155P

THE Radio Constructor

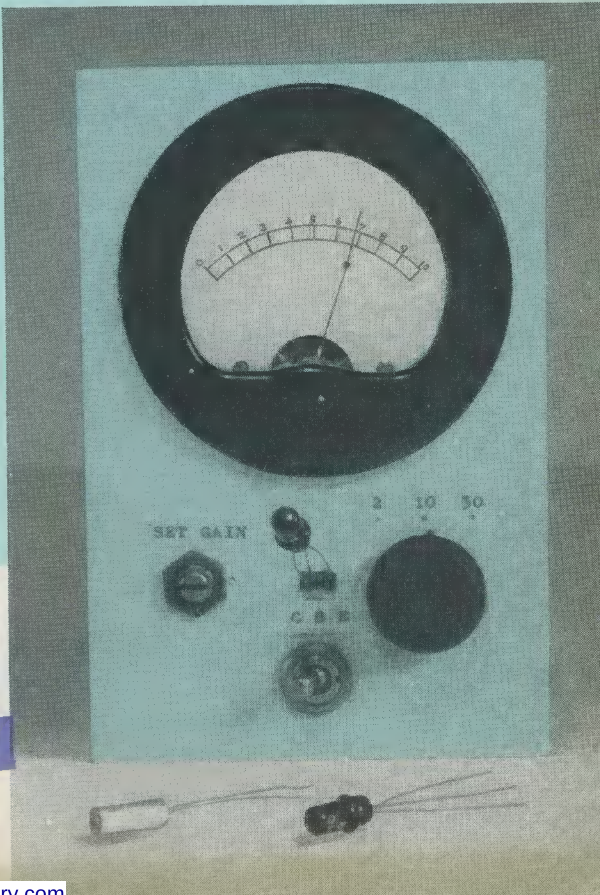
RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 18 NUMBER 10
A DATA PUBLICATION
TWO SHILLINGS & THREEPENCE

Frequency Sub-Standard ★ Improving the AR88 ★ Transistor P.A. Amplifier ★ Simple Echo Unit

May 1965

Dynamic Gain Transistor Tester



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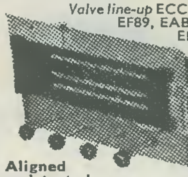
7 VALVE AM/FM RADIOGRAM CHASSIS

Valve line-up ECC85, ECH81 EF89, EABC80, EL84 EM81, EZ80



Three Waveband & Switched Gram positions. Med. 200–550m. Long 1,000–2,000m. VHF/FM 88–95 Mc/s. Phillips Continental Tuning insert with permeability tuning on FM & combined AM/FM IF transformers. 460 kc/s and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC & Neg. Feedback. 3 watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½" x 6½". Height 7½". Edge illuminated glass dial 11¼" x 3½". Vert. pointer Horiz. station names. Gold on brown background. A.C. 200/250V operation. Magic-eye tuning. Circuit diag. now available.

Aligned and tested ready for use. **£13.10.0** *Carr. & Ins.* 7/6.

Comp. with 4 knobs—walnut or ivory to choice. Indoor FM aerial **3/6** ex. 3Ω P.M. Speaker only required. Recommended Quality Speakers 10" Rola, **27/6.** 13½" x 8" E.M.I. Fidelity, **37/6.** 12" R.A. with conc. Tweeter, **42/6.** Carr. 2/6.

ANOTHER TAPE RECORDER BARGAIN

Manufacturers' end of production Surplus Offer

A 24 gns. Tape Recorder offered at the bargain price of only **15 gns.** plus 10/– carr. Supplied in 3 Units already wired and tested. A modern Circuit for quality recording from Mike Gram or Radio, using latest B.S.R. Twin Track Monardeck Type TD2. Valve line-up—EF86, ECL82, EM84, EZ80 and Silicon Diode. **Send for detailed list—3d. stamp.**

Complete Kit comprising items below

BARGAIN PRICE 15 Gns. + 10/– Carr.

