equal to the potential across C_3 minus the working potential of the tube V_3. The value of R_5 should be approximately equal to the voltage across it divided by the calculated total current passing through it. (The potential across capacitor C_3 will be somewhat less than $\sqrt{2}$ times the r.m.s. voltage of half the transformer secondary winding.)

C_1, C_2, C_3 and L_1 of Fig. 3 and C_1, C_2 and L_1 of Fig. 1 are normal smoothing components, typical values for the capacitors being 8 or 16μF and for the inductors 5 or 10 henrys.

FEEDBACK SHUNT STABILISERS

The circuits which have been discussed so far are bridge type stabiliser and smoothing circuits in which hum voltages, etc., may be entirely eliminated by the use of a valve as a part of a balanced bridge.

Another type of electronic smoothing circuit is shown in Fig. 4. Although this circuit does not, at least at first sight, appear very much different from those described previously, the principle of operation is rather different. In particular it should be noted that the grid is coupled to the anode of the valve and not to the input from the power pack. Thus the circuit cannot entirely eliminate mains voltage variations, since only the variations of the output are coupled to the grid. This type of feedback stabiliser circuit has, however, the compensating advantage that the output impedance is usually lower than that of the bridge circuits of Figs. 1 and 3. Thus, the circuit of Fig. 4 is likely to be most suitable when changes of loading are expected to occur.

An analysis of the circuit will show that this circuit will reduce the amount of hum by the factor

$$1 + gm\frac{R_1R_L}{R_1 + R_L}\left(\frac{1}{1 + gm\,R_3}\right)$$

where R_l is the resistance of the load.

Hence the mutual conductance, gm, of the valve should be large, whilst R_3 should be kept as small as possible.

The output resistance effectively connected across the load is approximately the resistance R_1 connected in parallel with the output resistance of the valve in series with R_3. As in the case of the cathode follower, 100% negative feedback is used and therefore the output impedance of the valve alone is approximately 1/gm, as with the cathode follower. Thus the output impedance, R, is given by the approximate equation:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{1/gm + R_3}$$

In order to keep the output impedance, R, small, gm should therefore be large and R_3 small. This is the same condition as is required to obtain the best rejection of hum.

If C_1 is replaced by a resistor, a stabilising circuit is obtained which will operate at any frequency (including zero frequency), instead of having the lowest operating frequency limited by the time constant of C_1R_2. It is best to bypass the anode to grid resistor by a capacitor, however, since 100% negative feedback is then obtained at hum frequencies and the output impedance at such frequencies is also kept to a minimum.

Although only single valve shunt stabilisers have been discussed in this article, various circuits have appeared in the literature which employ several valves. These enable the hum or slow variations in the h.t. potential to be completely eliminated and may be designed so that the output impedance is very low or even zero in certain cases.

SERIES STABILISERS

The block diagram shown in Fig. 5 may be used to illustrate the functioning of a series stabiliser. All of the output current from the rectification and smoothing circuit passes through a series stabiliser valve to the output. The potential drop across this valve is dependent on its grid voltage, which is controlled by the output potential. The fraction of the output voltage tapped off by the potential divider at point A is amplified by the d.c. amplifier and used to control the grid voltage of the series valve. It is not possible to entirely eliminate output fluctuations with this type of feedback circuit, since the d.c. amplifier will only operate when small variations of the output occur.

The series valve should have a low internal anode resistance, r_a. The gm should be fairly high if a high degree of control is required. A power output valve is almost invariably used, since an appreciable current will probably have to be passed. (If the current requirements are small, the circuit of Fig. 1 or Fig. 3 will usually offer a more economical alternative.) Some valves, such as the 12E1, have been specially manufactured for use as series stabiliser valves; they are commonly employed in industrial equipment.

If the position of the tapping on the potential divider (A in Fig. 5) is made variable, the series voltage stabiliser circuit offers a method for obtaining a variable stabilised h.t. supply.

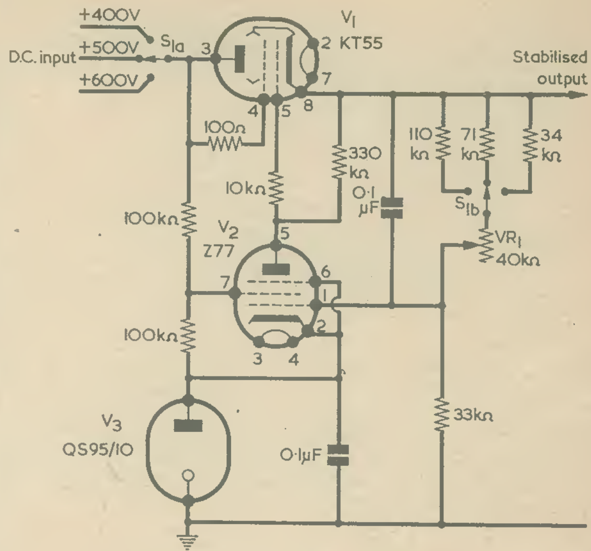


Fig. 6. A practical series stabilising circuit

PRACTICAL CIRCUIT

A practical circuit for obtaining a stabilised supply in the range 200–500 volts at 0–100mA is shown in Fig. 6.* The d.c. amplifier stage, V_2, is biased by the use of a QS95/10 voltage stabiliser tube. (If extremely good stability is required, a QS83/3 voltage reference tube should be employed.) Cathode bias cannot be used in this circuit.

The switch wafers S_{1a} and S_{1b} are ganged. The switch position must be selected so that the desired output voltage can be obtained. VR_1 is the fine output voltage control.

The output of this circuit does not vary by more than about 10 millivolts as the load current varies from 0 to 100mA. The regulation is about 1 volt for variations of + 21% to −7% ofthe input voltage.

*This design is taken from "Series Voltage Stabilisers", Application Report No. 1, published by M.O. Valve Co. Ltd.

CARRIER FREQUENCY STABILITY OF THE BBC's 200 Kc/s TRANSMISSION

The frequency stability of the BBC's high-power 200 Kc/s transmitter at Droitwich, which is widely used as a reference frequency standard by industry and scientific bodies in this country and in Europe has again been improved.

Since 1965 the long-term stability has been within ±5 parts in 10^{10} and with the use of automatic frequency correction the excursion from nominal has not usually exceeded 1 part in 10^{10}.

The frequency control source is now a rubidium gas cell standard provided by the National Physical Laboratory. This has a day-to-day stability of better than 1 part 10^{11} and the frequency will be maintained within ±2 parts in 10^{11} of nominal referred to the caesium beam frequency standard at the NPL.

The phase of the received 200 Kc/s carrier is monitored continuously at the NPL during the hours of transmission and the values of mean daily frequency are published monthly in the technical press. They are also available on application to:—

Director
National Physical Laboratory
Teddington
Middlesex

The "MINIFLEX" Dual Purpose Personal Receiver

by Sir DOUGLAS HALL K.C.M.G., M.A.(Oxon.)

This miniature 3-transistor medium wave receiver fits, complete with its battery and earpieces, into a neat plastic case measuring $4\frac{3}{8}$ x 3 x $1\frac{1}{4}$in only. If desired, an external loudspeaker unit may be plugged in, whereupon a larger battery is automatically connected and the output transistor circuit is altered for optimum speaker operation

THIS ARTICLE DESCRIBES A DESIGN which uses few components but which provides 6 stages, including two r.f. stages. It is capable of receiving a large number of stations in the medium waveband with two magnetic earphones, using only a 4in ferrite rod for signal pick-up. The gain provided is such that, unlike most miniature personal receivers, good speaker results can be obtained from several stations and "bedside volume" from many others, without the addition of any further amplification. All that is then necessary is the speaker, a suitable output transformer, a means of connection to the receiver, and a change in the value of the output transistor emitter resistor in order to allow that transistor to deliver the necessary power to drive the speaker. Also, in the interests of economy, a battery with a larger capacity is brought into circuit when the speaker is in use. The necessary circuit change and the coupling up of the larger battery is automatic when the speaker is plugged in.

The overall result is a miniature receiver which, together with the two ear pieces, are contained in a plastic box measuring about $4\frac{3}{8}$in x 3 x $1\frac{1}{4}$in, and which can be carried in a pocket on any occasion. The ancillary loudspeaker unit may be of reasonable size, and consists of a cabinet which also houses two large 1.5 volt cells, and which can be left at home for use there.

The Receiver Circuit

At first sight the circuit shown in Fig. 1 may seem to bear a resemblance to that used in previous designs by the author under the general title of "Simplicity and Sensitivity",* though apart from the fact that double reflex action is used in both instances there is little further in common and Fig. 1 does, in fact, show a completely new circuit.

The signal is picked up by the tuned circuit given by L_1 and VC_1 and is passed to TR_1 which functions as a common collector radio frequency amplifier. Thence it passes to TR_2 which acts as a common emitter radio frequency amplifier, and next appears across the r.f. choke, L_2. D_1 is a selenium rectifier which demodulates the signal and passes the resultant audio frequency to the base of TR_1. This transistor and TR_2 form a super alpha pair at audio frequencies, both devices functioning as common collector amplifiers. The output appears between the emitter of TR_2 and the positive supply line and is at low impedance, of the order of 50Ω. Because of this, it is necessary to use a voltage step-up transformer so that the signal offered to the base of TR_3 can work into an impedance of the order of 1kΩ. If the base of TR_3 is connected direct to the emitter of TR_2, which at first sight may seem an attractive alternative, it will be found that the effective gain given by TR_3 is small because of the serious damping of its base circuit. TR_3 functions as a normal common emitter audio frequency amplifier.

A positive feedback loop for r.f. is given over the TR_1 and TR_2 stages, it being completed from the collector of TR_2 via D_1, which couples to the end of the tuned circuit remote from TR_1 base. This loop enables VR_1 to function as a reaction control, and the value of C_1 has been carefully chosen to ensure that oscillation does not occur until VR_1 slider is near the TR_1 emitter end of its track. VR_1 also functions as an r.f. and a.f. volume control and it will be seen that it therefore controls gain in three ways. The fact that oscillation takes place only when VR_1 is set near the maximum volume setting ensures that little r.f. or a.f. amplification is lost when the control is just below oscillation point.

In addition to providing demodulation, D_1 acts as a dropping resistor to give suitable bias to the base of TR_1. The selenium rectifier specified for D_1 has a very much higher impedance and resistance than either a germanium or silicon diode, *and such devices will not work in this circuit. It is essential to use the M3.*

TR_1 and TR_2 are both diffused alloy types. Although the AF117 is specified here, because it is in general the cheapest in the range and is

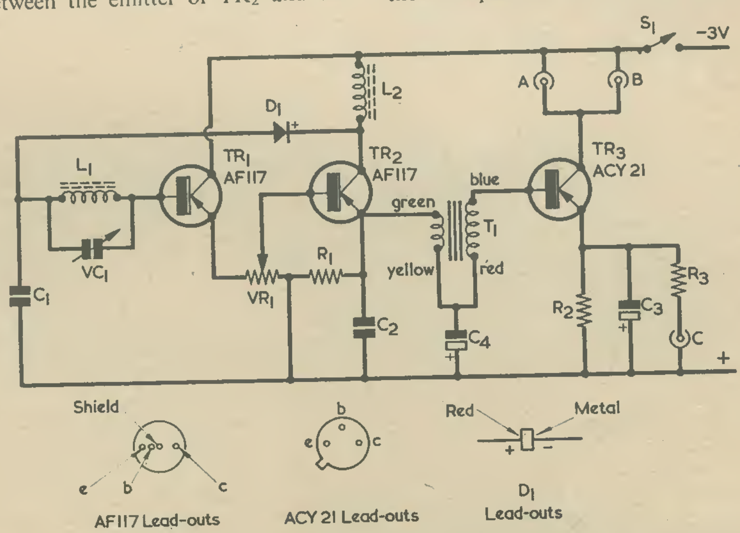


Fig. 1. The circuit of the Miniflex Personal Receiver. Sockets A, B and C are miniature 3.5mm jack sockets, the centre conductor shown in the diagram connecting to the tip of the jack plug and the outer conductor to the jack plug sleeve

* *Simplicity And Sensitivity With Two Transistors*, April 1964 issue; *Simplicity And Sensitivity With Three Transistors*, November 1965 issue.

equally suitable as the others, any from AF114 to AF117 inclusive may be used, but it is important to insist on a first grade transistor supplied in the Mullard packet. There are many surplus types on the market, not always advertised as such, and many of them are useless. This precaution is less vital in the case of TR_3 which is a high amplification low frequency transistor capable of passing a fairly substantial current.

High impedance magnetic earphones are required, and are plugged into sockets A and B. Those specified will, if the ear plugs are removed and packed by themselves, lie on top of the receiver panel with the lid able to shut over them and the controls when the receiver is not in use. In fact, the dimensions of the case are the *true* overall dimensions of the receiver. This is not often the case when knobs and switches protrude and the ear phones have to be carried separately. Incidentally, one earphone may be used on its own, if desired, this being plugged into either socket A or B.

In Fig. 1 the jack sockets are depicted as coaxial sockets, and it is important to note that the outer conductor shown corresponds to the sleeve of the jack plug, when inserted,

The prototype receiver coupled up to the loudspeaker unit

and that the centre conductor corresponds to the jack plug tip. The same applies to socket C, whose function is described next.

Employing A Loudspeaker

When a speaker is used, the primary of its output transformer is plugged into socket A, and it will be seen that this also enables the negative terminal of the large battery to be connected into circuit. See Fig. 3. A second jack plug, both leads of which are taken to the positive terminal of the large battery, plugs into socket C. This not only connects up the positive of the large battery but also places R_3 in parallel with R_2, whereupon TR_3 passes about 25 to 30mA instead of about 1mA, which flows with headphone reception and only R_2 in circuit. The switch, S_1, must be in the Off position when the speaker is being used, or the two batteries will be in parallel, and one may discharge into the other. The receiver is automatically switched on for speaker use when the two jack plugs are inserted, though there is no reason why a second switch should not be inserted in one of the leads of the large battery if that is preferred. This switch may be mounted on the speaker cabinet. As the large battery can be short-circuited if the two jack plugs touch each other, it is wise to cut a small piece of Paxolin with two holes separated by the same distance as are the sockets A and C, the plugs being cemented into these holes. The result is then a two pin (four contact) plug.

The output transformer requires to have a low ratio and a very low primary resistance. The component specified is very suitable, and although larger than many, will lie on its side beneath an 8 x 5in speaker. Two U14 cells will stand neatly behind the sides of the speaker, as shown in Fig. 3, and the whole can be contained in a case little larger than the minimum required to house the speaker on its own. If the speaker is to be employed only occasionally, a No. 800 battery may be used instead of the U14 cells, but these are recommended if heavy use is anticipated. It will be found that negative connections can be

COMPONENTS

Resistors
(All fixed values ⅛ watt 10%)
- R_1 470Ω
- R_2 1.2kΩ
- R_3 39Ω
- VR_1 5kΩ variable, linear track. Clarostat 37 modified (See text. Available from Alpha Radio, 103 Leeds Terrace, Winton St., Leeds 7)

Capacitors
- C_1 0.005μF
- C_2 0.01μF
- C_3 125μF 4V wkg. Mullard electrolytic
- C_4 250μF 4V wkg. Mullard electrolytic
- VC_1 300pF variable. "Dilemin" Cat No. 4150 (Jackson Bros.)

Inductors
- L_1 Aerial coil on 4 x ⅜in dia. ferrite rod (see text)
- L_2 2.5mH r.f. choke (Repanco)
- T_1 Interstage transformer type TT49 (Repanco)

Transistors
- TR_1 AF117
- TR_2 AF117
- TR_3 ACY21

Diode
- D_1 Diode type M3 (Available as "half-wave meter rectifier" from Henry's Radio, or under Cat. No. MR50 from Home Radio)

Switch
- S_1 Double pole slide switch, sub-miniature

Battery
3-volt battery type 1915 (Ever Ready)

Earphones
2 off. Miniature 1,000Ω with plug and cord, Ardente ER250 (Henry's Radio)

Case, Panel
Plastic case with lid, 4⅜ x 3 x 1¼in (Accessory No. 69(*a*)—Henry's Radio)
4 x 3in panel for same (Accessory No. 70—Henry's Radio)

Knobs
2 off. 1¼ x ⅜in (Ref. No. 17—Henry's Radio)

Jack Sockets
3 off. jack sockets, 3.5mm

Extra components for loudspeaker unit
Output transformer (T_2). Type TT12 (Repanco)
Speaker. 8 x 5in, 3Ω
2 off. jack plugs, 3.5 mm, each with 1 yd twin flex.
2 off. 1.5 volt cells type U14 (Every Ready)

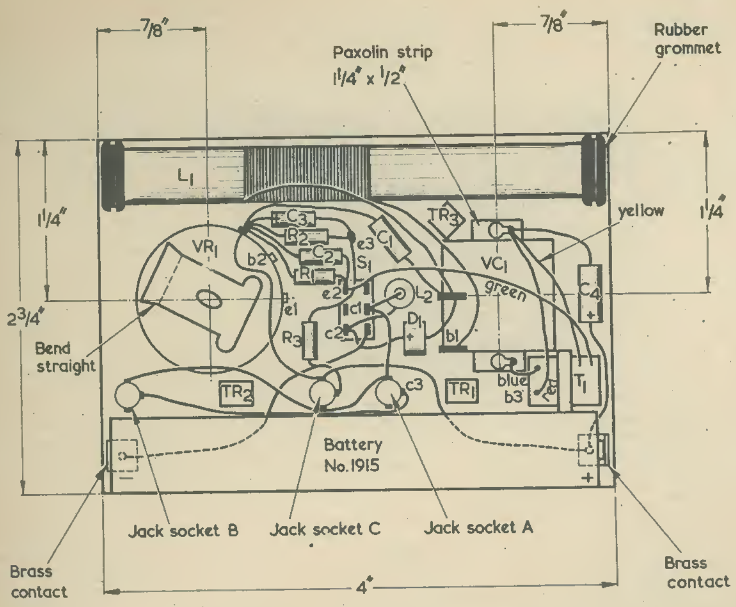


Fig. 2. Layout of the receiver. For simplicity, transistor lead-outs are not shown, the position of the transistor can being indicated, and the connecting points identified as E1, B1, C1, etc. The shield lead-outs of TR_1 and TR_2 are not connected into circuit. With the jack sockets shown, the upper tag connects to the jack plug sleeve and the right hand tag to the jack plug tip. Note that some sockets may have different tag positioning

soldered to the tin plate surrounds of the cases of the U14, and positive connections to the brass caps, provided that both are first cleaned up gently with a fairly smooth file.

So far as the receiver itself is concerned, there is, of course, no reason why the constructor should not design his own layout. However, the layout shown in Fig. 2 has proved satisfactory for the rather cramped conditions dictated by the use of the neat little plastic case quoted in the Components List. The only precaution to be taken—and this is important—is to prevent unwanted coupling between L_1 and L_2. L_2 should be roughly at right angles to the ferrite rod, as shown in Fig. 2, though in practice it may be necessary to tilt it a little, one way or the other. If it couples in phase, with L_1 there will be oscillation even when VR_1 is turned well back. If it couples out of phase, oscillation may prove impossible even with VR_1 at maximum. At the null point, which is aimed at, reaction should be very smooth and the oscillation point, which should appear with VR_1 advanced by about 70 to 80% of full rotation, should not vary much through the tuning range. If mounted as shown it is easy to move L_2 a little, if necessary, and its leads are sufficiently stiff to maintain the position of the component once the optimum has been found.

It is equally important that the leads from L_1 should not pass too close to L_2.

The Ferrite Aerial

L_1 consists of 70 turns of 32 s.w.g. enamelled wire, close-wound, on a paper sleeve fitted over a 4in by $\frac{3}{8}$in ferrite rod. Grommets are fitted at each end of the rod and thread—*not* wire, which would give a shorted turn—is passed through small holes in the panel and tied to hold the rod firm.