2-tone Cabinet and 8" x 5" Speaker. Size 14" x 10½" x 7½" ...	£3 5 0 + 5/– Carr.
Wired Amplifier complete with 4 Valves, front Panel, Knobs, etc. ...	£5 19 6 + 3/6 Carr.
B.S.R. Monardeck Type TD2 ...	£7 7 0 + 4/6 Carr.
Accessories: Mike, Tape, empty Reel, screened Lead and Plugs, Instructions, etc. ...	£1 0 0 + 2/– Carr.

Jack Plugs. Standard 2½" Igranic Type, **2/6.** Screened Ditto, **3/3.** Miniature scr. 1½", **2/3.** Sub-min. **1/3.**

Jack Sockets. Open Igranic Moulded Type, **3/6.** Closed Ditto, **4/–.** Miniature Closed Type, **1/6.** Sub-min. (deaf aid) ditto, **1/6.** Stereo Jack Sockets, **3/6.** Stereo Jack Plugs, **3/6.**

Phono Plugs, 9d. Phono Sockets (open), **9d.** Ditto (closed), **1/–.** Twin Phono Sockets (open), **1/3.**

Grundig Continental. 3 p. or 5 p. plug, **3/6.** Sockets, **1/6.**

Soldering Irons. Mains 200/220V or 230/250V. Solon 25 watt Inst., **22/6.** Spare Elements, **4/6.** Bits, **1/–** 65 watt, **27/6** etc.

Alumin. Chassis. 18g. Plain Undrilled, folded 4 sides, 2" deep, 6" x 4", **4/6**, 8" x 6", **5/9**, 10" x 7". **6/9**, 12" x 6", **7/6**, 12" x 8", **8/–** etc,

Alumin. Sheet. 18g. 6" x 6", **1/–**, 6" x 9", **1/6**, 6" x 12", **2/–**, 12" x 12". **4/6** etc.

RECORDING TAPE

Famous American Columbia (CBS) Premier quality tape at NEW REDUCED PRICES. A genuine recommended Quality Tape—TRY IT Brand new, boxed and fully guaranteed. Fitted with leader and stop foils.

Standard		Double Play		Long Play	
5" 600'	13/–	1,200'	31/6	900'	17/6
5¾" 900'	16/–	1,800'	37/6	1,200'	19/6
7" 1,200'	21/–	2,400'	47/6	1,800'	28/6

Post & Package per reel, 1/– plus 6d. each for additional reels.

SPECIAL OFFER. 3" Message tape 150', 3/9; 3" L.P. 225', 4/9; 3" D.P. 300', 6/6. P. & P. per reel 6d.

TAPE REELS. Mnfrs. surplus 7", **2/3**; 5¾", **2/–**; 5", **2/–**; 3", **1/3**; Plastic spool containers, 5", **1/9**; 5¾", **2/–**; 7", **2/3.**

New Boxed VALVES Reduced Bargain Prices

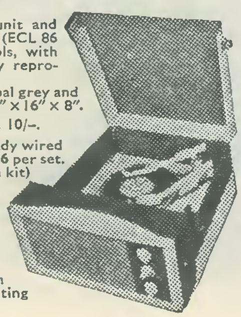
1T4	3/6	EF80	7/6	PCF80	8/–
1R5	6/–	EF86	8/6	PCL83	10/6
1S5	6/–	EL33	12/6	PCL84	10/–
3S4	7/–	EL34	12/6	PCL85	11/6
3V4	7/–	EL84	7/–	PL36	10/6
ECC81	7/–	EY51	9/–	PL81	9/6
ECC82	7/–	EY86	9/–	PL83	8/–
ECC83	7/–	EZ80	7/–	PY33	10/6
ECL80	9/–	EZ81	7/–	PY82	7/–
ECL82	10/–	GZ32	9/6	U25	10/6
ECL86	10/6	PCC84	8/–	UL84	9/–

Electrolytics All Types New Stock

TUBULAR		CAN TYPES	
25/25V	1/9	8+8/450V	4/6
50/12V	1/9	16+16/450V	5/6
50/50V	2/–	32+32/275V	4/6
100/25V	2/–	50+50/350V	6/6
8/450V	2/3	60+250/275V	12/6
4/350V	2/3	100+300/275V	12/6
16+16/450V	5/6		
32+32/450V	6/6	2000+4000/6V	3/6
1000/25V	3/9		

Ersin Multicore Solder 60/40, **4d.** per yard. Cartons **2/6**, etc.