The No. 1915 battery is held in position between two small springy brass strips, the latter being bent at right angles and fixed to the panel by $\frac{1}{4}$in 6BA bolts. These, and all other bolts used, should have countersunk heads. The brass strips can be taken from an old No. 1289 battery. A piece of stiff card is placed under the battery to prevent the possibility of short-circuits due to the paper covering becoming torn by the ends of the bolts.

T_1 is mounted on one of its small ends and is fixed to the panel by means of a suitable adhesive in the position shown.

The choice of a tuning capacitor was easy. This component is as specified in the Components List, and should be mounted on a strip of $\frac{1}{16}$in Paxolin about $1\frac{1}{4}$in x $\frac{1}{2}$in by means of $\frac{1}{4}$in 6BA bolts passing through suitable holes in the strip into the threaded holes in the capacitor. Washers should be fitted between the strip and the front of the capacitor to allow for a slight rise round the spindle and to ensure that the component is not damaged by the bolts passing too deeply into it. Two further holes near the ends of the strip allow this to be bolted to the panel. The $\frac{1}{4}$in 6BA bolts used here should have solder tags under the nuts as these are used as wiring anchoring points. See Fig. 2.

The choice of a suitable volume control is less easy. There is little room for this, especially with respect to depth. There are a number of small volume controls on the market but many of these are unsuitable when, as in the case of the present circuit, a small direct current is passed through them. They may soon become noisy. Some constructors may have found a reliable small component but the control specified is inexpensive and is favoured by the authors. In order to fit it in the space available it is necessary for its metal dust cover to be removed and the stop plate, which will then be exposed, to be straightened with a pair of pliers. This means that the component is now used without

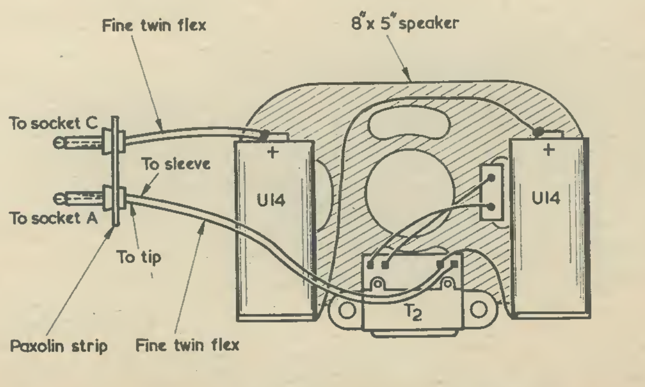


Fig. 3. The add-on loudspeaker unit. A suitable baseboard may be used for mounting the components

a mechanical stop at the maximum and minimum positions. The more ingenious constructor could devise a stop pivot fitted, say, to the front panel, but the author found it satisfactory to mark the panel with red over the small range between the maximum and minimum positions, taking care not to adjust the knob into this red area. Damage to the slider may result if the control is adjusted so that the slider leaves the track. The spindle will need to be cut down to about $\frac{1}{4}$in and it will be necessary to use packing washers or a second nut behind the panel when mounting the control, so that the outside locking nut only just gets a good grip. With these precautions the lid of the small case used should shut comfortably. A little extra room can be obtained, if necessary, by filing a little off the underneath of the knobs.

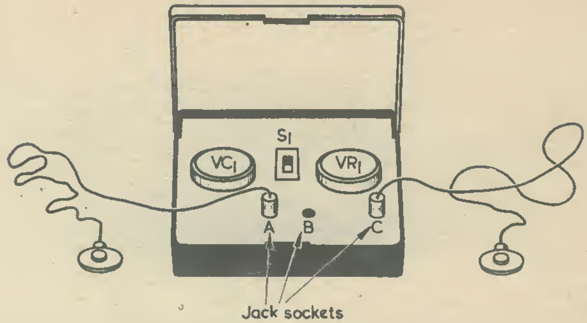


Fig. 4. The appearance of the receiver with two earphones plugged in. When closed, the case measures $4\frac{3}{8}$ x 3 x $1\frac{1}{4}$in only

Jack Sockets

Jack sockets seem to vary in the position of their contacts and connecting tags. The third contact, used for switching, is left disconnected in the present circuit, and the two tags which correspond to the outer sleeve and jack plug tip should be verified before wiring to these components is undertaken. In all cases the connection to the outer sleeve is the battery connection. Note that socket C is positioned between sockets A and B.

Liberal use should be made of fine gauge plastic sleeving on component leads to prevent short-circuits. The case of TR_3 is live to the base and should be covered with a turn or two of Sellotape or similar. The fourth lead on the AF117 transistors, which is connected to the case, is not used in this circuit and may be cut short. Transistor lead-outs are not shown in Fig. 2. Instead, the position taken up by the body of each transistor is shown, and its connection points identified by the letters E, B or C, as applicable, and the number of the transistor. Thus, the base of TR_2 connects to the slider of VR_1, this point being identified as "B2".

It will be seen that only one of the two sections of S_1 is used as a switch, two tags on the unused section being employed as anchoring points. The only connections which are not taken to some form of anchoring point are those which join together R_2, R_3, C_3 and the emitter of TR_3. This junction point is "in the air", but the component lead-outs are sufficiently stiff to give adequate rigidity.

Fig. 4 gives a view of the front panel when the complete receiver is fitted in its case.

If any constructor who is interested in this design is discouraged by the somewhat cramped arrangement of the components he may, if he wishes, use a rather larger case which is also available from Henry's Radio, Ltd. This measures $5\frac{3}{4}$ x $3\frac{1}{2}$ x $1\frac{1}{2}$in and offers quite a useful amount of extra space. The general layout, expanded a little, may still be followed. Henry's Radio do not advertise a panel for this case but one can easily be cut from a piece of $\frac{1}{16}$in Paxolin.

It should be mentioned that reducing volume by backing down VR_1 reduces the current passed through TR_2 and TR_3. In general, this is useful, since quiet listening is accompanied by battery economy. But it could happen that distortion would be introduced through overloading when receiving a very powerful local station, in which case the directional properties of the rod aerial should be used to prevent the need for a drastic backing-off of VR_1. This precaution has not proved necessary at the author's home despite a very strong signal from the local Start Point station.

A further peculiarity of the circuit is that for the first minute or so after switching on it will, if tuned to a weak station demanding a critical reaction setting, tend to "spill over" and oscillate. This can be put right by a touch on the controls, and the effect soon stops.

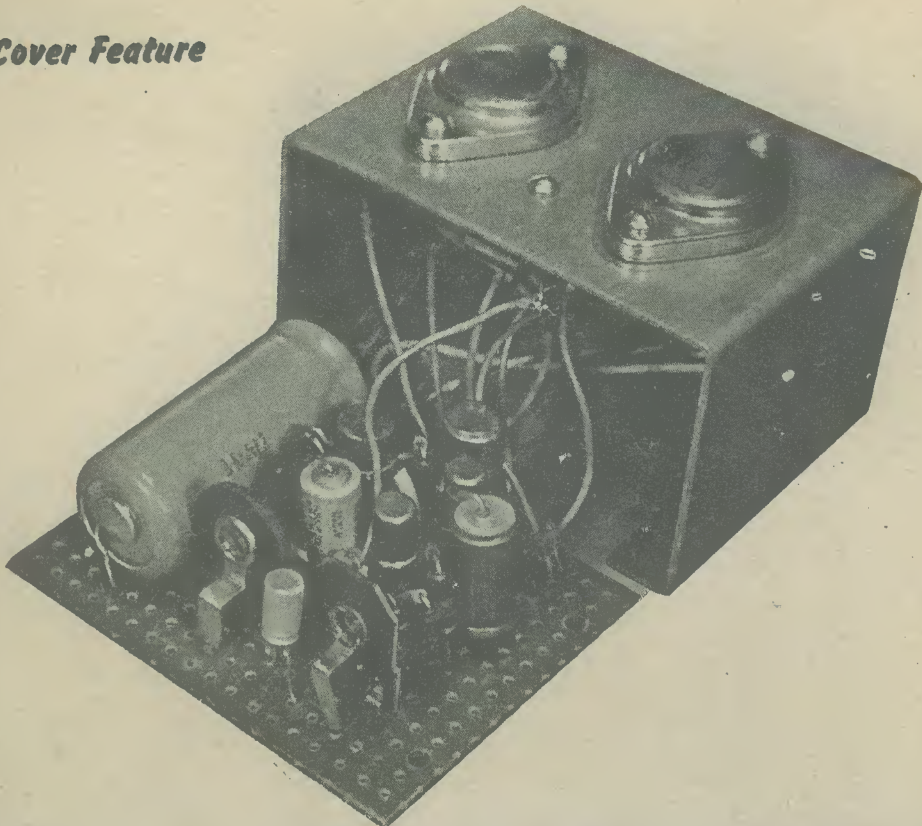
BIG STUDIOS ORDERS FOR EMI RECORDERS

EMI Electronics have received an order worth nearly £18,000 from the Independent Television Authority for 28 BTR4 studio tape recorders. The BTR4's will be used to provide music and test tone sequences for trade transmission from I.T.A. transmitting stations.

The EMI studio tape recorder is used by the majority of broadcasting organisations in the United Kingdom and extensively abroad. Other recent orders include Granada TV (2), Yorkshire TV (9), Scottish TV (3) and broadcasting organisations in Angola (4) and Nigeria (2).

The BTR4 is a high quality professional tape recorder available in half and full track monaural, or two-track stereo using 0·25 in. tape in rack-mounted or console form. The head block can be rapidly changed and compatible linking units, such as mixers and microphone amplifiers, can be provided. Alternative tape speeds of 15–$7\frac{1}{2}$ i.p.s. or $7\frac{1}{2}$–$3\frac{3}{4}$ i.p.s. are available. It is fully tropicalised and has switchable equalisation for CCIR, NAB or IEC standards.

Cover Feature



★Miniature 5-Watt Hi-Fi Amplifier

by B. T. HATHAWAY

Offering a flat response from 65 c/s to 30 kc/s and a distortion of less than 1%, this miniature power amplifier provides an output of 5 watts in a 3Ω speaker. The input requirement is 70mV into 1kΩ for 3 watts output, and the amplifier may be preceded by a transistor radio or a pre-amplifier unit

This versatile little amplifier measures a mere 3 x 2¼ x 2 in, but will give a power output of up to 5 watts into a 3Ω speaker. The circuit is designed to operate from supply voltages of between 9 and 18 volts at load currents up to 1 amp. Frequency response is flat within 3dB over the range 65 c/s to 30 kc/s, and can be extended down to 20 c/s, if required, by simply increasing the value of one capacitor in the circuit. The input impedance of the amplifier is of the order of 1kΩ, and the input sensitivity for a 3 watt output into a 3 ohm load is 70mV. Signal distortion is less than 1%, so the amplifier really enters the hi-fi class as currently understood.

The ability of the amplifier to operate from a 12 volt supply makes it suitable for fitting in a car complete with 3Ω speaker, whereupon it can be driven from the output socket of a pocket transistor portable radio. The amplifier circuitry is completely transformer-less, and this feature makes the unit ideal for building into mains powered equipment, since there is no danger of inductive pick-up of mains hum, as in the case of conventional transformer coupled circuitry.

Basic Operation

Technically, the main feature of this amplifier is the fact that it is completely transformer-less.

The elimination of all transformers from the design results in a circuit which, although rather simple in appearance, is very complex in actual detail of theoretical operation. To understand the theory of operation we must start from basic principles.

In any transistor audio power amplifier, the final aim is to feed a fairly large amplitude signal from the moderately high output impedance of a transistor pre-amplifier into the very low impedance of an external speaker, and to do this without introducing distortion. Quite clearly, this specification calls for the use of some kind of impedance transformation in the amplifier. Whilst an iron-cored transformer could be incorporated in the design, such components suffer from a number of disadvantages, amongst which are a proneness to signal distortion and high cost. The use of some kind of solid-state impedance transformer is clearly to be preferred.

The first possibility that springs to mind in this respect is to employ an emitter follower in the output stage, as shown in Fig. 1 (*a*). It is known that an emitter follower exhibits near-unity voltage gain between input (base) and output (emitter), and has a high input impedance and low output impedance. In consequence, it might seem reasonable to suppose that by connecting a low impedance speaker to the emitter via a large capacitor, the circuit of Fig. 1 (*a*) will give the desired results with low distortion. In fact this is not the case, as can be shown in the following manner.

Suppose that the values of R_1 and R_2 are chosen so that, in the absence of an input signal, the emitter of TR_1 is at a potential of 5 volts with respect to

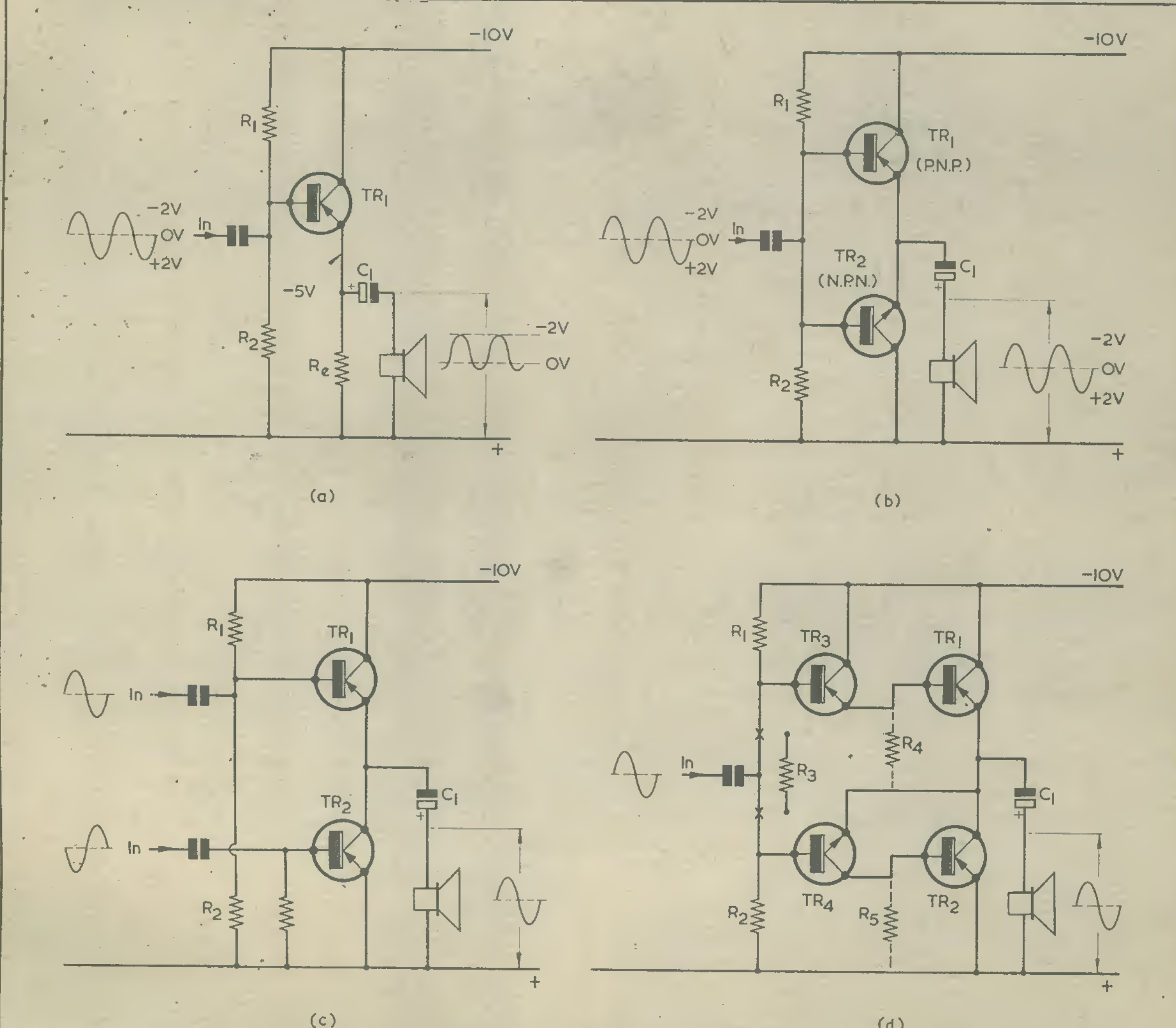
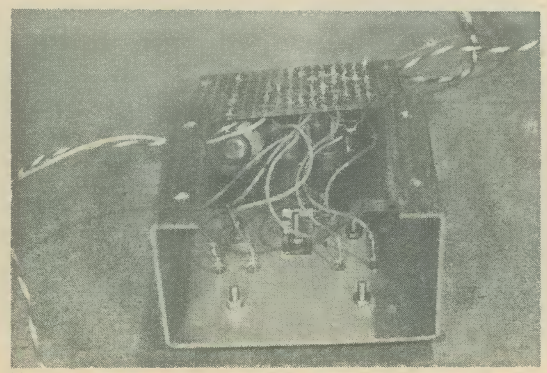


Fig. 1 (a). Demonstrating the distortion which results when a single emitter follower works into a load with capacitive coupling
(b). The distortion is overcome if a complementary emitter follower circuit is used. (The forward biasing components needed to eliminate cross-over distortion are omitted here)
(c). An alternative output stage employing p.n.p. transistors. This requires anti-phase input signals
(d). Combining the circuits of (b) and (c) to allow the use of p.n.p. transistors in the output stage together with a single-phase input

the positive supply. C_1 will then be charged to this potential. If an input signal of 4 volts peak-to-peak is now connected, as shown, the negative-going part of the signal will cause TR_1 emitter potential to rise to a peak of 7 volts, and the major part of the emitter current will be derived in this transition via the speaker and C_1; a potential of 2 volts negative will be developed across the speaker, while the potential across C_1 will remain constant at 5 volts. When the input signal goes positive, however, TR_1 base will swing down to a minimum of 3 volts, and the emitter will tend to follow it, but in fact it will only be able to do so down to about 5 volts, at which level the 5 volt charge in C_1 will tend to hold the emitter steady and cause the emitter-base junction of TR_1 to be reverse biased as the base falls to 3 volts. C_1 can then only discharge via the series combination of the speaker and r_e and, since the value of r_e will usually be large relative to the resistance of the speaker, C_1 will discharge with a long time constant and the signal across the speaker will be severely distorted, as shown.

Thus, one of the paradoxes of the conventional emitter-follower is that, although it has a low output impedance, it is not suited to feeding into low impedance capacitively coupled external circuits, unless those circuits have an impedance that is comparable in value with r_e.

One way to overcome this difficulty is to use the complementary p.n.p./n.p.n. emitter follower circuit shown in basic form, in Fig. 1 (*b*). Here, TR_1 can be regarded as a normal emitter follower using TR_2 as its emitter load. The values of R_1 and R_2 are chosen so that, in the absence of an input signal, TR_1 emitter is at 5 volts. Under this condition, TR_1 base will be slightly above 5 volts, as also will TR_2 base, and TR_2 emitter-base junction will therefore be reverse-biased and TR_2 will be cut off. In the presence of a negative-going input signal, TR_1 will act in the manner of the emitter follower circuit already outlined, and a copy of the signal will appear across the speaker. In this case, however, when the input signal swings in a positive direction and TR_1 base falls to 3 volts, the emitter-base junction of TR_1 will be reverse-biased and that transistor cut off, while the emitter-base junction of TR_2 will be forward-biased and that transistor driven on, with the result that the signal across the speaker still follows the input signal. Consequently, the common emitter junction of TR_1 and TR_2 can faithfully follow the input signals applied at the input, and these signals appear with negligible distortion across the speaker.