DE LUXE R/PLAYER KIT



Incorporating 4 Speed Garrard Auto-Slim unit and Mullard latest 3 watt printed circuit amplifier (ECL 86 and EZ 80), volume, bass and treble controls, with 8" x 5" 10,000 line speaker. Superb quality reproduction.

Contemporary styled two-tone cabinet, charcoal grey and off-white with matching blue relief. Size: 17½" x 16" x 8".

COMPLETE KIT £13.19.6 Carr. & ins. 10/–.

Illuminated Perspex escutcheon, **7/6** extra. Ready wired **30/-** extra. 4 Contemporary legs (6" or 13") **12/6** per set. Catalogue & construction details **2/6** (free with kit)

STANDARD RECORD PLAYER KIT

Using BSR UA14 Unit, complete kit **£11.10.0**, carr. 7/6. Ready wired Amplifier, 7" x 4" quality Speaker and O/P trans., **£3.19.6**, carr. 2/6. BSR UA14 Unit, **£6.10.0**, carr. & ins. 5/–. Rexine covered cabinet in two-tone maroon and cream, size 15¾" x 14¾" x 8½" with all accessories plus uncut record player mounting board 14" x 13", **59/6**, carr. & ins. 5/–.

6 VALVE AM-FM TUNER UNIT

Med. and VHF 190m–550m, 86 Mc/s–103 Mc/s, 6 valves and metal rectifier. Self-contained power unit, A.C. 200/250V operation. Magic-eye indicator, 3 push-button controls, on/off, Med., VHF. Diodes and high output Sockets with gain control. Illuminated 2-colour perspex dial 11½" x 4", chassis size $11\frac{5}{8}$" x 4" x 5¾". A recommended Fidelity Unit for use with Mullard "3-3" or "5-10" Amplifiers. Available only at present as built-up units, aligned and tested ready for use.

Bargain Price £12.10.0. Carr. 5/–. **We hope to produce this popular unit in kit form very shortly.**

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1¼" diam. Guar. 1 year. LOG or LIN ratios less Sw. **3/–.** DP. Sw. **4/6.** Twin Stereo less Sw. **6/6.** D.P. Sw. **9/6** (100 k. to 2 Meg. only). ½ Meg. VOL Controls D.P. Sw. ½" flatted spindle. Famous Mfrs. 4 for **10/–** post free.

COAX 80 OHM CABLE

High grade low loss Cellular air spaced Polythene — ¼" diameter. Stranded cond. Famous mfrs. **Now only 6d. per yard.**

Bargain Prices—Special lengths:
20 yds. **9/–.** P. & P. 1/6.
40 yds. **17/6.** P. & P. 2/–.
60 yds. **25/–.** P. & P. 3/–.
Coax Plugs **1/–.** Sockets **1/–.** Couplers **1/3.** Outlet Boxes **4/6.**

Condensers—S/Mica all values 2pF to 1,000pF **6d.** Ditto Ceramic **9d.** each, .005, .01 and .1, etc., **1/–.** Paper Tubular 450V .001 mfd to .01 mfd and .1/350V **9d.** .02–.1 mfd **1/–**, .25 mfd **1/6**, .5 mfd **1/9.**

Close Tol. S/Micas—10% 5pF–500pF **8d.** 600–5,000pF **1/–.** 1% 2pF–100pF **9d.** 100pF–500pF **11d.** 575pF–5,000pF **1/6.** **Resistors—Full Range** 10 ohms–10 megohms 20% ¼ and ½W **3d.**, ditto 10% **4d.**, ¾W **5d.** (Midget type modern rating) 1W **6d.**, 2W **9d.** **Hi-Stab** 5% ¼–½W 100 ohms 1 megohm **6d.** Other values **9d.** 1% ½W **1/6.** **W/W Resistors** 25 ohms to 10K 5W **1/3**, 10W **1/6**, 15W **2/–.** **Pre-set T/V Pots. W/W** 25 ohms–50K **3/-.** 50K-2 Meg. (Carbon) **3/-.**

Speaker Fret—Expanded gilt anodised metal ¼" x ⅛" diamond mesh, 4/6 sq. ft., multiples of 6" cut. Max. size, 4ft. x 3ft. **47/6.** Carr. extra. Ditto, finer mesh, 4/6 sq. ft. Multiples 12" only, max size 3ft x 2ft. **27/6.** Plus Carr.

TYGAN FRET (contemp. pat.) 12" x 12" **2/–**, 12" x 18" **3/–**, 12" x 24" **4/–**, 18" x 18" **4/6**, etc.

BONDACOUST Speaker Cabinet Acoustic Wadding, superior grade, 1" thick, 18" wide, any length cut **2/3** per ft, **6/–** per yd.

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TINNED COPPER WIRE—14–22g **2/6** ¼ lb.

PVC CONNECTING WIRE—10 colours (for chassis wiring, etc.)—Single or stranded conductor, per yd., **2d.** Sleeving, 1mm. and 2mm., **2d.** yd., etc.

KNOBS—Modern Continental types: Brown or Ivory with Gold Ring, 1" dia., **9d.** each; 1⅜", **1/–** each; Brown or Ivory with Gold Centre, 1" dia., **10d.** each; 1⅛", **1/3** each. LARGE SELECTION AVAILABLE.

TRANSISTOR COMPONENTS

Midget I.F.'s—465 kc/s $\frac{9}{16}$" diam.	**5/6**
Osc. Coil—$\frac{9}{16}$" diam. M/W.	**5/3**
Osc. coil M. & L.W.	**5/9**
Midget Driver Trans. 3.5:1	**6/9**
Ditto O/Put Push-pull 3 ohms	**6/9**

Elect. Condensers—Midget Type 15V 1mfd–50mfd, ea. **1/9.** 100mfd. **2/–.**

Ferrite Aerial—M. & L. W. with car aerial coupling coil, **9/3.**

Condensers—150V. wkg. .01 mfd. to .04 mfd., **9d.** .05 mfd., .1 mfd., **1/–.** .25 mfd., **1/3.** .5 mfd., **1/6**, etc.

Tuning Condensers. J.B. "00" 208+176pF, **8/6.** Ditto with trimmers, **9/6.** 365pF single, **7/6.** Sub-min. ¾" DILEMIN 100pF, 300pF, 500pF, **7/–.**

Midget Vol. Control with edge control knob, 5kΩ with switch, **4/9**, ditto less switch, **3/9.**

Speakers P.M.—2" Plessey 75 ohms, **15/6.** 2½" Continental 8 ohms, **13/6.** 7" x 4" Plessey 35 ohm, **23/6.**

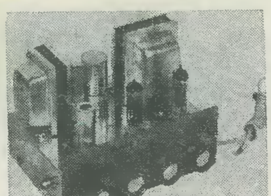
Ear Plug Phones—Min. Continental type, 3ft. lead, jack plug and socket. High Imp. **8/–.** Low Imp., **7/6.** High sensitivity M/coil 8–10 ohms, **12/6.**

JASON FM TUNER UNITS

Designer-approved kit of parts:
FMT1, 5 gns. 4 valves, **20/–.**
FMT2, 7 gns. 5 valves, **35/–.**
JTV MERCURY 10 gns. 3 valves, **22/6.**
JTV2 £13.19.6. 4 valves, **28/6.**
NEW JASON FM HANDBOOK, 2/6. 48 hr. Alignment Service **7/6.** P. & P. **2/6.**

MULLARD "3—3" & "5—10" HI-FI AMPLIFIERS

3 OHM AND 15 OHM OUTPUT



"3–3" Amp. 3-valve, 3 watt, Hi-Fi quality at reasonable cost. Bass Boost and Treble controls, quality sectional output transformer, 40 c/s–25 kc/s ± 1dB. 100mV for 3W, less than 1% distortion. Bronze escutcheon panel.