A view of the underside of the chassis

In practice, it is necessary to apply a slight forward bias to each of the transistors so that distortion will not occur at the "cross-over" point, at which one transistor switches on and the other off. The provision of the forward bias can be simply accomplished by wiring a resistor between the bases of TR_1 and TR_2. An interesting point about this circuit is that, since one transistor is cut off when the other is on, and vice versa, it acts effectively as a current phase splitter. The only snag with the circuit is that it calls for the use of both p.n.p. and n.p.n. transistors, and these tend to be rather expensive, in pairs, when high current types are required.

Fig. 1 (*c*) shows another way of overcoming the difficulty given with a conventional single emitter follower, but this time by using two p.n.p. transistors.

Here, TR_1 acts as a conventional emitter follower, with TR_2 as its emitter load; in the absence of an input signal, TR_2 is cut off. This circuit is fed from a phase splitter, one signal passing to TR_1 base, while an anti-phase signal passes to TR_2 base. Thus, when TR_1 would normally be cut off by the emitter follower action previously referred to, TR_2 is forward-biased and provides a low impedance path to the positive supply line. A copy of the input signal then appears across the speaker with negligible distortion. This circuit has the advantage that low cost high power p.n.p. transistors can be used, but the disadvantage that a phase splitter is required.

The circuits of Fig. 1 (*b*) and 1 (*c*) can be effectively combined, as in Fig. 1 (*d*), to form a circuit that will give a high current output from a single ended input, using low-cost p.n.p. power transistors in the output. Here, TR_1 and TR_2 correspond to the similarly identified transistors of Fig. 1 (*c*). Also, TR_3 and TR_4 correspond to the p.n.p./n.p.n. pair of Fig. 1 (*b*), but in this case they are used as a current phase splitter for driving the output transistors. The no-signal output voltage at TR_1 emitter is approximately the same as that at the junction of R_1 and R_2. The transistors can be given a slight forward bias, to minimise cross-over distortion, by wiring R_3 between the bases of TR_3 and TR_4. The effects of leakage currents at high temperatures on the two output transistors can be minimised by wiring shunt resistors R_4 and R_5 between base and emitter, as shown.

The circuit of Fig. 1 (*d*) gives near-unity voltage gain between input and output, has a high input and very low output impedance, and gives an output that is virtually free from distortion. This circuit forms the basis of the 5 watt power amplifier to be described.

The Final Circuit

The final circuit diagram of the miniature 5 watt amplifier is shown in Fig. 2. Here, the input signal is fed via C_1 to RV_1, which acts as a pre-set volume control, and a fraction of this signal is then passed on to the base of TR_1 via R_1 and C_2. TR_1 is connected as an emitter follower, with its emitter feeding directly into the base of amplifier TR_2.

TR_2 is connected as a common emitter amplifier, with a collector load made up of R_8, R_9, RV_2 and D_1 in series. TR_3, TR_4, TR_5 and TR_6 make up a

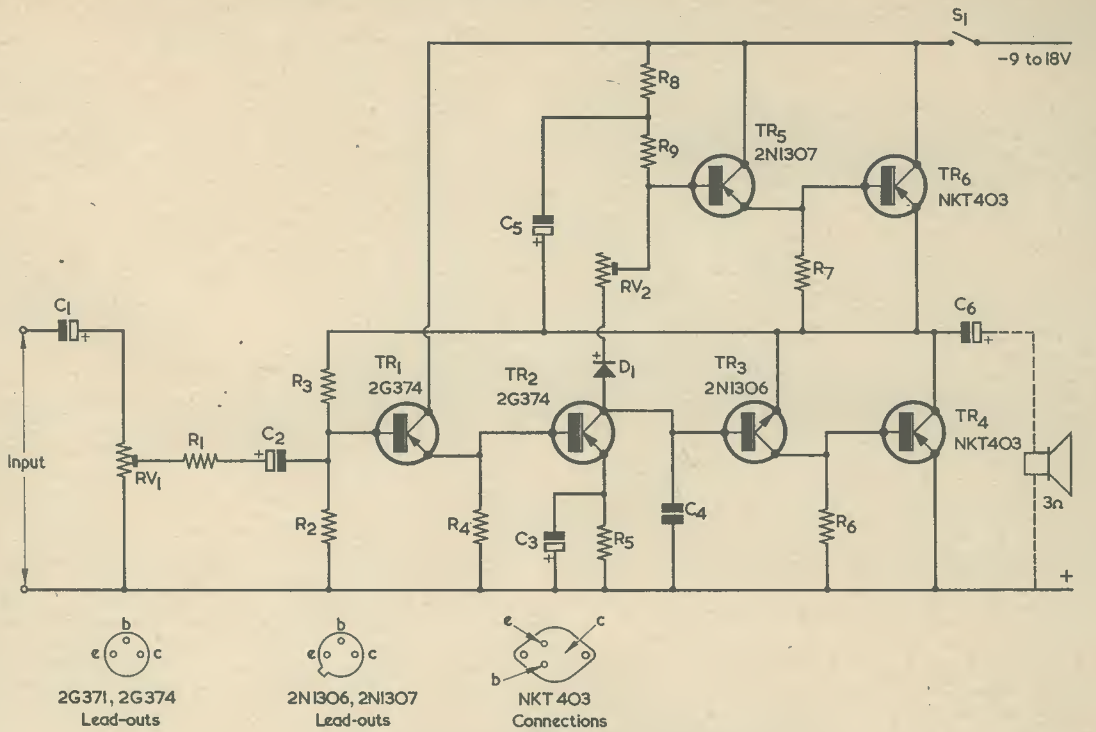


Fig. 2. The complete circuit of the 5 watt miniature amplifier

COMPONENTS

Resistors
(All fixed values ½ watt 10%)

R_1 820Ω
R_2 5.6kΩ
R_3 47kΩ
R_4 1.8kΩ
R_5 180Ω
R_6 180Ω
R_7 180Ω
R_8 330Ω
R_9 2.2kΩ
RV_1 5kΩ skeleton pre-set potentiometer (vertical mounting)
RV_2 100Ω skeleton pre-set potentiometer (vertical mounting)

Capacitors

C_1 8μF electrolytic, 15V wkg.
C_2 16μF electrolytic, 15V wkg.
C_3 400μF electrolytic, 2.5V wkg.
C_4 0.005μF Mylar
C_5 50μF electrolytic, 15V wkg.
C_6 1,000μF electrolytic, 25V wkg. (For supplies below 15 volts, may be 15V wkg.)

Semiconductors

TR_1 2G374 (Texas)
TR_2 2G374 (Texas)
TR_3 2N1306 (Texas)
TR_4 NKT403 (Newmarket)
TR_5 2N1307 (Texas)
TR_6 NKT403 (Newmarket)
D_1 2G371 (Texas)

N.B. In case of difficulty, all semiconductors are available from L.S.T. Components, 23 New Road, Brentwood, Essex

Switch

S_1 s.p.s.t. switch, toggle

Speaker

3Ω speaker

Miscellaneous

Veroboard, 0.15in hole matrix (see Fig. 3)
Insulated washers and bushes for TR_4 and TR_6
Metal transistor clip for D_1
Aluminium for chassis
Fablon, or similar self-adhesive plastic material
Wire, sleeving, nuts, bolts, etc.

unity-gain emitter follower circuit of the type illustrated in Fig. 1 (*d*), and the input of this section of the circuit is direct coupled to the collector of TR_2. RV_2 and D_1 give a small amount of forward bias to TR_3 to TR_6 in order to minimise cross-over distortion.

The output at the emitter of TR_6 and collector of TR_4 is at approximately the same potential as TR_2 collector (due to emitter follower action) and the top of R_3 (in the base bias network of TR_1) is direct coupled to the output line. Thus, since the bias of TR_1 controls the bias of TR_2, a d.c. negative

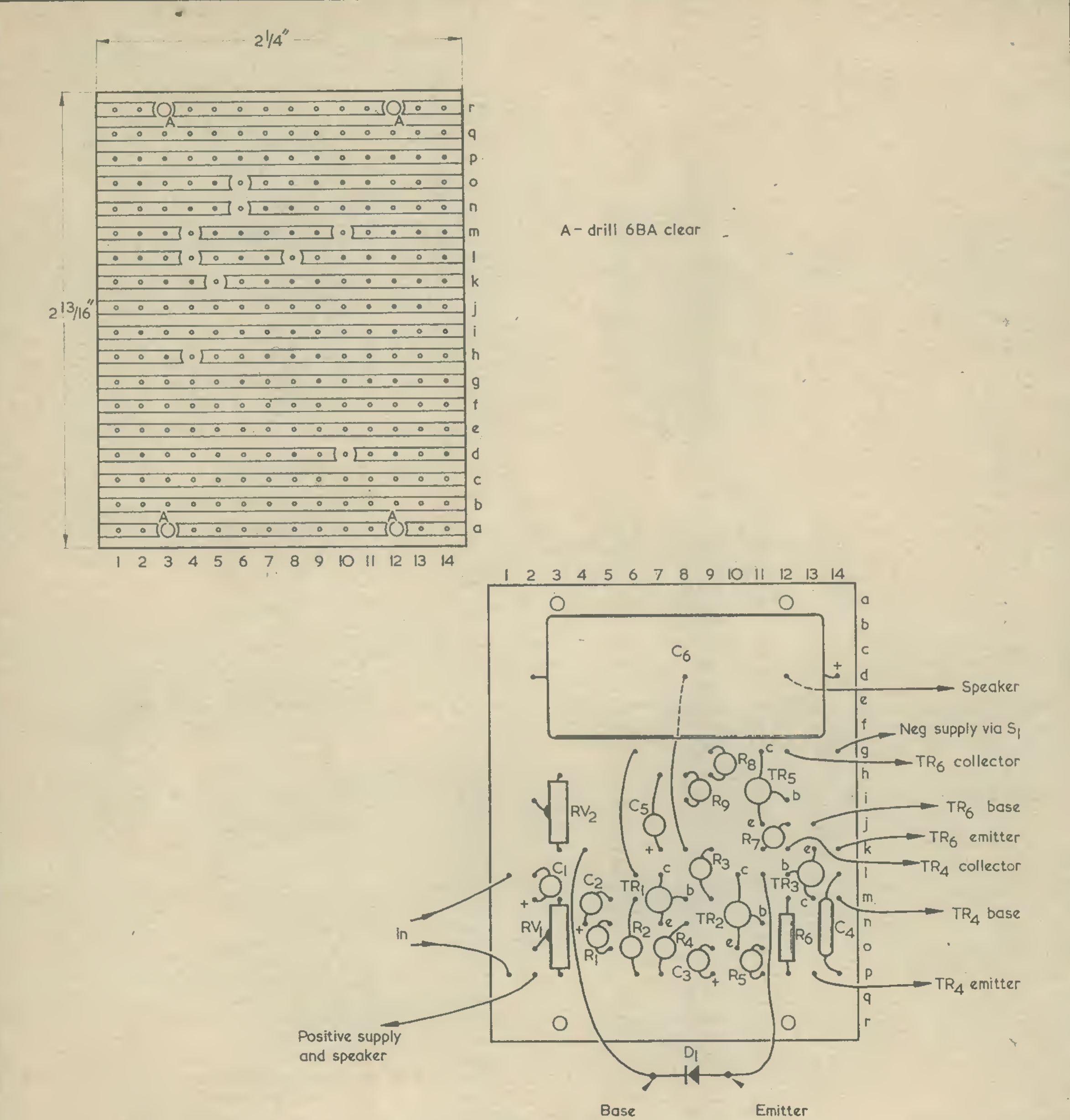


Fig. 3. Copper and component sides of the Veroboard panel. D_1 is the emitter-base junction of a p.n.p. transistor

feedback loop is formed over the complete circuit to give close control of all quiescent operating voltages. As a result of this feedback the output at TR_6 emitter is constant at a quiescent potential of approximately half supply voltage over a wide spread of transistor characteristics and supply line potentials. A.C. feedback also takes place via the same mechanism, so that very little distortion appears on the amplified signal.

Part of the output signal from the emitter of TR_6 is fed, via C_5, to the junction of R_8 and R_9 in the collector circuit of TR_2. Now, the signal at the lower end of R_9 is virtually identical with, but effectively isolated from, the signal at TR_6 emitter, with the result that virtually identical signals appear at either end of R_9 and very little signal current flows in this resistor. As a result, R_9 exhibits a far greater impedance than its 2.2kΩ real resistance, whereupon TR_2 gives a very high voltage gain. This technique of increasing the effective impedance of a resistor is known as "bootstrapping".

The natural frequency response of this amplifier extends up to several hundred kc/s, and there is a risk that high (ultra-sonic) signals could inadvertently appear in the amplifier, with consequent high power consumption but low audio output. To avert this danger it is necessary to restrict the amplifier's upper frequency response, and C_4 is fitted for this purpose.

D_1 is a temperature compensation diode, and automatically adjusts the bias voltages for TR_3 to TR_6 to compensate for changes in operating temperature. This diode consists, in fact, of the emitter-base junction of a standard transistor, and is thermally coupled to the two output transistors, TR_4 and TR_6.

Construction

The major part of the electronic circuitry 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 four 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, as indicated, and cut back the copper slightly from around the four mounting holes.

Start component assembly by soldering the two shorting links, covered with insulated sleeving, in place as shown in Fig. 3, and then solder all components and connecting leads in position as indicated. Diode D_1 (actually the base-emitter junction of a 2G371 transistor) is mounted later on the chassis, which also functions as a heat sink for the output transistors. D_1 is connected to the Veroboard panel by two flexible wires of the requisite length. Note that all components other than R_6 and C_6 are mounted vertically on the panel. Insulated sleeving should be used where there is any danger of components short-circuiting against one another. The width of the mounting legs of RV_1 and RV_2 should be reduced with the aid of a small file so that they fit easily in the holes in the panel before attempting to solder these components in place.

On-off switch S_1 is not mounted on the Veroboard or the chassis, and may be fitted at any convenient external position.

Once assembly on the Veroboard panel is complete, cut, bend and drill the aluminium chassis, using a medium gauge material, as shown in Fig. 4, and then cover the inside and outside of the lower lips with Fablon or a similar self-adhesive plastic material. Now drill suitable holes to take TR_4 and TR_6, and bolt these to the chassis using the insulated washers and bushes supplied for these transistors. Fit a solder tag under one securing nut for each transistor on the underside of the chassis. These tags act as collector take-off points.

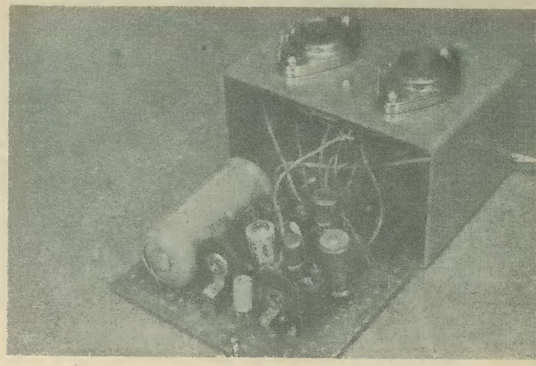
Next, take the transistor that is used as diode D_1, cut off the collector lead close to the body of the transistor, and then bolt the "diode" to the underside of the chassis with the aid of a small transistor clip.

Check that the Veroboard panel fits easily inside the chassis and that the mounting holes line up correctly, trimming if necessary. When assembled, the chassis lips are on the copper side of the board, and diode D_1 is at the same end as RV_1 and RV_2. Finally, connect the leads from the Veroboard panel to TR_4 and TR_6 as indicated in Fig. 3, and then bolt the panel inside the chassis with the aid of four 6BA screws and nuts.

Testing The Amplifier

Once assembly is complete, double check all wiring and then carry out the following functional checks.

Short-circuit the two input leads together, adjust RV_2 for minimum resistance (slider at D_1 end of track) and then, with no speaker connected, apply a 9 to 12 volt supply to the circuit, taking care to connect with the correct polarity. Check that no more than a few milliamps are drawn from the



The appearance of the amplifier before the Veroboard panel is fitted in the chassis

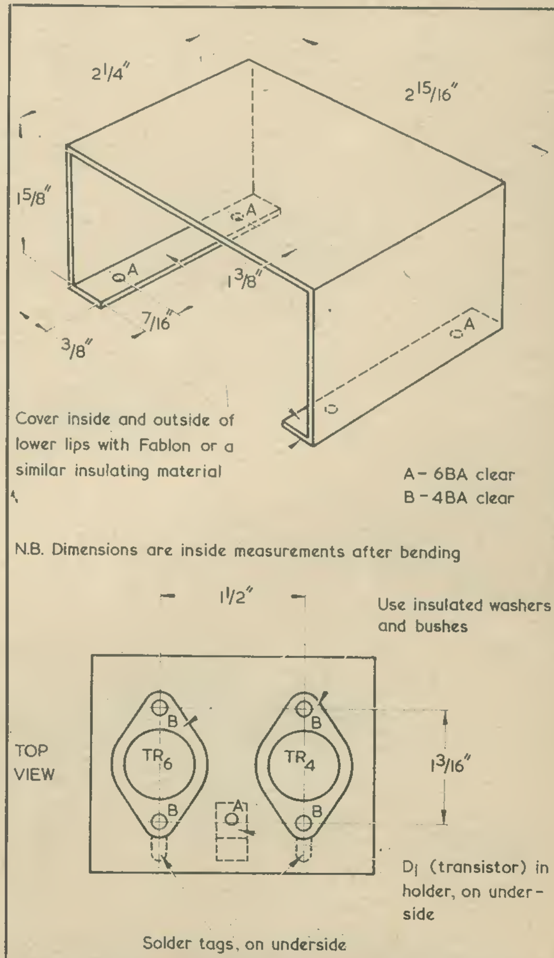
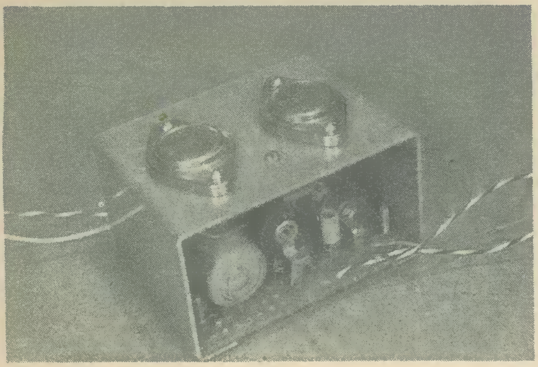


Fig. 4. Side view and top view of the chassis, which also functions as a heat sink for the output transistors



The neat and compact appearance of the completed amplifier

supply; check also that the current can be adjusted up to a high value by means of RV_2. Also check that the negative side of C_6 is at roughly half supply line potential. If the above conditions cannot be met, it can be assumed that an error has been made in construction or that a component is faulty. Now connect up a 3Ω speaker and again check that, apart from a brief surge as the speaker is connected, a current of only a few milliamps is drawn from the supply.

Next, connect the output of a transistor radio or similar sound source to the input of the amplifier and check the sound quality of the system, adjusting RV_2 for minimum cross-over distortion consistent with low quiescent current consumption (5 to 15mA). Adjust the pre-set volume control, RV_1, to give the required degree of overall sensitivity. Note that if RV_1 is adjusted for maximum sensitivity overall gain will be so high that it will be necessary to set the volume control of the radio to almost zero if a moderately low volume is to be heard in the speaker, and under this condition the output of the radio will contain a great deal of noise which will be audible from the speaker.

This completes the assembly and test procedure, and the miniature 5 watt high quality amplifier is now ready for use.

Using The Amplifier

To use the amplifier, simply connect a suitable power supply (9 to 18 volts), a 3Ω speaker, and an input signal, and adjust RV_2 for low cross-over distortion consistent with a low (5 to 15mA) quiescent current consumption. Adjust the pre-set volume control, RV_1, to give a degree of gain suitable for the equipment with which the amplifier is to be used; adjustment of this control will be found to be self-evident when the amplifier is employed in practice.