Complete Kit only £6.19.6. Carr. 5/–. **Wired and tested 8 gns.**

MULLARD "5-10" AMPLIFIER—5 valves 10W, 3 and 15 ohms output. Mullard's famous circuit with heavy duty ultra-linear quality output tfr.

Basic amplifier kit price £9.19.6. Carr. 7/6. **Ready built 11½ gns.**

CONTROL PANEL KIT

Bass, Treble and Volume controls with 4-position selector switch for radio, tape and pick-up and 11" x 4" escutcheon panel.

Amplifier Kit and Control Panel Kit £11.19.6. Ditto ready wired £14.19.6.

2-VALVE PRE-AMP. UNIT

Based on Mullard's famous 2-valve (2 x EF86) circuit with full equalisation with volume, bass, treble, and 5-position selector switch. Size 9" x 6" x 2¼".

Complete Kit £5.19.6. Carr. 3/6. **Ready built £7.19.6.**

TRS Est. 1946

Send for detailed bargain lists, 3d. stamp. We manufacture all types Radio Mains Transf. Chokes, Quality O/P Trans., etc. Enquiries invited for Specials, Prototypes for small production runs. Quotation by return.

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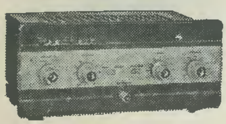
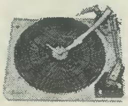
HI-FI AMPLIFIERS — RECORD PLAYERS — RADIO TUNERS

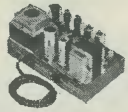
S-33



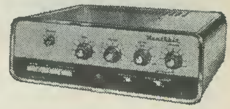
AT-6



MA-12



S-99



GOLDRING LENCO TRANSCRIPTION PLAYER. Model GL-58. With G-60 pick-up arm and Ronette 105 cartridge. **£20.1.3** incl. P.T.

GARRARD AUTO/RECORD PLAYER. Model AT-6. With R 105 cartridge **£13.12.1** Decca Deram pick-up **£14.6.1** incl. P.T.

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Presentation similar to S-33 Kit **£10.19.6** Assembled **£15.10.0**

HI-FI MONO AMPLIFIER. Model MA-12. 12W output, wide freq. range, low distortion. Kit **£11.18.0** Assembled **£15.18.0**

R.P.M. INDICATOR (Electronic Rev. Counter). A must for the motoring enthusiast. For 4 cylinders, pos. or neg. earth. 12V. Send for details. (Assembled only) **£8.19.0**

HI-FI 6W STEREO AMPLIFIER. Model S-33. 3 watts per channel 0.3% distortion at 2.5W/chnl., 20dB N.F.B. Inputs for Radio (or Tape) and Gram, Stereo or Monaural, ganged controls. Kit **£13.7.6** Assembled **£18.18.0**

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

HI-FI STEREO AMPLIFIER. Model S-99. 18W output. Ganged controls. Stereo/Mono gram., radio and tape inputs. Push-button selection. Printed circuit construction. Kit **£27.19.6** Assembled **£37.19.6**

POWER SUPPLY UNIT. Model MGP-1. Input 100/120V, 200/250V 40–60 c/s. Output 6.3V, 2.5A A.C. 200, 250, 270V, 120mA max. D.C. Kit **£5.2.6** Assembled **£6.12.6**

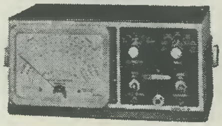
A wide range of American equipment available under direct mail order scheme. Full details and catalogue 1/– post paid.