The power supply with which the amplifier is used must have a fairly low output impedance (i.e. its output voltage should remain reasonably high at load currents of 1 amp or so) otherwise the full 5 watts of audio output will not be obtainable. The supply should also be well smoothed. A car battery meets these requirements. If a mains powered unit is required, a power pack such as the Sinclair PZ.3 is recommended.

The 5 watt amplifier can be mounted to a chassis or panel by drilling two small holes in the side of the amplifier's aluminium chassis and similar holes in the supporting chassis, or panel. Self-tapping screws may then be used to secure the amplifier in place.

Circuit Modifications

The frequency response of 65 kc/s to 30 kc/s quoted at the beginning of this article is obtained when C_4 has a value of 0.005μF and C_6 has a value of 1,000μF. The low frequency response can be extended down to about 20 c/s, if desired, by increasing the value of C_6 to 5,000μF. The upper end of the frequency response can be restricted, if required, by increasing, by trial-and-error, the value of C_4. Note, however, that the value of this capacitor should not be *reduced* below that quoted in the Components List in an effort to increase the upper frequency response, as the circuit may then suffer damage.

The pre-set volume control, RV_1, can be replaced, if desired, by an externally mounted variable volume control of the same value. If an input signal is to be applied from a potential of greater than 15 volts d.c., the voltage rating of C_1 should be increased to a suitable value.

BRITISH AMATEUR TELEVISION CLUB ANNUAL CONVENTION

The British Amateur Television Club will hold its Amateur Television Convention on Saturday 14th September 1968 in the I.T.A. Conference Suite, 70 Brompton Road, London, S.W.3. Further details from the Hon. Sec. D. S. Reid, 71a Rose Valley, Brentwood, Essex.

Advertisers Correction

We have been asked to state that the price of *Practical Wireless Service Manual* should be 25s. and not 5s. as announced in a recent advertisement.

Photographer's Metronome

by

F. L. THURSTON

This unusual device, which features a unijunction a.f. oscillator, provides warning "bleeps" at 1 second, 5 second and 10 second intervals, as desired, to assist in photographic processing work

THIS DEVICE IS DESIGNED TO GIVE A SHARP AUDIBLE "bleep" tone at repetitive intervals of either 1, 5 or 10 seconds, so that the passage of time can be accurately judged without the use of visual aids. This facility is of great assistance when "shading" areas of an enlargement print in the darkroom with the intention of bringing out fine detail or achieving subtle changes of tone.

The unit can be built in either of two versions. In the first only a 4-transistor circuit is used and the audible output is available via a crystal earphone. If the crystal earpiece is not worn in the ear but is simply placed on the work bench the tone will still be audible up to a range of several feet in a normally quiet workshop. The second version of the unit incorporates an audio power amplifier so that the bleep tone can be fed directly into a small speaker, and uses a total of 8 transistors. This second version of the unit is built up on a piece of Veroboard panel, and the complete circuit measures 4¼ x 1⅞ x 1in.

In this article, technical circuit descriptions and constructional details will be concerned primarily with the 8-transistor version of the unit. The simple 4-transistor version can be built by simply omitting the audio amplifier section of the more complex unit.

BASIC PRINCIPLES OF OPERATION

Fig. 1 shows the block diagram of the circuit used in the metronome. The heart of the unit is the *timing generator* shown on the left; this "block" acts as a switch that is normally open, but closes momentarily at regular intervals. Switching intervals of 1 second, 5 seconds, or 10 seconds may be selected by means of S_1. The output of the timing generator is fed to a *gate switch*, which opens and closes in sympathy with the timing generator, but which takes negligible power from it. The gate switch is wired in series between a *tone generator* and the battery supply, and thus switches the generator on and off in sympathy with the timing generator.

The output of the tone generator is of large amplitude, but is at very high impedance. This output can be fed directly to a crystal earpiece, if required. Alternatively, it can be fed to a speaker via a *high impedance buffer* and an *a.f. power amplifier* stage, as shown in the diagram.

The output waveform of the unit, taken either from the tone generator or from the speaker, is shown in Fig. 2. Here, the output pulse has a duration of approximately 0.25 seconds on all ranges, and controls a tone frequency of approximately 900 c/s. On range 1 the total switching period, P, is 1 second, and the off time of the output, T, is 0.75 seconds. On the 5 second range, T is 4.75 seconds, and on the 10 second range T is 9.75 seconds.

Figs. 3 (*a*) to 3 (*d*) show the basic circuits from which the final unit is developed. In Fig. 3 (*a*) we have a conventional astable multivibrator, which is used as the basis of the timing generator. The astable multivibrator is a two state switching circuit, in which either TR_1 is *on* and TR_2 is *off*, or vice versa. The

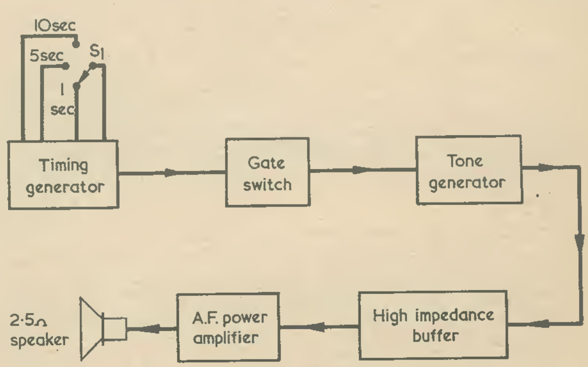


Fig. 1. Block diagram illustrating the basic functioning of the metronome

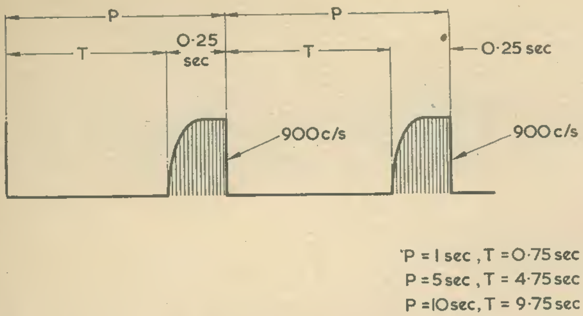


Fig. 2. The output waveform provided by the unit

output waveform of the circuit, taken from either collector, is of approximately rectangular form.

As shown in Fig. 3 (*a*) the astable multivibrator circuit has two snags for the present application. The first of these is that, due to the method of operation, reverse voltages of approximately 9 volts are applied between base and emitter of the transistors when the circuit is operating. However, most n.p.n. silicon planar transistors (as used in this unit) are only designed to withstand a maximum of about 6 volts reverse voltage, and above this the emitter-base junction breaks down. This breakdown of the junction will not result in any permanent damage to the transistor nor will it cause the circuit to cease operating, but what it will do is upset the timing of the multivibrator, so that if stable timing is required the breakdown must be prevented. This can be achieved quite simply by wiring a normal germanium diode in series with the emitter-base junction. One way of wiring the diodes, as shown in Fig. 3 (*a*), is to connect each diode between points X–X in the base circuit, thereby giving the circuit good frequency stability.

The second snag with the basic astable multivibrator is that there is a slight danger that under some circumstances both transistors may switch on at the same time, and the circuit will then cease to operate. This danger is particularly acute when very wide mark/space ratios (on/off times) are used, as in the case of the timing generator described here. This snag can be overcome, as shown in Fig. 3 (*b*) by wiring a pair of diodes between the collectors of TR_1 and TR_2 and then connecting the tops of the timing resistors (R_1 and R_2) to the junction of the two diodes. If, now, both transistors tried to switch on at the same time both collectors would go to ground potential and auto-

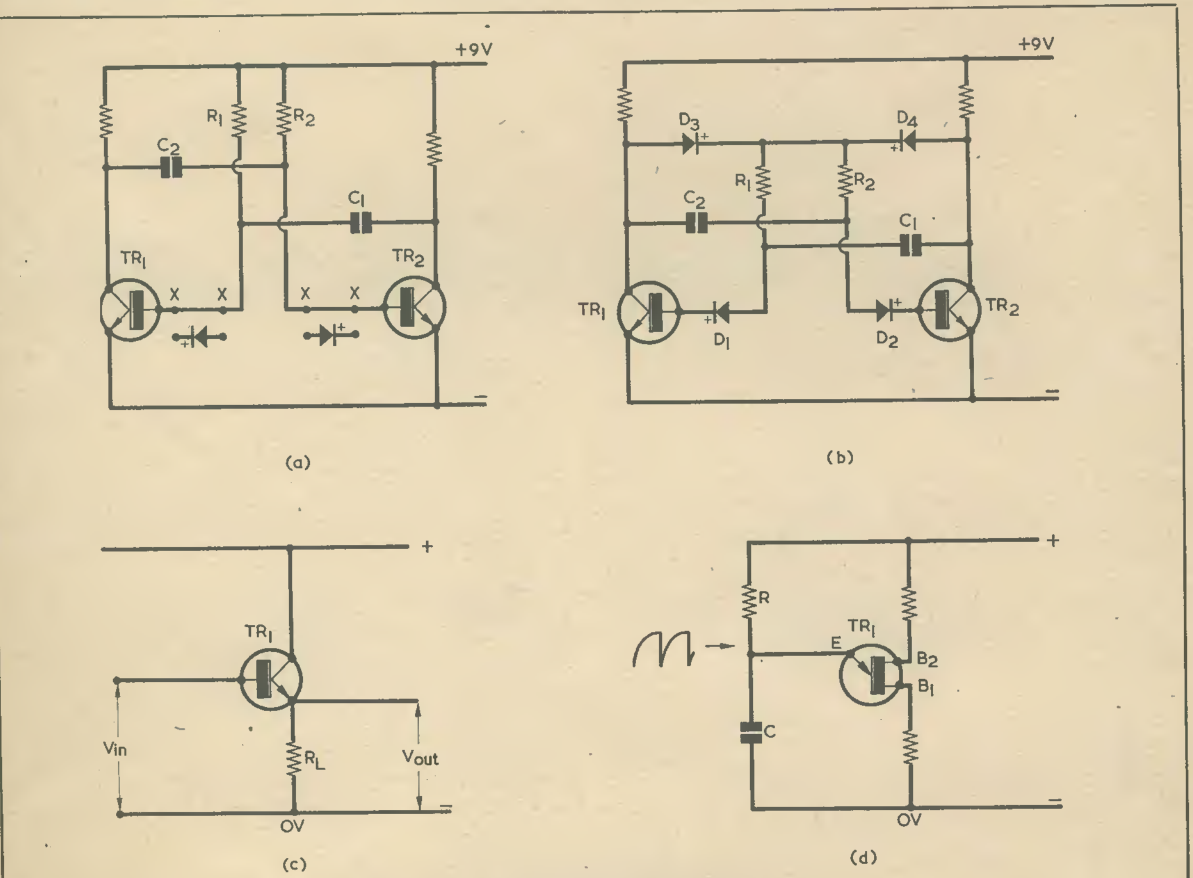


Fig. 3 (a). The basic astable multivibrator
(b). The astable multivibrator with sure-start and "frequency correction" diodes
(c). The basic emitter follower
(d). The unijunction oscillator

(*continued on page* 697)

CUT ALONG THIS LINE

RC/DS/9

RADIO CONSTRUCTORS DATA SHEET 9

EUREKA RESISTANCE WIRE

The Table gives diameters of Eureka wire gauges from 8 to 40 s.w.g. and resistance per yard. The approximate amperes needed to maintain a temperature of 100°C apply to the wire held straight and horizontal and with free radiation; for meter shunt use and the like operating currents should be kept considerably below those shown in this column. (Details for this Table are provided by the London Electric Wire Co. & Smiths Ltd.)

Size S.W.G.	Diameter		Nominal resistance per yard, ohms, at 15.5°C	Approximate amperes to maintain a temperature of 100°C	Size S.W.G.	Diameter		Normal resistance per yard, ohms, at 15.5°C	Approximate amperes to maintain a temperature of 100°C
	In	Mm				In	Mm		
8	0.160	4.06	0.0345	36					
9	0.144	3.66	0.0427	32	25	0.020	0.51	2.21	2.1
10	0.128	3.25	0.0540	26	26	0.018	0.46	2.73	2.0
11	0.116	2.95	0.0658	23	27	0.0164	0.42	3.29	1.8
12	0.104	2.64	0.0818	20	28	0.0148	0.38	4.04	1.7
13	0.092	2.34	0.104	16	29	0.0136	0.35	4.78	1.5
14	0.080	2.03	0.138	14	30	0.0124	0.31	5.75	1.4
15	0.072	1.83	0.171	12	31	0.0116	0.29	6.57	1.3
16	0.064	1.63	0.216	10	32	0.0108	0.27	7.58	1.2
17	0.056	1.42	0.282	8.0	33	0.0100	0.25	8.84	1.1
18	0.048	1.22	0.384	6.4	34	0.0092	0.23	10.4	0.98
19	0.040	1.02	0.553	4.6	35	0.0084	0.21	12.5	0.85
20	0.036	0.91	0.682	4.0	36	0.0076	0.19	15.3	0.75
21	0.032	0.81	0.863	3.4	37	0.0068	0.17	19.1	0.66
22	0.028	0.71	1.13	2.9	38	0.0060	0.15	24.6	0.58
23	0.024	0.61	1.53	2.4	39	0.0052	0.13	32.7	0.50
24	0.022	0.56	1.83	2.2	40	0.0048	0.12	38.4	0.46

RECENT PUBLICATIONS

RADIO AND ELECTRONIC HANDBOOK. By G. R. Wilding. Published by Iliffe Books Ltd. 149 pages, including 84 diagrams, $8\frac{1}{4}$ x 6 in. Price 17s. 6d.

Technicians and service engineers in the radio and electronics industry require a considerable amount of data which is spread over many books. It is often difficult and time consuming to locate in a hurry. Students, however, who may have to study a whole series of course books will find a condensation of such information, which gets down to the essentials, extremely useful. Radio and Electronic Handbook has been designed to provide, on the one hand, a reference book and, on the other, a revision guide.
The intention has been to summarise basic electronics into four separate easily assimilated sections which will provide rapid reference to important principles, formulae and applications. These four main sections are – Direct current theory, Alternating current theory, Valve theory and applications and Transistor theory and applications. Practical worked examples and circuit diagrams have also been utilised whenever necessary. The concise presentation, which covers all the relevant ground, makes for maximum learning absorption and the book will prove invaluable for both practical and examination requirements.

Contents

Section 1: Direct Current Theory.
2: Alternating Current Theory
3: Valve Theory and Applications.
4: Transistor Theory and Applications.

NEW CATALOGUE. Henry's Radio Ltd., 303 Edgware Road, London, W.2.

The new 9th Edition of this well-known catalogue is now available to readers. This new Edition contains more than 280 pages listing some 6,000 stock lines. As previously, discount vouchers for use with purchases–five at 2s.–are supplied with each catalogue. The price of the catalogue remains unchanged at 7s. 6d. plus 1s. postage and packing.

NEW ELECTRONICS CENTRE

Henry's Radio Ltd., are pleased to announce to readers the opening of a new Electronic Centre at 309 Edgware Road, London, W.2.–a few shops away from their existing premises.
The new Centre will be devoted to the sale and demonstration of all the latest high-fidelity equipment with a vast range on display. Additionally, intercoms, public address equipment, microphones and a large range of test equipment, plus many hundreds of other stock lines will also be available for inspection and purchase. The existing premises at 303 Edgware Road will be expanded to cater for an ever-increasing range of electronic components and accessories. Also, electronic organ components, equipment sales and demonstration, the mail order and accounts departments will remain at the "303" address.

PHOTOGRAPHER'S METRONOME

continued from page 694

matically cut off the base currents to the transistors, which would then inevitably be switched off again. In this application, these diodes are referred to as "sure-start diodes". The circuit shown in Fig. 3 (*b*) has both sure-start and frequency correction diodes,

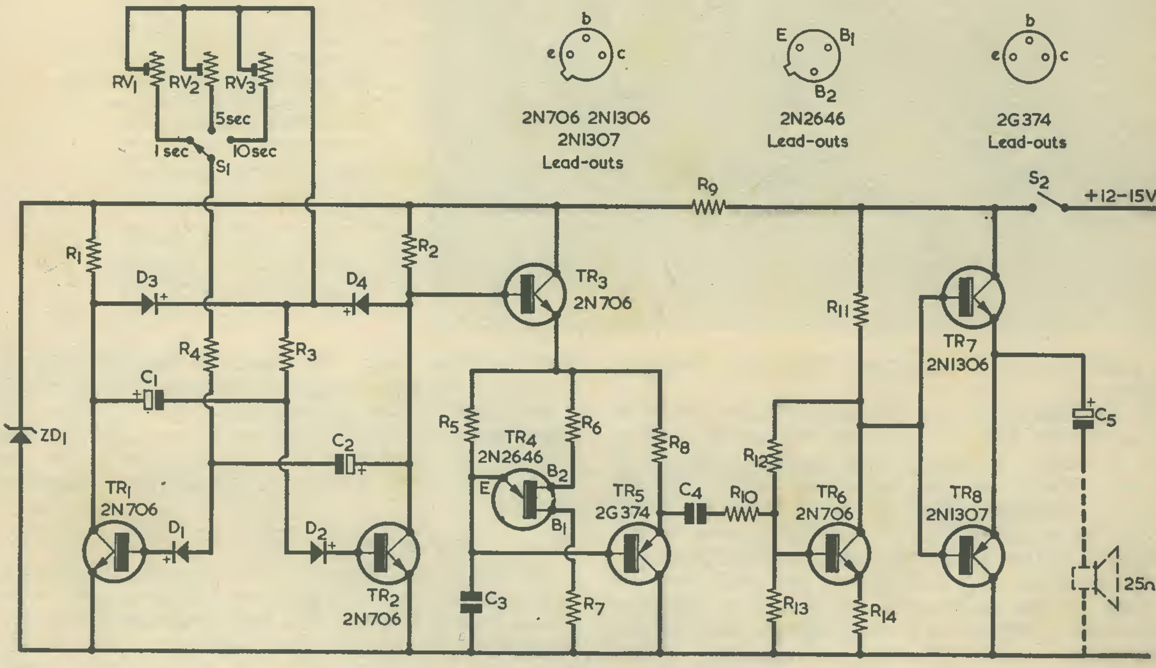


Fig. 4. Complete circuit of the photographer's metronome

COMPONENTS

Resistors
(All fixed values 10% ½ watt)

- R_1 2.2kΩ
- R_2 2.2kΩ
- R_3 22kΩ (see text)
- R_4 5.6kΩ
- R_5 22kΩ
- R_6 100Ω
- R_7 270Ω
- R_8 8.2kΩ
- R_9 180Ω
- R_{10} 1kΩ
- R_{11} 1kΩ
- R_{12} 10kΩ
- R_{13} 2.2kΩ
- R_{14} 56Ω
- RV_1 10kΩ skeleton preset, vertical mounting
- RV_2 150kΩ skeleton preset, vertical mounting
- RV_3 250kΩ skeleton preset, vertical mounting

Capacitors

- C_1 8μF, 15V wkg., electrolytic
- C_2 100μF, 15V wkg., electrolytic
- C_3 0.04 or 0.05μF, Mylar or polyester
- C_4 0.1μF, Mylar, polyester or paper
- C_5 100μF, 25V wkg., electrolytic

* Due to relatively wide tolerances in value for the electrolytic capacitor C_1, it may be necessary to slightly adjust the value of R_3 if it is desired that the "bleep" period be almost exactly 0.25 second.—Editor.

Semiconductors

- TR_1 2N706
- TR_2 2N706
- TR_3 2N706
- TR_4 2N2646 (unijunction)
- TR_5 2G374
- TR_6 2N706
- TR_7 2N1306
- TR_8 2N1307
- D_1, D_2 OA90, or similar germanium diode
- D_3, D_4 OA200, or similar silicon diode
- ZD_1 9 volt (approx.) zener diode (e.g. OAZ-207)

(In case of difficulty, all semiconductors are available from L.S.T. Components, 23 New Road, Brentwood, Essex)

Switches

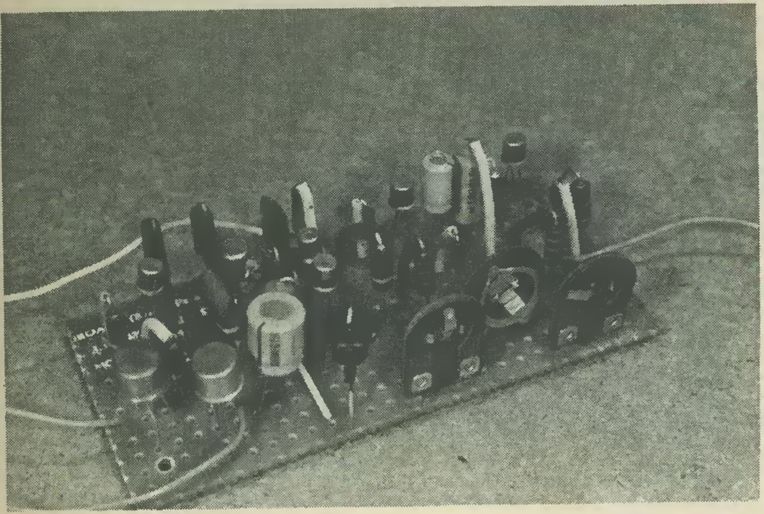
- S_1 single pole, 3 way, rotary
- S_2 single pole, on-off

Speaker

25Ω speaker

Miscellaneous

Veroboard panel, 0.15in matrix, 1⅞ x 4¼in (see Fig. 5)
12–15 volt supply
Wire, sleeving, etc.
Crystal earphone (required for testing)



The neat and compact appearance of the metronome unit on its Veroboard panel

and gives fool-proof operation with good frequency stability.

Fig. 3 (*c*) shows a simple common collector or emitter follower circuit. This circuit, which will be very familiar to most readers, is used, in one form or another, in the *gate switch*, the *high impedance buffer*, and the *a.f. power amplifier* stages of the metronome circuit. Briefly, the characteristics of an emitter follower are as follows. The potential at the emitter of the transistor, and thus across R_1, will always be approximately the same as that at the base, so it can be said that the emitter "follows" the base signal. Due to the inherent gain of the transistor, however, the current taken by the base (input) will be very small compared to that available at the emitter (output), so that the effective input impedance of the circuit is quite high, while the output impedance is quite low. The circuit thus acts as a useful impedance transformer, or buffer stage, between circuits with different impedance levels. The circuit shown in Fig. 3 (*c*) is an n.p.n. emitter follower; the p.n.p. version is similar, but has the supply line polarity reversed.

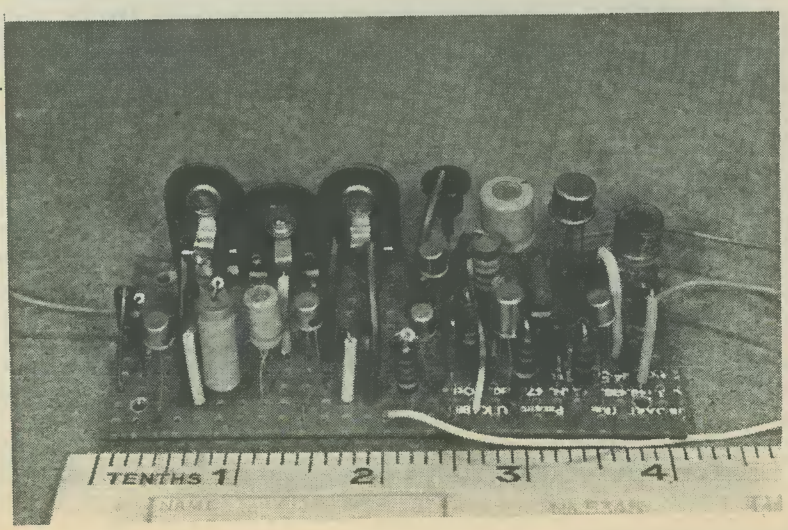
Fig. 3 (*d*) shows the only other section of the metronome that is worthy of special comment. This is the unijunction oscillator, which forms the basis of the *tone generator* stage. The essential characteristics of this circuit are that an approximate sawtooth waveform is generated at the junction of R and C, that the signal has a very high output impedance, and that the frequency of operation is controlled simply by the values of R and C. The circuit has excellent frequency stability.

FINAL METRONOME CIRCUIT

The full circuit diagram of the metronome is shown in Fig. 4. TR_1 and TR_2 form the astable multivibrator timing generator stage, and have frequency correction provided by D_1 and D_2 and sure-start by D_3 and D_4. R_3 and C_1 control the ON time of the circuit, while C_2 and the series combination R_4 and RV_1, RV_2, or RV_3 control the OFF time via S_1.* The multivibrator is powered from a 9 volt zener stabilised supply line.

The output of the multivibrator is fed to emitter follower TR_3, which acts as the gate switch supplying current to TR_4, the unijunction oscillator. If only a crystal earphone version of the unit is required, the

*Due to relatively wide tolerances in value for the electrolytic capacitor C_1, it may be necessary to slightly adjust the value of R_3 if it is desired that the "bleep" period be almost exactly 0.25 second.—Editor.



The small overall dimensions of the unit are readily demonstrated here

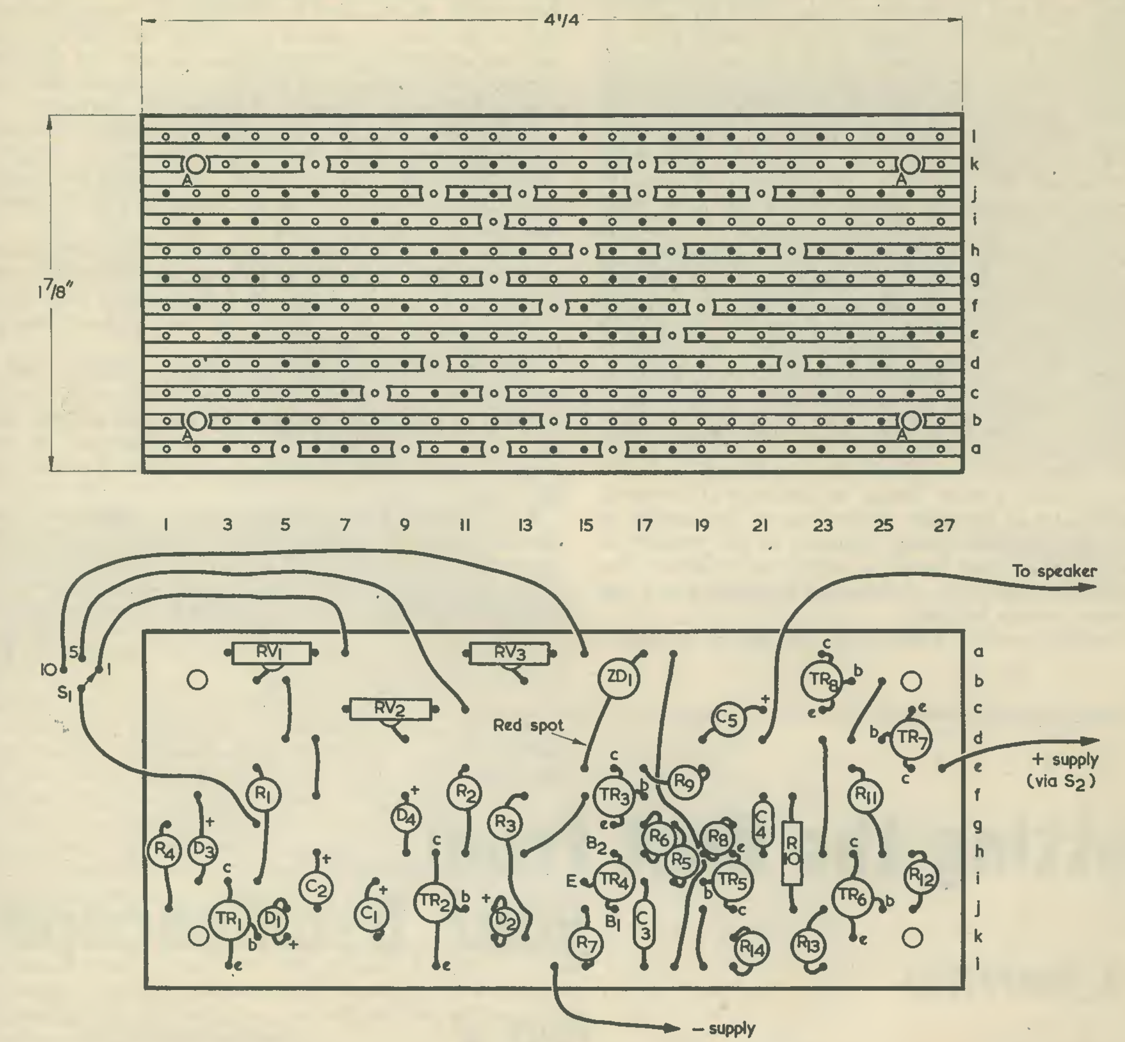


Fig. 5. The copper and component sides of the Veroboard panel on which the metronome is assembled. Switches S_1 and S_2 are not mounted on the panel

earpiece can be connected across R_5 and the circuit considered as complete. In this instance, a 12 to 15 volt supply should be applied via R_9.

In the case of the 8-transistor version shown in Fig. 4, the output of the unijunction stage is fed to TR_5, the p.n.p. emitter follower buffer stage, and thence on via C_4 and R_{10} to the base of TR_6. This transistor is wired as a conventional common emitter amplifier with d.c. negative feedback provided, by way of R_{12} and R_{13}, to hold TR_6 collector at approximately half supply rail potential. The emitter of TR_6 is not decoupled to a.c. since the amplification of the circuit is adequate as it stands. Finally, the amplified signal at TR_6 collector is direct coupled to the bases of TR_7 and TR_8, which are wired as complementary n.p.n./p.n.p. emitter followers, giving a large amplitude low impedance output to the external 25Ω speaker via C_5. This completes the description of the circuit.

CONSTRUCTION

Start construction by cutting the Veroboard panel to size and then drill the four small mounting holes, to clear 6BA screws, as shown in Fig. 5. Now break the copper strips, with the aid of a small drill or the special cutting tool that is available, where indicated. Cut back the copper from around the four mounting holes, to prevent the possibility of short circuits to the mounting screws if the unit is fitted to a metal chassis or panel.

It is recommended that component assembly be carried out in a number of stages, so that each stage can be given a functional check before proceeding with the next. In this case, the following procedure should be adhered to, it being noted that, unless stated otherwise, all components are mounted vertically. Insulated sleeving should be used where there is any danger of component lead-outs short-circuiting against one another.

Solder 7 jumper wire links, fitted with insulated sleeving, in place as shown, Secure ZD_1, R_9, and the positive and negative supply leads in place. Connect a supply of 12 to 15 volts and check that approximately 9 volts are developed across ZD_1. Remove the supply.

Solder in place R_1, R_2, R_3, R_4, TR_1, TR_2, D_1, D_2, D_3, D_4, C_1, C_2, switch S_1 (external to the board) and its connecting leads, and RV_1, RV_2 and RV_3. When fitting the last three components, reduce the width of the mounting legs with the aid of a small file, so that they fit easily in the holes in the Veroboard, before attempting to solder these components in place. Connect a voltmeter between TR_2 collector and the negative supply line, connect a supply to the unit, and check that the multivibrator pulses in the manner described earlier. RV_1 enables the period to be set to 1 second, RV_2 to 5 seconds, and RV_3 to 10 seconds. Remove the supply.

Solder R_5, R_6, R_7, TR_3, TR_4, and C_3 in place. Connect a crystal earpiece across R_5, connect the power supply to the circuit, and check that the circuit functions correctly, giving a brief "bleep" at intervals of 1 second, 5 seconds, or 10 seconds, depending on the setting of S_1 and the variable timing resistors. If the version of the unit with crystal earpiece output is required, this completes the assembly and testing procedure and the unit is now ready for use.

If the loudspeaker version of the unit is required, continue the construction in the following manner. Solder TR_5, R_8, C_4, and R_{10} in place, R_{10} being mounted flat on the panel. Connect the crystal earpiece between the free end of R_{10} (remote from C_4) and the negative supply line, connect the supply, and check that the circuit functions correctly. Remove the supply.

Solder TR_6, R_{11}, R_{12}, R_{13} and R_{14} in place. Connect the supply and check that TR_6 collector is at roughly half of the supply line potential. Check with the crystal earpiece that the pulsed tone is heard at TR_6 collector. Remove the supply.

Solder TR_7, TR_8, and C_5 in place. Solder the speaker lead in place, connect a 25Ω speaker between this lead and the negative supply line, connect the 12 to 15 volt supply, and check that the pulsed "bleep" tone is heard at all positions of S_1.

This completes the final assembly procedure, and it only remains to fit the panel, switches, and battery in place in a suitable cabinet, and the unit is ready for use. The *on/off* switch, S_2, is incorporated in the positive supply line, between the Veroboard panel and the battery.

As a guide for checking circuit operation, the current drawn by the prototype, without a loudspeaker connected, was 20mA at 12 volts and 36mA at 15 volts. These figures are approximate only and may vary somewhat between different units built up to the circuit.

✱

Getting the Best from your Oscilloscope

by **D. J. GRIFFITHS**

Part 2

This is the second article in our four-part series on obtaining maximum advantage from the oscilloscope. This month our contributor describes harmonic waveforms and a.f. amplifier testing with sine waves

THE EFFECTS OF HARMONICS ON A SINE WAVE ARE best understood by performing a short, but extremely profitable, experiment. The only instrument required (apart from an oscilloscope) is an audio sine-wave oscillator with a frequency range of 90 c/s to 410 c/s. Actually, it is not necessary to have a variable frequency oscillator; fixed frequencies of 2 times, 3 times, etc., the mains frequency are all that is required. The type of oscillator used should be of the sine wave variety. Any oscillator described as "phase shift" or "wien bridge" will be suitable—many other types of audio oscillator do not give a pure sine wave and are therefore unsuitable.

ADDING HARMONICS

We now come to the experiment itself. A voltage of 6.3, obtained from the mains via a heater transformer, is applied to the Y terminals of the oscilloscope by way of potentiometer VR_1, as shown in Fig. 1. The audio oscillator is applied to the slider and earthy end of this potentiometer, with the result that the signal level it injects into the circuit is adjustable. The value of VR_1 may be between 5 and 50kΩ.

We next set up the oscilloscope timebase to show two or three cycles of the 50 c/s input. If this is a perfect sine wave it will have the appearance shown in Fig. 2 (*a*), but there may be slight irregularities due to the

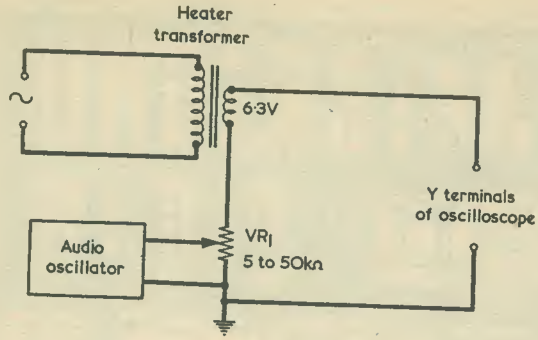


Fig. 1. A simple circuit which enables the effects of adding harmonics to be studied

presence of harmonics. The oscillator is set up to 100 c/s, the second harmonic, and an output voltage of 0.6 (which will correspond to approximately 10% of second harmonic) is then injected. The result will be a waveform similar to that shown in Fig. 2 (*b*). If the second harmonic input is varied slightly in phase, the irregularity it introduces can be made to travel along the fundamental. See Fig. 2 (*c*). Also, the amplitude of the second harmonic can be varied by adjusting VR_1. It will be noticed that harmonic voltages below about 5% are almost unnoticeable.

The effect of adding the third harmonic, at 150 c/s, can next be examined, and this will give a trace similar to that shown in Fig. 2 (*d*), or, with a different phase relationship, to that illustrated in Fig. 2 (*e*).

Note the basic difference between even and odd harmonics. Odd harmonics do not alter the symmetry of the fundamental, whereas even harmonics introduce marked asymmetry. Fig. 2 (*f*) shows the result of adding the fourth harmonic, at 200 c/s.

The effect of injecting higher harmonics can also be checked with the aid of the circuit of Fig. 1. It is possible, simply by connecting a second audio generator in series with the first, to study the effects of two harmonics on the fundamental.

A.F. AMPLIFIER TESTING

A.F. amplifiers can be tested with an oscilloscope by making sequential stage checks, using a sine wave input. The circuit of a typical 10 watt high quality valve amplifier is given in Fig. 3, and the circled numbers in this diagram indicate the test points to which the oscilloscope may be applied, and the order in which the checks should be made. It will be seen that tests commence at the speaker transformer secondary, and next proceed back to the input. Points 11 to 16 are bypassed, and little signal should be present at these points. A large signal amplitude indicates a faulty bypass capacitor, which must be replaced before further tests can be made. Points 17 and 18 are also bypassed, but it has to be remembered that a small level of signal will be present here due to the negative feedback from the speaker transformer secondary. The final test is at point 19, which is the positive terminal of the reservoir capacitor for the h.t. rectifier. Some ripple voltage will be evident at this point, and also at point 13. Experience with serviceable amplifiers will assist in determining the acceptable level for such ripple and will also give a good working idea of the waveform amplitudes to be expected at other points in the amplifier.

If the amplifier is faulty it may be necessary to adjust the volume control to the level where distortion is most apparent. Be careful not to overload the amplifier, or this will result in distortion, such as is shown in Figs. 4 (*a*) and (*b*). If any stage introduces distortion, the signal at its output will be a distorted version of that at its input, and this fact will enable the stage to be located.

The oscilloscope will also give traces which may indicate the nature of the fault. Fig. 4 (*c*) shows the result of too low a bias voltage in a valve amplifier stage. Clipping occurs on one half of the sine wave due to the onset of grid current. Too high a bias voltage can result in the waveform shown in Fig. 4 (*d*), in which one half of the sine wave undergoes greater amplification than does the other. These last two waveforms may require a fairly high signal input (but below that which would normally cause the amplifier to overload) to give a recognisable indication of the fault.