Heathkit DAYSTROM

Enjoy Yourself and Save Money with these Kits

No previous experience required to build any Heathkit model

INSTRUMENTS



IM-13U

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

AUDIO SIGNAL GENERATOR. Model AG-9U 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%, 10V sine wave output metered in volts and dB's. Kit **£22.10.0** Assembled **£30.10.0**

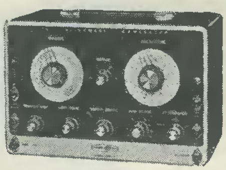
V-7A

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

RF-1U

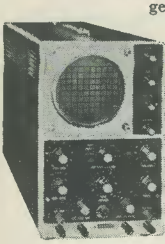
MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0.2Ω to 20MΩ. 4½″ 50μA meter. Kit **£12.18.0** Assembled **£18.11.6**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100mV output. Kit **£13.8.0** Assembled **£19.18.0**



HFW-I

T.V. ALIGNMENT GENERATOR. Model HFW-1. Offers max performance at lowest cost. Covers 3.6 to 220 Mc/s fundamentals. Electronic sweep oscillators. Built in marker generators (5 Mc/s crystal). **£34.18.0** Kit **£44.10.0** Assembled



IO-12U

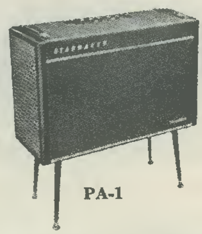
5″ GENERAL-PURPOSE LABORATORY OSCILLOSCOPE. Model IO-12U. This outstanding oscilloscope, with its professional specification and styling, fulfils most laboratory and service requirements. Vertical frequency response 3 c/s to over 4.5 Mc/s, sensitivity 10mV r.m.s. per cm. at 1 kc/s. T/B covers 10 c/s–500 kc/s. Kit **£32.12.6** Assembled **£41.10.0**

2¾″ PORTABLE SERVICE 'SCOPE. Model OS-1. This is a light, compact oscilloscope, ideal for servicing, etc. Dimensions 5″ x 8″ x 14½″ long. Wt. 10½lb. Fitted mumetal CRT shield. Kit **£22.18.0** Assembled **£30.8.0**

ELECTRONIC SWITCH. Model S-3U. Converts a single beam 'scope to double beam operation at low cost. Kit **£12.18.0** Assembled **£18.10.0**

TRANSISTOR TESTER, IM-30U. Gives complete d.c. analysis of NPN, PNP Transistors and Diodes. Large, easy-to-read meter. Kit **£24.18.0** Assembled **£35.10.0**

FOR THE MUSIC MAKER



PA-1

PA AMPLIFIER PA-1. The ideal compact unit for VOCALISTS, INSTRUMENTALISTS, RECORDS, with 50 Watt amplifier, 2 Heavy Duty Speakers. Variable TREMOLO. Elegant modern cabinet. Kit **£54.15.0** Assembled **£74.0.0**
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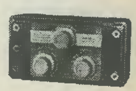

UJR-1

JUNIOR TRANSISTOR RADIO. Model UJR-1. Single transistor set. Excellent introduction to radio. Kit **£2.7.6** incl. P.T.

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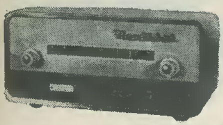
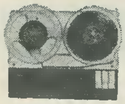
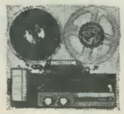
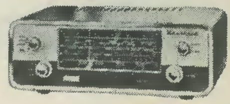
TAPE AMPLIFIERS — TAPE DECKS — CONTROL UNITS


FM-4U


STUDIOMATIC


TRUVOX


AM/FM

HI-FI FM TUNER. Model FM-4U. Also available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and amplifier unit, with power supply and valves (£13.3.0). Total Kit **£15.18.0**

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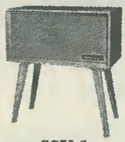
SPEAKER SYSTEMS


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 **£11.12.0,** without legs, Kit **£10.17.6** incl. P.T.