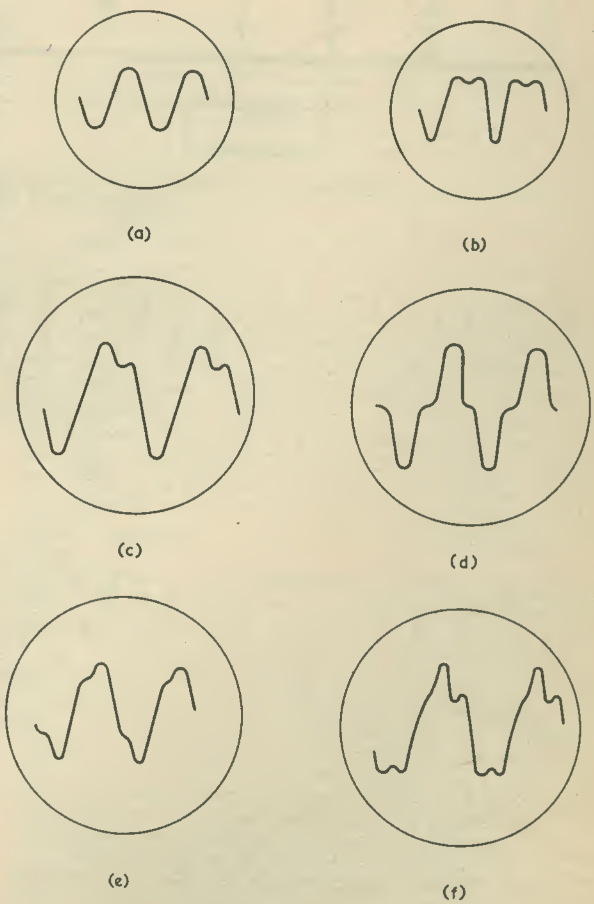


Fig. 2 (a). The fundamental sine wave
(b). Adding approximately 10% second harmonic
(c). The effect given by second harmonic with a different phase relationship
(d). Adding third harmonic
(e). Third harmonic with a different phase relationship
(f). The markedly asymmetric waveform given by adding fourth harmonic

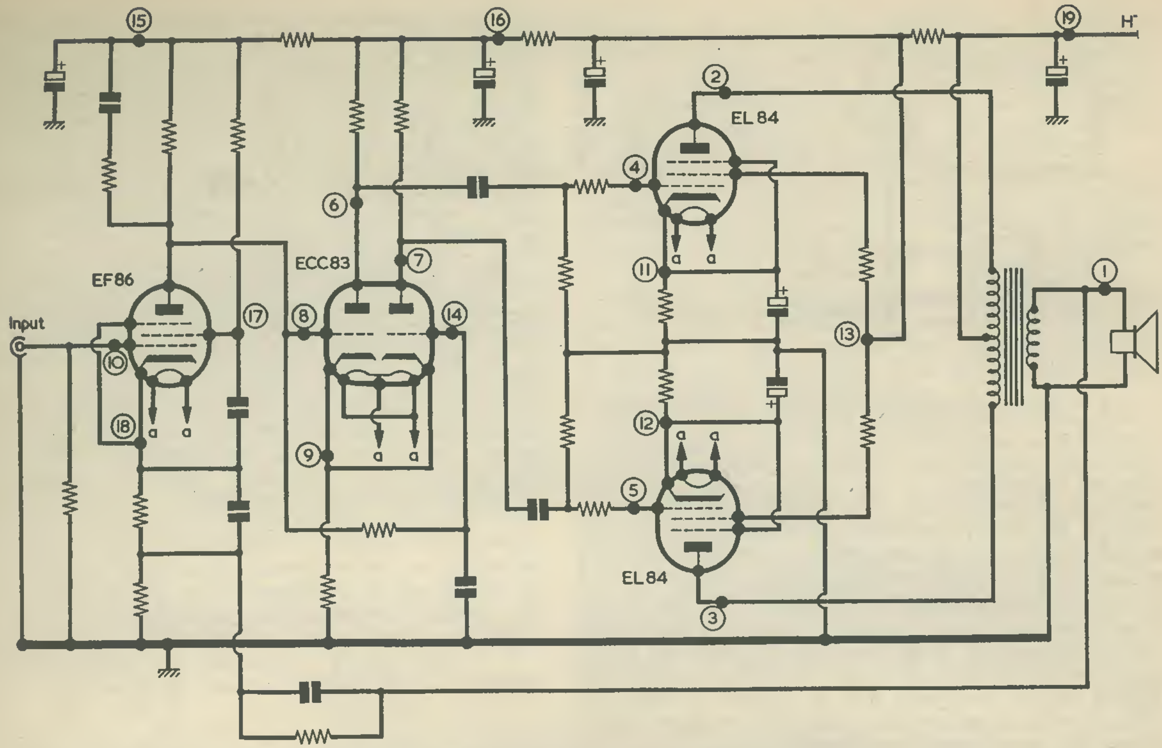


Fig. 3. A typical high quality a.f. amplifier circuit. The circled figures indicate the points at which oscilloscope checks may be made and the order in which they should be carried out

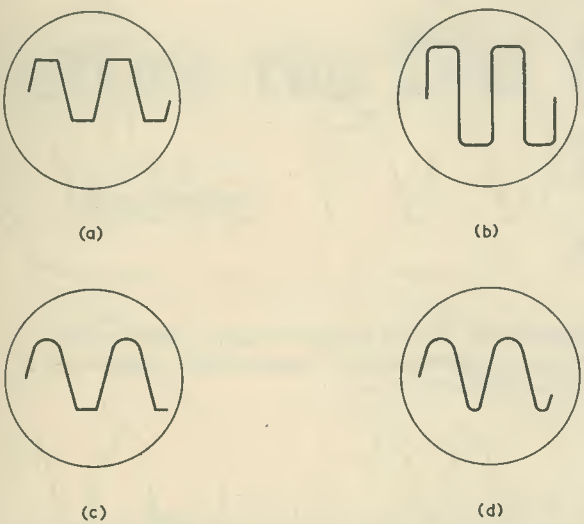


Fig. 4 (a). The clipping which results from overloading
(b). Severe overloading may cause the appearance of a waveform which approaches that for a square wave
(c). An effect given by too low a bias voltage
(d). Too high a bias voltage may give this waveform

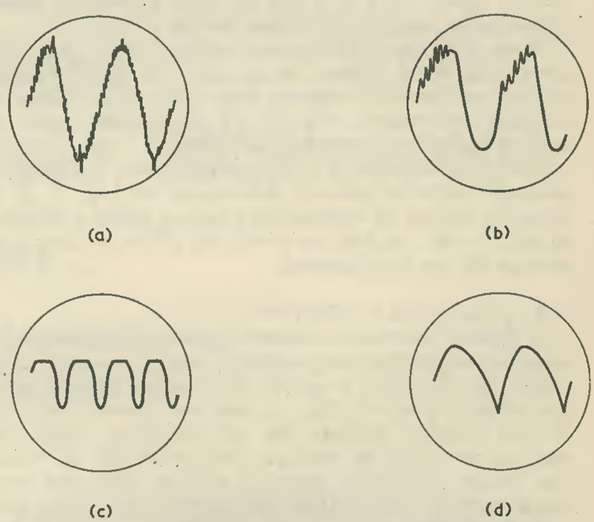


Fig. 5 (a). The result of noise due to a faulty component
(b). The appearance of a parasitic oscillation
(c). A clipping effect, combined with low amplification, given by too low a screen-grid voltage
(d). The ripple across the reservoir capacitor of Fig. 3 may have this appearance

A further series of waveforms is given in Fig. 5. That shown in Fig. 5 (*a*) illustrates the effect given due to noise introduced by a faulty component. A parasitic oscillation is shown in Fig. 5 (*b*), this occurring at one point of the sine wave only. The parasitic oscillation may only occur at some input signal levels. Fig. 5 (*c*) shows the clipping given by too low a screen-grid voltage in a voltage amplifier. The amplitude of this waveform will also indicate a low level of amplification in the associated valve. The ripple voltage appearing across the reservoir capacitor of Fig. 3 can have the appearance shown in Fig. 5 (*d*). (To be continued)

UNDERSTANDING RADIO

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

Superhet Tracking

by W. G. Morley

IN LAST MONTH'S ARTICLE WE INTRODUCED THE SUPERhet in its complete basic form after having, in the previous article, examined in detail the manner in which a difference frequency is produced by a *mixer* when two separate frequencies are applied to it. In the superhet one of these frequencies is that of the signal picked up by the aerial, whilst the other is generated by the local oscillator. Following the mixer is the intermediate frequency amplifier. This possesses a relatively large number of tuned circuits resonant at the difference frequency and it provides most of the selectivity exhibited by the superhet. Normally, the i.f. amplifier provides a considerable proportion of the signal amplification before the detector stage as well.

In the superhets we saw in "block" form last month, tuning was carried out by means of a ganged variable capacitor, one section of which controlled the resonant frequency of the local oscillator tuned circuit whilst the other section (or sections, if the superhet had an r.f. stage before the mixer) controlled the resonant frequency of the signal tuned circuit. It was stated that the oscillator and signal tuned circuits are so arranged that the difference between their resonant frequencies is equal to the intermediate frequency at all settings of the ganged capacitor.

In this issue we shall now see in detail how this frequency difference is maintained.

SINGLE FREQUENCY TRACKING

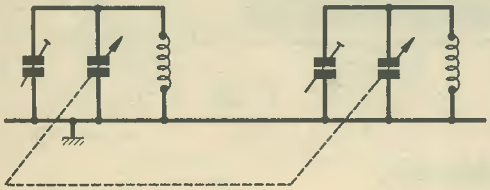
In Fig. 1 (*a*) we see two tuned circuits controlled by a 2-gang variable capacitor, and we will commence by assuming that the two tuned circuits are intended to resonate at the *same* frequency for all settings of the 2-gang capacitor. Such a circumstance arises if the tuned circuits are the aerial and detector tuned circuits of a straight receiver having an r.f. stage, or if they are the aerial and signal frequency mixer tuned circuits of a superhet with an r.f. stage. After a first glance at the diagram it might seem self-evident that, if both coils have exactly the same inductance and if both sections of the 2-gang capacitor present the same capacitance regardless of its setting, the two resonant frequencies must always be equal.

Unfortunately, conditions as "ideal" as this cannot be realised in practice. Fig. 1 (*a*) does not, for instance, show the stray capacitances which appear across each tuned circuit, and which will be particularly in evidence if the two tuned circuits are connected into the appropriate stages of a receiver. These stray capacitances would then be given by such things as capacitances between wiring and chassis, by interelectrode capacitances in any valves to which the tuned circuits couple and by self-capacitance in the coils. The total stray capacitance in one tuned circuit will almost inevitably be dissimilar to the total stray capacitance in the other whereupon, if the two tuned circuits are always to resonate at the same frequency, some means must be provided to counteract the effect of this difference. The stray capacitances will normally be much lower than the maximum capacitance of each section of the ganged capacitor, and it is obvious that they will cause greatest relative difference in the resonant frequencies when the ganged capacitor is set to its minimum capacitance value.

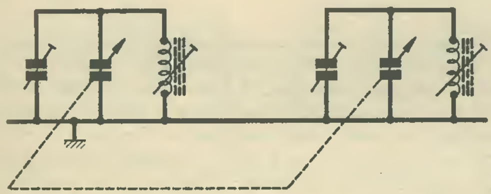
The simplest practicable method of overcoming the effect of stray capacitances is to connect trimming capacitors across each tuned circuit, as in Fig. 1 (*b*). These trimming capacitors, or trimmers, have a much lower maximum value than the maximum value of each section of the ganged capacitor and, like the stray capacitances, have greatest effect on resonant frequency when the ganged capacitor is at minimum capacitance. The trimmers are adjusted so that the sum of stray plus trimming capacitance across each tuned circuit becomes equal. If we next make the assumption that both coils have exactly the same inductance and the two sections of the ganged capacitor always the same capacitance, then the two tuned circuits will always have the same resonant frequency despite the initial unbalance caused by the dissimilar stray capacitances across them.

Again, however, a practical difficulty intervenes, this being that it is by no means an easy task to produce two coils having exactly the same inductance if these are of the air-cored type. Fortunately, this particular difficulty can be overcome very readily by providing

(a)



(b)



(c)

Fig. 1 (a). Two tuned circuits, adjusted by a 2-gang capacitor. It is required that both resonate at the same frequency at all settings of the capacitors
(b). To counteract the effects of dissimilar stray capacitances, a trimmer is added to each tuned circuit
(c). Since it is difficult to manufacture two air-cored coils having exactly the same inductance, it is preferable to use coils with adjustable iron dust cores

the two coils with adjustable iron dust cores, as in Fig. 1 (*c*). The coils may then be wound to be as physically similar as is reasonably economic (e.g. to have the same number of turns on the same size former) after which small discrepancies in inductance may be taken up by appropriate adjustments of the iron dust cores.

The two tuned circuits of Fig. 1 (*c*) now have all the adjustments required to enable them to be fitted in a straight or superhet receiver having an r.f. stage, this being the application which was mentioned earlier. It should next be noted that we would then set them up in terms of resonant frequency, and *not* in terms of the intrinsic value of stray capacitance or inductance. We would initially inject (or pick up on the aerial) a signal at the high frequency end of the range we wish the tuned circuits to cover, set the ganged capacitor to minimum value, and adjust the *trimmers* for maximum receiver response. We would then inject a signal at the low frequency end of the range we wish the tuned circuits to cover, set the ganged capacitor to maximum value, and adjust the *iron dust cores* for maximum response. We would next repeat these two operations, adjusting the trimmers at the high frequency end of the desired range and the iron dust cores at the low frequency end of the range, until no further improvement in performance could be obtained.

It is necessary to repeat these two operations because the adjustments are interdependent. Altering the trimmers necessitates a compensatory readjustment of the iron dust cores at the low frequency end of the range and *vice versa*. In general, iron dust core adjustments have much greater effect on resonant frequency at the high frequency end of the range than have the trimmers at the low frequency end of the range. Nevertheless, if the procedure just described is carried out properly, the final and correct mutual adjustments are very quickly arrived at. Usually, it is rarely necessary to repeat the operations more than two or three times.

When the adjustment procedure just described has been completed it can be presumed that the two tuned circuits have the same resonant frequency at all settings of the ganged capacitor. The procedure also, incidentally, takes up any slight differences in capacitance which may exist in the sections of the ganged tuning capacitor itself.

If the coils employed in a circuit of the type shown in Fig. 1 (*c*) are obtained for a home-constructor application, the manufacture of the coils usually specifies the high and low frequencies at which the trimmers and iron dust cores should be set up. With a commercially manufactured receiver the high and low frequencies are specified in the service manual.

The adjustment process at the high frequency end of the range covered by the tuned circuits is referred to as *trimming* and that at the low frequency end as padding, whilst the maintenance of the same resonant frequency in both circuits at all settings of the ganged capacitor is referred to as *tracking*. If, in Fig. 1 (*c*), the resonant frequencies are always exactly the same, then tracking is described as being perfect. The term "tracking" is a general one, and it applies to any set of ganged tuned circuits which are required to have a specific frequency relationship at all points of the range they cover. This includes the ganged signal and oscillator tuned circuits of a superhet which, as we have already observed, are expected to present a standard difference frequency.

The circuits of Fig. 1, which show what occurs when tuned circuits controlled by a ganged variable capacitor have to resonate at the same frequency for all settings of the ganged capacitor, introduce most of the basic requirements for the signal and oscillator tuned circuits of a superhet. They also demonstrate the important fact that, so far as adjustments are concerned, trimmers are set up at the high frequency end of the range and iron dust cores at the low frequency end.

SUPERHET TRACKING

In a superhet we require to control two tuned circuits so that they always present a fixed difference between their resonant frequencies. One tuned circuit is at signal frequency and selects the desired aerial signal to be passed to the mixer, whilst the other tuned circuit is in the oscillator section and controls the frequency presented to the mixer by the local oscillator.

The two tuned circuits will present the required difference frequency regardless of whether the oscillator frequency is lower or higher than the signal frequency, and so the first question which has to be settled is which of these two frequency relationships is to be adopted.

It will be helpful here to consider a numerical example. Let us say that we want to tune the medium wave band of (approximately) 600 to 1,600 kc/s in a superhet whose intermediate frequency is the commonly encountered figure (in domestic superhet receivers) of 460 kc/s. If it is intended that the oscillator tuned circuit operates at a lower frequency than the signal frequency tuned circuit it will have to cover 600 minus 460 kc/s to 1,600 minus 460 kc/s, or 140 to 1,140 kc/s. If the oscillator tuned circuit is to operate at a higher frequency than the signal frequency it will have to cover 600 plus 460 kc/s to 1,600 plus 460 kc/s, which works out as 1,060 to 2,060 kc/s. With the oscillator running at the lower frequency, the ratio of minimum to maximum oscillator frequencies is 140:1,140 or 1:8. When the oscillator is running at the higher frequency the ratio becomes 1,060:2,060 or, roughly, 1:2. At the same time the ratio of minimum to maximum signal frequencies is 600 to 1,600, or 1:2.7.

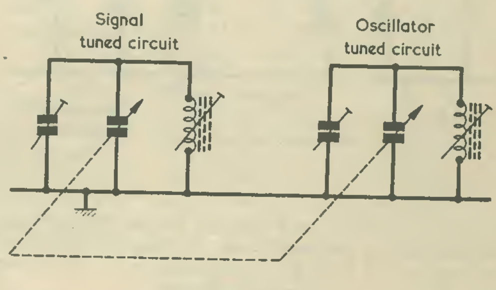
The provision of an oscillator tuned circuit covering a frequency range ratio as great as 1:8 would necessitate the use of a variable tuning capacitor having an exceptionally high maximum capacitance. In practice, it would be extremely doubtful if such a circuit could be made to function satisfactorily whilst employing standard low-cost components. At the same time, an oscillator tuned circuit covering a frequency range of 1:2 can be provided very simply. Since this frequency range ratio is lower than the signal frequency range ratio the variable tuning capacitance in the oscillator circuit can have a lower maximum value than the variable tuning capacitance in the signal frequency circuit. It follows from this simple numerical example that an oscillator tuned circuit having a frequency higher than the signal frequency tuned circuit is a much more attractive proposition than one having a lower frequency; and this point is borne out by the fact that, in all domestic long, medium and short wave receivers, the oscillator frequency is always higher than the signal frequency. The same applies to all conventional short-wave receivers as well. Some specialised receivers which cover a limited frequency range and in which tuning is carried out by a ganged variable capacitor may employ an oscillator running below signal frequency, but these represent an isolated case. Usually, such receivers operate at frequencies of the order of 100 Mc/s or above, where it is possible to obtain slightly greater oscillator stability with the lower oscillator frequency.

The numerical example just given demonstrates somewhat dramatically the desirability of having the oscillator frequency higher than the signal frequency. For instances where the signal frequency is considerably greater than the difference frequency the advantages of having the oscillator run higher tend to diminish, but this method of operation still requires that the maximum oscillator tuning capacitance be less than the signal frequency tuning capacitance. This last factor eases circuit design for all frequency ranges covered by standard ganged capacitors, and makes the choice of a high oscillator frequency that which is to be preferred.

Returning to domestic superhet receivers, there is a further subsidiary point which dictates that the oscillator frequency should be above signal frequency, and it is due to the fact that such receivers cover the long wave band of some 150 to 300 kc/s. If the oscillator were to run below signal frequency, the intermediate frequency would have to be less than 150 kc/s, which would be incompatible with requirements on the other bands covered by the receiver.

Figs. 2 (*a*) and (*b*) illustrate one practical method of ganging together signal frequency and oscillator tuned circuits in a superhet so as to obtain a fixed difference frequency between them. Although Fig. 2 (*a*) looks the same as Fig. 1 (*c*), where the resonant frequencies were the same, there are two important differences not apparent in the diagram. Firstly, the oscillator coil in Fig. 2 (*a*) has a lower inductance than the signal frequency coil so that, when the 2-gang capacitor is set to minimum value, the oscillator tuned circuit resonates at the desired higher frequency. Secondly, the tuning capacitor is designed such that its oscillator section has a lower maximum capacitance than the signal frequency section, with the result that when it is set to maximum value it still enables the oscillator tuned circuit to resonate above the signal frequency tuned circuit by the required difference frequency. Fig. 2 (*b*) shows how the smaller maximum capacitance for the oscillator section of the 2-gang capacitor is achieved, and illustrates that the moving vanes of this section are made smaller in size than those in the signal frequency section. It will be noted, in passing, that the lower frequency range ration required of the oscillator tuned circuit (when it runs above signal frequency) is reflected physically here in the lower maximum capacitance of the oscillator section of the 2-gang capacitor.

We set up the circuit of Fig. 2 (*a*) in the same manner as we did Fig. 1 (*c*). We first inject a signal at the high frequency end of the range to be covered, set the 2-gang capacitor for minimum value and adjust both trimmers for maximum receiver response. We next inject a signal at the low frequency end of the range, put the 2-gang capacitor to maximum value, and adjust the iron dust cores of both coils for maximum receiver response.



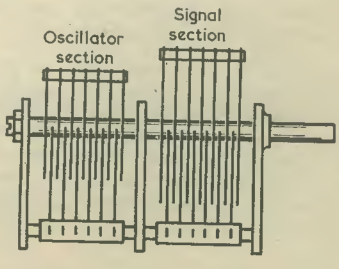
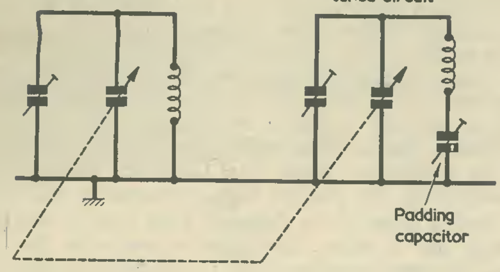
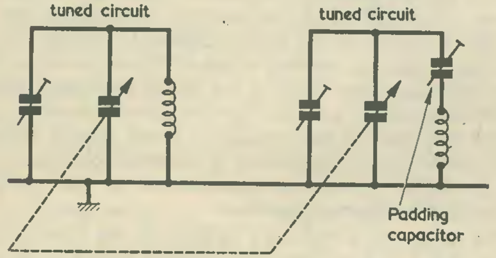


Fig. 2 (a). Signal frequency and oscillator tuned circuits in a superhet. The oscillator coil has a lower inductance than the signal frequency coil, and the oscillator section of the 2-gang capacitor has a lower value than the signal frequency section

(b). A side view showing the practical construction of the 2-gang capacitor





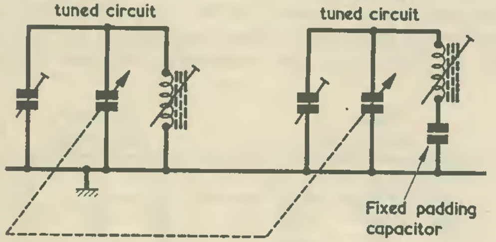


Fig. 3 (a). When both sections of the ganged tuning capacitor have the same value, tracking can be achieved by inserting a pre-set padding capacitor in series with the oscillator coil

(b). The padding capacitor of (a) has the same effect as if it were inserted in series with the upper end of the oscillator coil

(c). With coils having adjustable iron dust cores, it is possible to use a fixed padding capacitor

The operation is then repeated until no further improvement is obtained. If the shaping and dimensions of the two sets of 2-gang capacitor vanes are correct, the two circuits will then provide the required tracking which, in this case, means that they will offer the same difference in resonant frequency at all settings of the 2-gang capacitor.

The design approach shown in Figs. 2 (*a*) and (*b*) is eminently practicable and has been employed in quite a large number of commercially manufactured medium wave or medium and long wave superhets. A disadvantage is that the specially shaped 2-gang capacitor plates may only be manufactured to meet a single intermediate frequency and a single range of signal frequencies. Typically, 2-gang capacitors of this nature are manufactured to work over the medium wave band only, and for an intermediate frequency in the range of 450 to 475 kc/s. If the receiver has a long wave band, an additional trimming or fixed capacitor is connected in series with the long wave oscillator tuned coil when the latter is switched in, whereupon the oscillator circuit reverts to an alternative type which we shall next be considering. In America, where there is no long wave band as we have in Europe, the use of the Fig. 2 design technique has been quite widespread for medium-wave-only receivers. It should be added that a 2-gang capacitor of the specific type we are considering, and which is intended for medium wave operation, is of no use on the short wave bands.

A more common approach in superhet design is to employ a ganged capacitor whose sections all have the same maximum value of capacitance. An external capacitor is then inserted in series with the oscillator tuned coil to ensure that maximum oscillator tuning capacitance is less than occurs in the signal frequency tuned circuit. A typical example which was employed in earlier superhets having air-cored coils is illustrated in Fig. 3 (*a*). In this diagram both sections of the ganged capacitor have the same maximum value and the signal frequency tuned circuit basically is the same as in Fig. 2 (*a*). The oscillator tuned circuit has, however, a trimmer inserted in series between the ganged capacitor oscillator section and the oscillator coil.

It will be of assistance now to compare Fig. 3 (*a*) with Fig. 2 (*a*) by assuming that the signal frequency tuned circuits are identical, that trimming adjustments have been carried out, and that the oscillator coil in Fig. 3 (*a*) has the same inductance as the oscillator coil in Fig. 2 (*a*). When, in Fig. 3 (*a*), the ganged capacitor is set to maximum capacitance, the series trimmer can then be set up so that the total capacitance across the coil is the same as the total capacitance across the oscillator coil in Fig. 2 (*a*). The circuit of Fig. 3 (*a*) will then be virtually identical with that of Fig. 2 (*a*) both when the 2-gang capacitor is at minimum and when it is at maximum value.

In practice the circuit of Fig. 3 (*a*) is set up by working with injected signals in much the same manner as Fig. 2 (*a*), the trimmers being adjusted for maximum response at the high frequency end of the range covered and the series capacitor of Fig. 3 (*a*) at the lower frequency end of the range. (A disadvantage with the air-cored coils in Fig. 3 (*a*) is that no low frequency adjustment of the signal frequency tuned circuit is available). The series capacitance in the oscillator tuned circuit is known as the *padding capacitor* or *padder.** In a typical medium wave oscillator circuit its final adjusted value will be of the order of 400pF and, in a long wave circuit, of the order of 150pF. Adjustable padders are, in consequence, fairly bulky components.

The padding capacitor would be just as effective if connected in the manner shown in Fig. 3 (*b*), where it may be seen as being more obviously in series with the tuned circuit. It is preferable to have it at the chassis end of the coil however, as stray capacitances to chassis then more closely match the stray capacitances in the signal frequency tuned circuit.

The more modern version of Fig. 3 (*a*) appears in Fig. 3 (*c*). Here, the coils are fitted with adjustable iron dust cores, and the variable padder of Fig. 3 (*a*) is

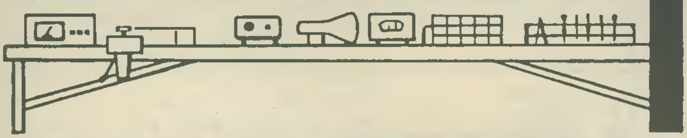
* The general term "padding", to define adjustment at the low frequency end of the range covered by a tuned circuit, derives from the use of the "padder" capacitor in earlier superhet oscillator circuits.

replaced by a fixed close-tolerance capacitor having a value specified for the particular coils employed. Once again, trimming is carried out at the high frequency end of the range to be covered, whilst padding is carried out (by adjusting the iron-dust cores) at the low frequency end.

NEXT MONTH

In next month's issue we shall conclude on the subject of tracking and shall then turn to the mixer stage itself.

In your workshop



As is to be expected, transistor amplifying circuits bear a marked resemblance to the valve circuits they supersede. This is particularly true of the f.m. "front end" stages in a.m./f.m. superhets, as Smithy demonstrates to his assistant, Dick

"POLITICS!"

Dick burst through the Workshop door, thumped himself down moodily on his stool and glared at the contents of the Workshop through belligerent eyes. One of which, it may be added, was surrounded by a corona of delicately tinted purple flesh.

"My goodness," remarked Smithy, staring critically at his newly arrived assistant, "you've certainly got a shiner there, haven't you?"

"I know I have," returned Dick indignantly. "And what infuriates me is that I picked it up just by trying to be helpful to other people."

"That," sighed Smithy, "is probably the most dangerous occupation that's going. How *were* you trying to help them?"

"I was attempting," said Dick aggrievedly, "to get a political discussion going."

"A political discussion?"

"That's right," replied Dick eagerly. "Now that there's all this talk of the vote going to people under twenty-one, I feel that it's my duty to get fully genned up on the political scene so that, when it's my turn to cast my own very first vote, I can do so from a fully informed background. And I think that others in my age group should be similarly clued-up."

"Very commendable," approved Smithy, glacing meaningly at the Workshop clock. "I hope that, when you *do* arrive at the polling booth to record that carefully reasoned vote of yours, you don't get there ten minutes late as you have done this morning."

A.M./F.M. PORTABLE

Taking the hint, Dick discarded his political aspirations for the moment and morosely donned his overall jacket. He then walked over to the "For Repair" racks. After some deliberation he eventually picked out a portable radio from whose upper surface projected several inches of a telescopic aerial together with a row of wave-change push-buttons. Burdened with this receiver, he returned to his bench.

Relative peace then descended on the Workshop, broken only by intermittent bursts of music from Dick's bench as he initially checked the performance of the set he had selected. These were followed by the removal of the receiver back and, later, Dick's departure from his bench towards the filing cabinet in which the service manuals were kept.

Dick returned to his bench and, for no less than ten consecutive minutes, there was complete silence.

Subconsciously aware that all did not appear to be well, Smithy glanced absently over his shoulder across the Workshop. Had Rodin decided that his Thinker would have possessed even greater impact with an open service sheet on his knee and with one eye puffy and contused, he could hardly have chosen a better model than Dick at that moment.

"What on earth," queried Smithy irritably, "is up with you?"

Disturbed from his absorption, Dick straightened himself and cast a reproachful glance at the Serviceman.

"It's this darned set," he replied. "I'm having the dickens of a job trying to understand how it works."

Smithy strode over and glanced briefly at the receiver on Dick's bench and then at the service manual, which Dick had opened out at the circuit diagram.

"Well, there's nothing complicated there," he said shortly. "It's just an ordinary transistor a.m./f.m. portable."

"Perhaps so," replied Dick. "But I've still got stuck with it. It works fine on a.m. but I can't get a peep out of it on f.m. I've had a quick look round for obvious snags and I just can't find anything wrong."

"Not even with the aid of the circuit diagram?"

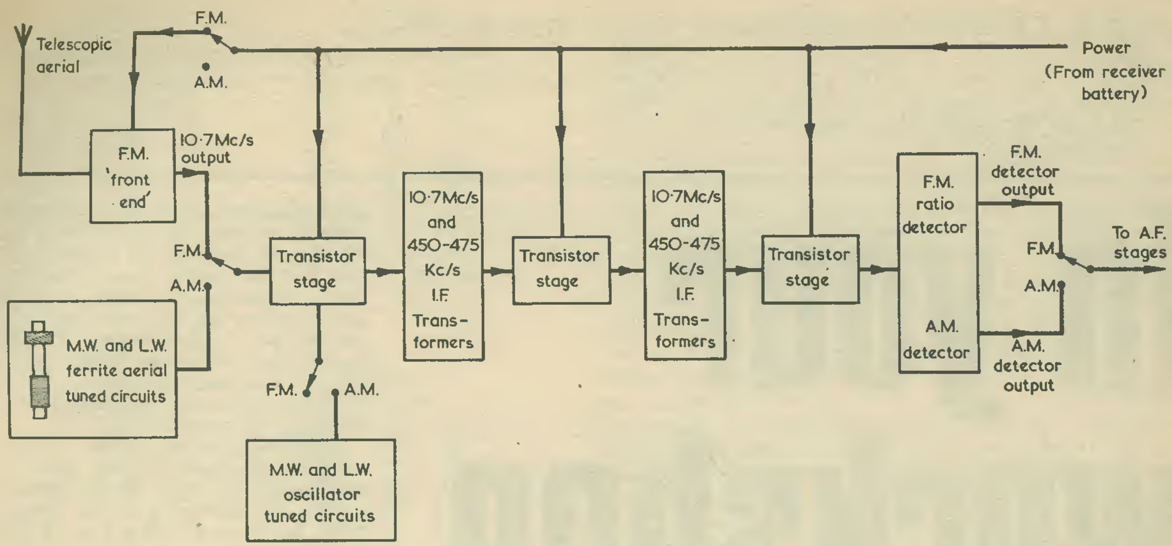
"It's that," replied Dick aggrievedly, "which has brought me shuddering to a halt! It's so *complicated*."

"Nonsense," returned Smithy sternly. "These a.m./f.m. transistor sets are no more difficult than the old valve versions used to be. In fact, they use pretty well the same stage line-up. Like the valve sets, for instance, they have a separate 'front end' section which covers the Band II range of 87.5 to 100 Mc/s, and which gives an output at the standard 10.7 Mc/s f.m. intermediate frequency. In most transistor sets, this 10.7 Mc/s i.f. then goes on to the a.m. mixer/oscillator transistor, which doubles as an f.m. i.f. amplifier when the set is switched to f.m. (Fig. 1 (*a*)). After this there are, normally, two further transistor stages of 10.7 Mc/s i.f. amplification up to the f.m. demodulator, which is always a ratio detector in sets of this class. A section of the wave-change switch then selects the output of this detector and passes it on to the a.f. amplifier."

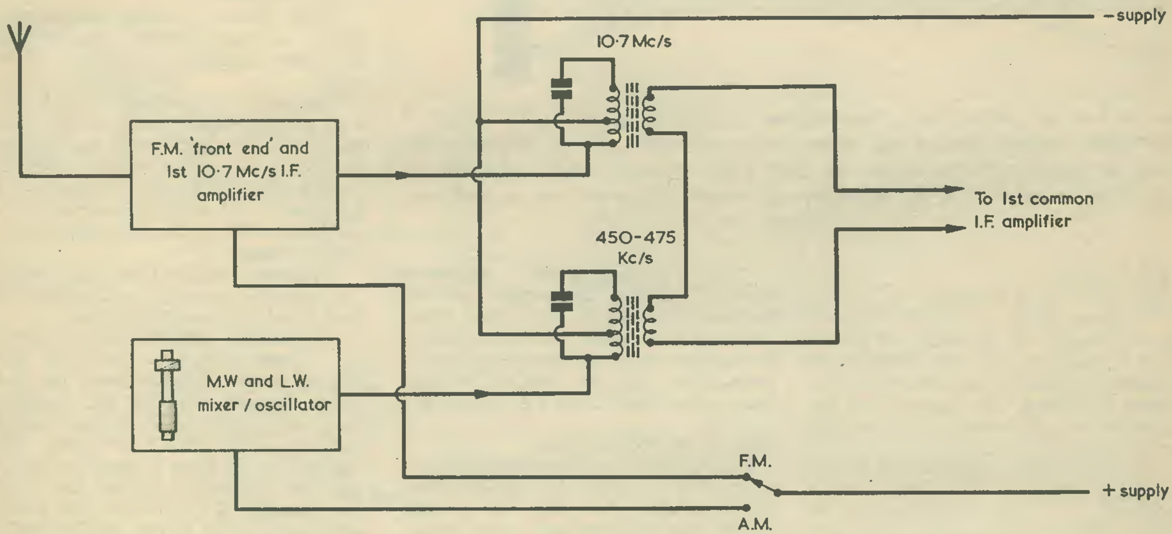
As Smithy spoke, Dick examined the service manual circuit. He was brightening quite perceptibly.

"Well that," he remarked, "seems easy enough. What about a.m. reception?"

"A.M. is automatically switched in," replied Smithy, "when you select the



(a)



(b)

Fig. 1 (a). Simplified block presentation of an a.m./f.m. transistor portable. The switches shown move to the a.m. position when medium or long waves is selected. On f.m. the first transistor stage after the "front end" functions as a 10.7 Mc/s i.f. amplifier. On a.m. this transistor stage couples into the medium and long wave aerial and oscillator tuned circuits and functions as a mixer/oscillator

(b). An alternative line-up that is sometimes encountered. The outputs to the two i.f. transformers are from p.n.p. transistor collectors

medium or long wave band. What happens then is that power is taken off the f.m. front end and the following transistor is disconnected from the f.m. front end output. This transistor is coupled instead into a conventional medium and long wave ferrite rod aerial circuit and to the medium and long wave oscillator tuned circuits. It then works in exactly the same way as the mixer/oscillator in an a.m.-only receiver and produces an i.f. output in the range of 450 to 475 kc/s according to the particular receiver design. This i.f. is next amplified by the two following transistor stages which previously amplified at 10.7 Mc/s, and is then fed to the a.m. detector, which is a standard series diode job. The section of the wave-change switch at the end of the i.f. amplifier selects the output of the a.m. detector instead of the output from the ratio detector, and passes it on to the a.f. amplifier."

Dick absorbed this information.

"Do all sets," he asked, "use the same transistor as first 10.7 Mc/s i.f. amplifier as well as a.m. mixer/oscillator?"

"Not entirely," replied Smithy. "That's the circuit configuration that is most commonly used, but you'll find that a few sets have a slightly different line-up. The normal alternative approach consists of incorporating a further transistor in the f.m. front end section, this operating simply as the first 10.7 Mc/s i.f. amplifier when f.m. is selected. Its collector feeds into a separate 10.7 Mc/s i.f. transformer primary, the secondary being in series with the secondary of the first a.m. i.f. transformer. (Fig. 1 (*b*)). The primary of this a.m. i.f. transformer is coupled to the collector circuit of a standard medium and long wave mixer/oscillator, and the signal from the two i.f. secondaries is applied to the first common i.f. amplifier. After this, you have another i.f. amplifier, followed by the ratio detector and a.m. detector circuits as before. The advantage of this method of working is that a.m./f.m. switching is simplified. So far as the r.f. side is concerned, f.m. is selected by merely applying power to the f.m. front end and its first i.f. amplifier. And a.m. is selected by applying power, instead, to the a.m. mixer/oscillator."

COMBINED I.F. STAGES

"I suppose," remarked Dick, "that the transistor i.f. stages employ the same techniques as are used in valve a.m./f.m. sets."

"Oh, definitely," agreed Smithy, pointing to the appropriate section in the circuit diagram in Dick's service manual. "The i.f. transformer windings are merely connected in series, the 10.7 Mc/s ones being closest to the collector of the i.f. transistor. (Fig. 2 (*a*)). This is just the same sort of thing that was given in valve a.m./f.m. sets. So the dual frequency i.f. amplifiers in these transistor a.m./f.m. sets don't introduce any unfamiliar techniques at all."

"The ratio detector and a.m. detector transformers are also in series, aren't they?"

"Their primaries are," corrected Smithy. "Their secondaries connect to their own individual diode circuits. Once again, there is quite a standard arrangement, with the 10.7 Mc/s ratio detector primary being the one which is nearest to the collector of the last i.f. transistor. (Fig. 2 (*b*)). As I've already mentioned, you have a switch section at the detector end which selects either the f.m. detector output or the a.m. detector output. There may also be one or two a.m./f.m. switch sections within the composite i.f. amplifier which change the a.g.c. circuit for the different systems. In all conventional receivers you will also encounter a further a.m./f.m. switch section which switches the windings of the first i.f. transformers. A typical example is a switch which short-circuits the first 10.7 Mc/s i.f. transformer primary when a.m. is selected."

Smithy turned his head and glanced carelessly at his assistant. Frowning, he concentrated his gaze and stared closely for some moments.

"Did you know," he remarked, critically, "that that eye of yours has just started to go green?"

"Don't keep looking at it," replied Dick testily, "as though it was a national catastrophe or something. It's just a black eye, that's all."

"I'll say," agreed Smithy warmly. "It's the best one I've seen for years! Seeing that you didn't have it when you left the Workshop yesterday evening, my logical mind arrives at the conclusion that you must have picked it up last night."

"Your logical mind," replied Dick irritably, "is dead right."

"Where at?"

"If you *must* know, it was at Joe's Caff."

Smithy's eyebrows rose.

"Joe's Caff?" he queried. "I thought you hadn't been there for ages."

"We stay away for a bit," explained Dick despondently. "But, somehow or other, we always seem to start going back again after a spell."

"Didn't Joe have a lot of trouble some time ago because of the rougher element amongst his customers?"

"That was in the days," replied Dick, "when he was running the place as 'The Adelphi Boutique And Salt-Beef Counter'. He's gone all Guru-minded and transcendental since then, and he's changed its name to 'The Ganges Fried-Fish Garden', with square bottles of mango chutney on all the tables. The trouble now," concluded Dick sourly, "is that you have to wait such a long time before he serves you. He's always flaming well meditating."

Dick's face brightened for a moment.