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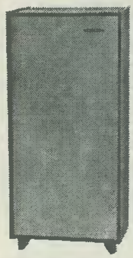
Kit **£23.4.0** Assembled **£30.15.0**


MFS

THE "COTSWOLD". This is an acoustically designed enclosure 26" x 23" x 15½" housing a 12" bass speaker with 2" speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 32–20,000 c/s. Capable of doing justice to the finest programme source, its polar distribution makes it ideal for really Hi-Fi Stereo.
Kit **£23.4.0** Assembled **£30.15.0**

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RA-1

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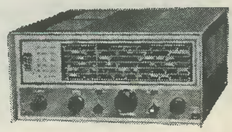
RG-1

160-10M TRANSMITTER. Model DX-100U. Careful design has achieved high performance and stability. Completely self-contained.
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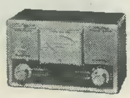
HM-11U

REFLECTED POWER METER. Model HM-11U. And SWR Bridge indicates reliably, but inexpensively, whether the RF power output of your TX is being transferred efficiently to radiating antenna.
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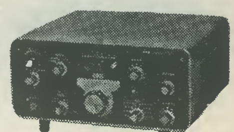
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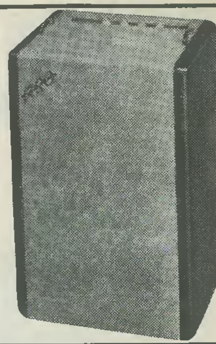
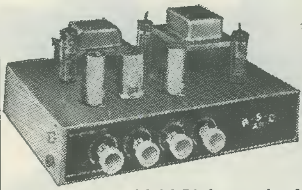


HIGH FIDELITY 12–14 WATT AMPLIFIER TYPE A11

PUSH-PULL ULTRA LINEAR OUTPUT "BUILT-IN" TONE CONTROL PRE-AMP STAGES



Two input sockets with associated controls allow mixing of "mike" and gram., as in A10. High sensitivity. Includes 5 valves, ECC83, ECC83, EL84, EL84, EZ81. High Quality sectionally wound output transformer specially designed for Ultra Linear operation and reliable small condensers of current manufacture. INDIVIDUAL CONTROLS FOR BASS AND TREBLE "Lift" and "Cut". Frequency response—3dB 30–30,000 c/s. Six negative feedback loops. Hum level 60dB down. ONLY 23 millivolts INPUT required for FULL OUTPUT. Suitable for use with all makes and types of pick-ups and microphones. Comparable with the very best designs for **STANDARD or LONG PLAYING RECORDS.** For **MUSICAL INSTRUMENTS** such as **STRING BASS, LEAD OR RHYTHM GUITARS,** etc. **OUTPUT SOCKET** with plug provides 300V 30mA, and 6.3V 1.5A for supply of a **Radio Feeder Unit.** Size approx. 12″ x 9″ x 7″. For A.C. mains 200–250V 50 c.p.s. Output for 3 and 15Ω speaker. Kit is complete to last nut. Chassis is fully punched. Full instructions and point-to-point wiring diagram supplied Only **8 Gns.**
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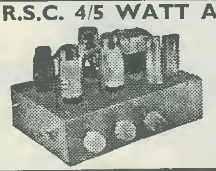
R.S.C. 4/5 WATT A5 HIGH-GAIN AMPLIFIER



A highly-sensitive 4-valve quality amplifier for home, small club, etc. Only 50 millivolts input for full output so is suitable for use with latest High-fidelity Pick-up heads and all other types of pick-ups and nearly all "mikes". Separate Bass and Treble Controls give full long-playing record equalisation. Hum level negligible, 71dB down, 15dB of Negative feedback used. H.T. of 300V 25mA and L.T. of 6.3V 1.5A available for supply of Radio Feeder Unit, or Tape-Deck pre-amplifier. A.C. mains input of 200–230–250V 50 c/s. Output for 2–3 ohms speaker. Chassis not alive. Kit complete with fully punched chassis (with baseplate), Gold Hammer finish, point-to-point wiring diagrams and instructions. Only **£4.15.0,** or assembled ready for use 25/– extra. Plus 3/6 carr., or deposit **22/6** and 5 monthly payments of **22/6** for assembled unit. (Total **£6.15.0.**)