"At any rate," he went on. "The Indian bit got rid of the rougher element."

"Because of the lack of service?"

"Not entirely," replied Dick darkly.

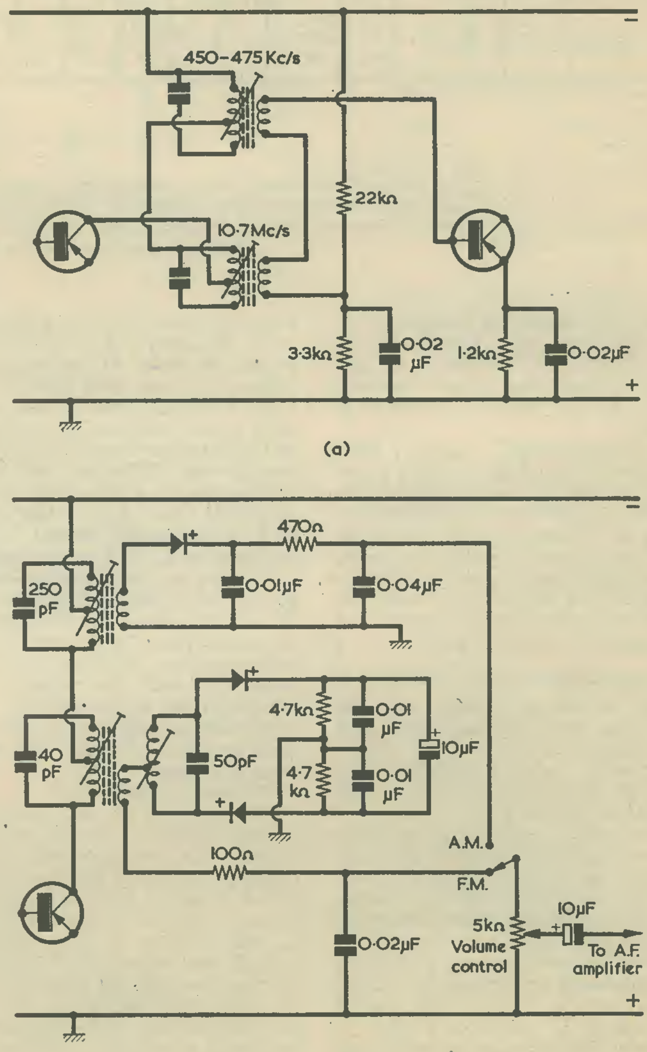


Fig. 2 (a). Typical interstage coupling in an a.m./f.m. i.f. amplifier. Signal transfer is provided at either of the two intermediate frequencies (b). A typical final i.f. stage, showing the simple a.m./f.m. switching employed. Component values are representative

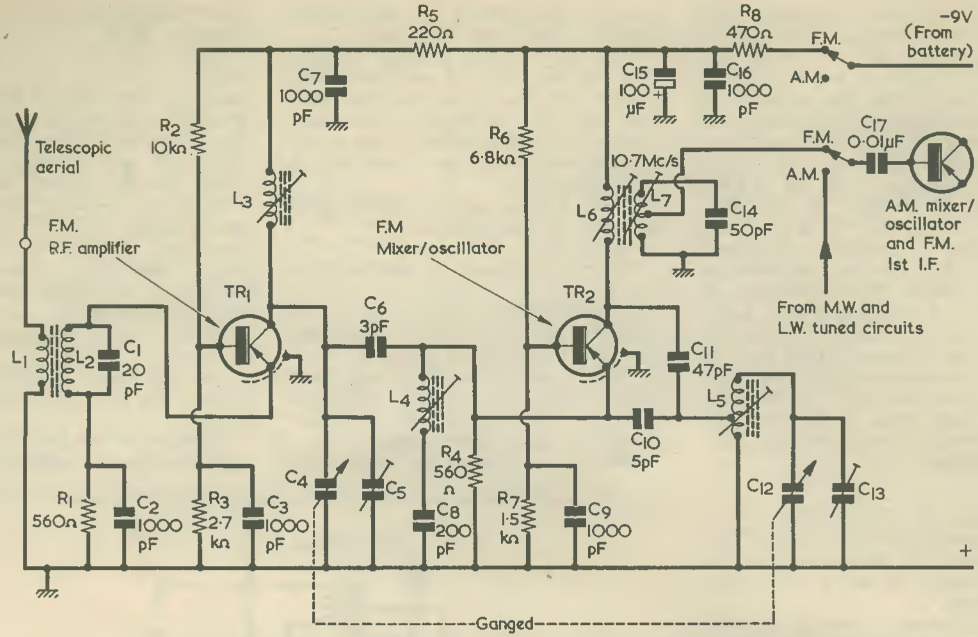


Fig. 3. Simplified circuit, with representative component values, illustrating basic commercial practice for f.m. "front end" design. There will be slight differences in actual commercial circuits encountered, largely in coil chassis returns, tuning capacitor padding, and the like

"It was Joe's curry that fixed *them*."

"It all seems very complicated to me," commented Smithy. "At any event, you and your crowd *do* seem to have got the place to yourselves at long last."

"I suppose so," agreed Dick grudgingly. "At first it wasn't too good though because immediately after the rougher element moved out a gang of college students moved in. A right menace we thought *they* were, too, with great long scarves and beards like Henry the Eighth and beefing on all the time about their grants, but we've got used to them now."

F.M. CIRCUIT

With an effort, Smithy tore his mind away from the intricacies and entanglements of Dick's social life.

"Oh well," he said briskly, "we'd better get back to this set we're supposed to be servicing."

"As you like," agreed Dick equably. "You've already explained how the i.f. stages work, and how they handle both the a.m. and the f.m. intermediate frequencies. What about the f.m. front end itself?"

"That," replied Smithy, indicating the appropriate section of the service manual circuit (Fig. 3), "is pretty easy. Again, it's roughly similar to the sort of f.m. front end you encounter in valve a.m./f.m. sets. If you look at the circuit, you'll see that the telescopic aerial is coupled to an input tuned circuit consisting of the dust cored coil, L_2, with a capacitor across it. This tuned circuit has a broad response and is pre-tuned to about the centre of Band II, so that it lets all Band II signals through. Valve f.m. front ends have a similar type of pre-set tuned circuit immediately after the aerial. The aerial signal is then passed on to TR_1, which is usually an AF114 or AF124, and which acts as a grounded base r.f. amplifier. The signal at the collector of TR_1 is then fed to coil L_3, which is tuned by C_4. C_4 is one section of the two-gang tuning capacitor controlled from the receiver panel, and the tuned circuit is completed by way of bypass capacitor C_7. This tuned circuit resonates at signal frequency, and the collector signal is next passed to the emitter of TR_2, which similarly operates as a grounded base amplifier. It also acts as f.m. mixer/oscillator."

"How does it do that?"

"If you look at the circuit," explained Smithy, "you'll notice the capacitor C_{11} which couples from the collector of TR_2 to a tap in the tuned circuit given by L_5 and C_{12}, and the further capacitor C_{10} which goes back to the emitter of TR_2. Now, the emitter and collector of a transistor in grounded base are always in phase, so these two capacitors provide a positive feedback loop and cause the transistor to oscillate. The frequency of oscillation is then governed by L_5 and C_{12}, which form the oscillator tuned circuit. C_{12} is the second section of the two-gang tuning capacitor. C_{13}, incidentally, is just a trimmer."

"Gosh," remarked Dick, "that's a neat feedback arrangement, isn't it?"

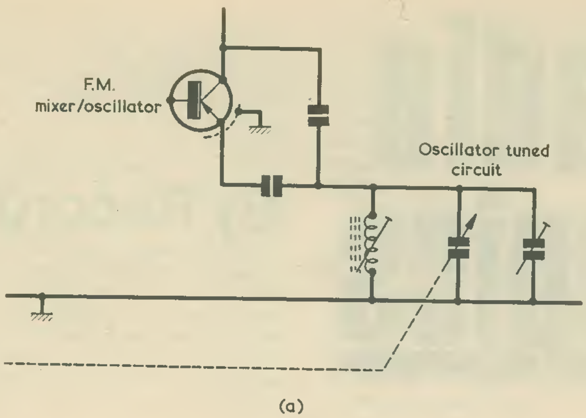
"It is, rather," agreed Smithy. "The capacitive feedback idea dispenses completely with coupling windings and it also enables one end of the oscillator tuned coil to be at chassis potential. In all the transistor f.m. front ends I've worked with, feedback for the f.m. mixer/oscillator has always been by way of capacitive coupling from the collector back to the emitter, with a single tuned circuit popping up somewhere in the loop. Sometimes, all the tuned circuit is in circuit (Fig. 4 (*a*)) and sometimes the collector goes to the tap only (Fig. 4 (*b*)), but the general idea remains the same. Occasionally, one of the series capacitors in the loop is a trimmer, this being normally the one which couples to the emitter. This trimmer is set up at the factory for best results with the particular transistor employed. Incidentally, the mixer/oscillator transistor is usually an AF115 or an AF125."

"That's funny."

"What's funny?"

"You said just now that the r.f. amplifier was usually an AF114 or AF124. It's peculiar that there should be a difference of ten in the type numbers of these alternative transistors you keep mentioning."

"I see your point," said Smithy. "Actually, there's a group of eight transistors which have the same relationship, these being the AF114 to AF117 and the AF124 to AF127. Electrically, the AF114 and AF124 are virtually the same, as are the



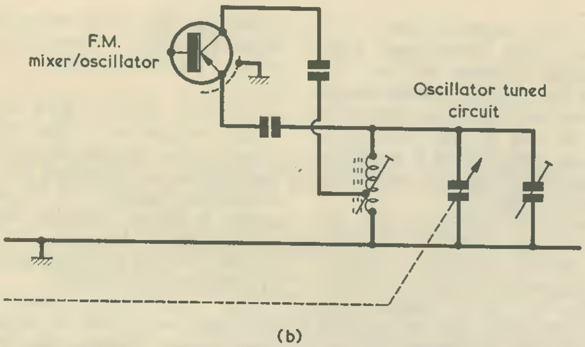


Fig. 4 (a). In some receivers, the whole oscillator tuned coil appears in the positive feedback loop
(b). An alternative oscillator feedback circuit

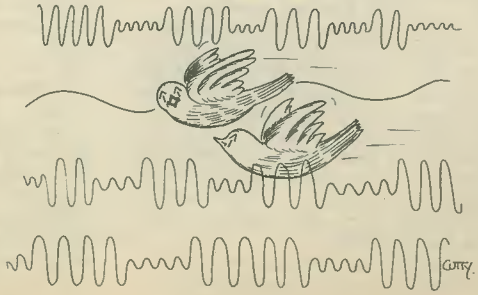
AF115 and AF125, the AF116 and AF126, and the AF117 and the AF127. They are all p.n.p. alloy diffused types, the four with the lower numbers being in a relatively bulky TO-7 can and the four with the higher numbers being in a smaller TO-18 can which is about half the size of the TO-7. The AF114 and AF124 are intended as r.f. amplifiers in a.m./f.m. sets, the AF115 and AF125 as mixer/oscillators in a.m./f.m. sets, the AF116 and AF126 as i.f. amplifiers in f.m. sets, and the AF117 and AF127 as mixer/oscillators, or i.f. amplifiers, in medium and long wave sets."

"Since the i.f. stages of an a.m./f.m. set have to handle 10.7 Mc/s, will these normally use AF116's or AF126's as i.f. transistors?"

"That's right," agreed Smithy. "When the first i.f. doubles as mixer/oscillator on medium and long waves, this will usually be an AF116, or an AF126, as well."

"That's an interesting little snippet of information." said Dick musingly. "I must remember that these two ranges of transistors are electrical equivalents. It should ease the replacement problem a bit."

(To be Concluded)



"Quite a bit of radio traffic this evening."

Radio Topics

By Recorder

SMITHY'S I.C. AMPLIFIER

Readers have exhibited considerable interest in the "In Your Workshop" feature which we published last February. You may recall that it was in this issue that Smithy demonstrated his a.f. amplifier incorporating the R.C.A. integrated circuit type CA3020.

The output transformer used by Smithy was the Ardente D3035, which is readily available through home-constructor retail channels. This, with a ratio of 7.3:1, presents an impedance of 159Ω to the output terminals of the integrated circuit when its secondary is loaded by a 3Ω speaker. Several readers have pointed out that a closer match is given with the Radiospares transistor transformer type T/T2. The T/T2 has a ratio of 6.6:1, whereupon it presents an impedance of 131Ω to the i.c. when coupled to a 3Ω speaker. (Radiospares components may only, incidentally, be obtained via retailers.)

Actually, the output impedance requirements for the CA3020, as shown by R.C.A. curves, are not excessively critical. When employed with a power supply of 9 volts, and with a 1Ω negative feedback resistor in series with terminals 5 and 6, this i.c. delivers an optimum power of about 470mW into an output load of 130Ω. At a load of 160Ω this drops to 450mW and, at 180Ω, to 420mW. On the low impedance side, output power is about 440mW at 80Ω, below which it drops sharply. Output load impedance should be between some 100 and 180Ω for best results.

The Radiospares T/T2 transformer is nominally a 200mW component, whilst the Ardente D3035 is nominally a 300mW component. The Ardente transformer works perfectly well with the CA3020 and, whilst we have not checked the Radiospares transformer ourselves, there seems little reason to doubt that it should not work equally well, even if its nominal wattage rating is exceeded a little.

There was a misprint in the "In Your Workshop" article in question, this appearing in one of the diagram captions. The last sentence in the caption to Fig. 4 should read: "Terminal 11 is unconnected".

MILLION VOLT TEST SET

As anyone who has twirled the handle of a Megger knows only too well, the best way of checking for insulation leakage in cables is to apply a higher voltage than normal and see what happens. What do we do, however, if the cable in question is rated for a.c. at 400kV?

The fascinating answer to that question was given by an exhibit at the recent International Electrical Engineers (A.S.E.E.) Exhibition held at Earls Court from March 27th to April 3rd, and consists of what is modestly called a "test set" capable of delivering one million volts d.c. on open-circuit, or 800kV at 8mA. This last voltage is essential for cables with working voltages of 400kV a.c. which, to meet British Standards requirements, must be tested at 800kV d.c. The unit is designed by British Insulated Callender's Construction Co. Ltd., and consists of two main parts—the towing vehicle and the main high-voltage assembly. The vehicle is fitted out as a mobile control desk and has seating accommodation for personnel witnessing the cable test while it is in progress, together with storage space for ancillary equipment as required.

An engine-driven power take-off drives an alternator which, when there is no local supply, provides power for the high voltage unit transformer. Alternatively, the high voltage unit transformer can be fed at 400 c/s from a rotary frequency changer. The high voltage secondary of the transformer feeds, via an oil-filled busbar, the rectifier section, this consisting of a Cockroft-Walton multiplier with an arrangement for reversing the polarity off-load. The rectifier components are contained in an oil-filled porcelain housing, and the whole high voltage unit is surmounted by a large diameter "anti-corona" spinning which is raised for testing and can be lowered by about 2ft to reduce overall height while in transit.

All this high voltage equipment is mounted in a trailer which can also be raised and lowered as desired. It is raised to increase clearance when operating at maximum output voltage and lowered to negotiate low bridges.

A variable liquid discharge "resistor" is employed to discharge the stored energy in the cable after the test voltage has been applied and the test completed, and this "resistor" consists of a unit which, at first, circulates de-ionised water of low conductivity through insulating tubes connected to the cable under test. The de-ioniser equipment is then removed from the water circuit and metered quantities of conducting solution are introduced into the water to lower its resistance as required and thus discharge the stored energy. The heat generated is extracted from the water by a heat exchanger. On completion of the discharge, the de-ioniser is again switched into circuit, lowering the conductivity of the water ready for a further test.

The process of checking cables at astronomic voltages of this level is hardly the sort of thing we encounter in the amateur workshop. But it's certainly very enlightening to learn what goes on in the heavy side of an industry which, as in radio, is primarily devoted to making electrons rush around at the desired quantity and in the required direction.

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.

F.M. Signal Generator.—E. M. Vivian, 1108a C. Mamelodi, Pretoria, Rep. S. Africa – would like to obtain the circuit of such a unit incorporating crystal control at 10.7 Mc/s, 87, 98 and 105 Mc/s.

Signal Generator Type CT53, Ref. 10S/16160—G. B. Brierley, 99 Chessel Street, Bristol 3 – purchase of manual, circuit, etc. Circuits, if loaned will be returned within 5 days.

BC799 and BC639A—D. J. Cooke, 3 Mill Close, Hartford, Huntingdon – manuals, circuit diagrams, alignment data. Loan or purchase.

Emerson Model EW-H505L Transistor Receiver—R. Cowen, 22 Michael Road, Burton Grange, Barnsley, Yorks. – this 8-transistor is fitted with 2 speakers, is an all-wave 3 band model and bears the legend "Emerson & Watham EW-H505L". Loan of the circuit or service sheet is urgently required.

Power Unit 619, 12V, Ref. No. 10KB/6180.—R. Begg, Ravenstone Estate, Whithorn, Newton Stewart, Wigtownshire, Scotland – circuit diagram or any information.

18 Set, Mk III Transceiver.—A. W. Bawden, 232 Exwick Road, Exeter, Devon – loan or purchase of handbook also circuit of suitable power supply and any other information.

CT54 Ex Air Ministry Valve Voltmeter.—A. Secker, 98 Warwick Avenue, Edgware, Middx.—any details. Also Monitor Unit II, ref. Z3/ZC.36723 Unit C2, and data or correspondence from other owners etc.

Philco Radio, Type 91-E.—E. C. Schembri, 39 Church Street, Zebbug, Malta – loan or purchase of circuit diagram or handbook of this American made radio (uses 3 x 37, 2 x 44, 36, 42 and 80 type valves).

Indicator 266/10QB6382.—J. Monagham, 22 Chain Bar Lane, Hattersley, Mottram via Hyde, Cheshire – loan or purchase of circuit diagram or any other information.

"The Radio Constructor".—L. Ashton, 54 Ellesmere Road, Altrincham, Cheshire – purchase of back issues from January, 1961 to July, 1961, inclusive.

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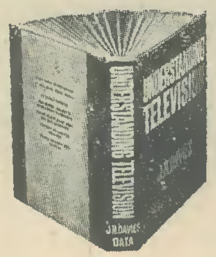

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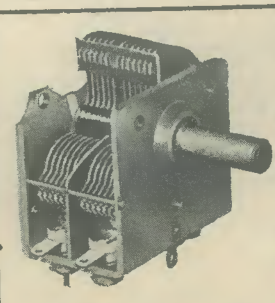

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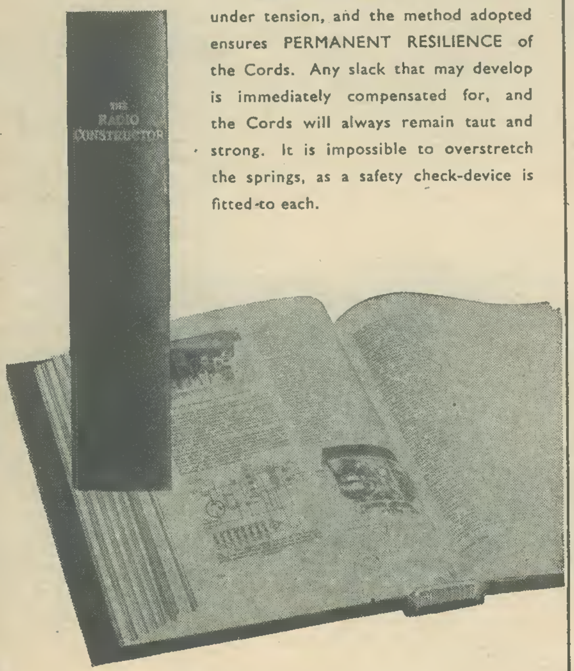

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