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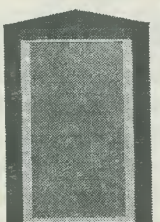

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Polished walnut veneer finish.
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250-0-250V 100mA, 6.3V 3.5A, C.T.	19/9
250-0-250V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
300-0-300V 130mA, 6.3V 4A, 6.3V 1A, for Mullard 510 Amplifier	35/9
300-0-300V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
350-0-350V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
350-0-350V 150mA, 6.3V 4A, 0-5-6.3V 3A	37/9

FULLY SHROUDED

250-0-250V 60mA, 6.3V 2A, 0-5-6.3V 2A, midget type 2½″ x 3″ x 3″	18/9
250-0-250V 100mA, 6.3V 4A, 0-5-6.3V 3A	29/9
300-0-300V 100mA, 6.3V 4A, 5V 3A	29/9
300-0-300V 130mA, 6.3V 4A, C.T. 6.3V 1A, for Mullard Amplifier	36/9
350-0-350V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
350-0-350V 150mA, 6.3V 4A, 0-5-6.3V 3A	38/9
425-0-425V 200mA, 6.3V 4A, C.T. 5V 3A	59/9
425-0-425V 200mA, 6.3V 4A, C.T., 6.3V 4A, C.T. 5V 3A	63/9
450-0-450V 250mA, 6.3V 4A, C.T. 5V 3A	69/9

OUTPUT TRANSFORMERS

Midget Battery Pentode 66:1 for 3S4, etc.	4/6
Small Pentode, 5,000Ω to 3Ω	4/6
Small Pentode, 7/8,000Ω to 3Ω	4/6
Standard Pentode, 5,000Ω to 3Ω	5/9
Standard Pentode, 7,000Ω to 3Ω	5/9
10,000Ω to 3Ω	5/9
Push-Pull 8 watts, EL84 or 6V6, to 3Ω or matched to 15Ω	9/9
Push-Pull 10-12 watts to match 6V6 or EL84 to 3-5-8 to 15Ω	19/9
Following types for 3 and 15Ω speakers:	
Push-Pull 10-12 watts, 6V6 or EL84	18/9
Push-Pull 15-18 watts, 6L6, KT66	22/9
Push-Pull Mullard 510 Ultra Linear	29/9
Push-Pull 20 watts, sectionally wound, 6L, KT66, EL34, etc.	49/9

MIDGET MAINS Primaries 200-250V 50 c/s, 250V 60mA, 6.3V 2A **12/9.** 250-0-250V 60mA, 6.3V 2A **13/9.** Both above size 2⅝″ x 2⅝″ x 2¼″

FILAMENT TRANSFORMERS All with 200-250V 50 c/s primaries: 6.3V 1.5A, **5/9;** 6.3V 2A, **7/6;** 12V 1A, **7/11;** 6.3V 3A, **8/11;** 6.3V 6A, **17/6;** 12V 1.5A, twice **17/6.**

SMOOTHING CHOKES 150mA 7-10H, 250Ω **11/9.** 100mA 10H, 200Ω **8/9.** 80mA 10H, 350Ω **5/9.** 60mA 10H 400Ω **4/11.**

CHARGER TRANSFORMERS
All with 200-250V 50 c/s primaries: 0-9-15V 1½A, **12/9;** 0-9-15V 2A, **14/9;** 0-9-15V 3A, **16/9;** 0-9-15V 5A, **19/9;** 0-9-15V 6A, **23/9;** 0-9-15V 8A, **28/9.**

AUTO (Step up/Step down) TRANSFORMERS. 0-110/120-230/250V 50-80W, **14/9;** 250W, **49/9;** 150W, **27/9.**

MICROPHONE TRANSFORMERS
120-1 high grade, clamped, **8/9.**

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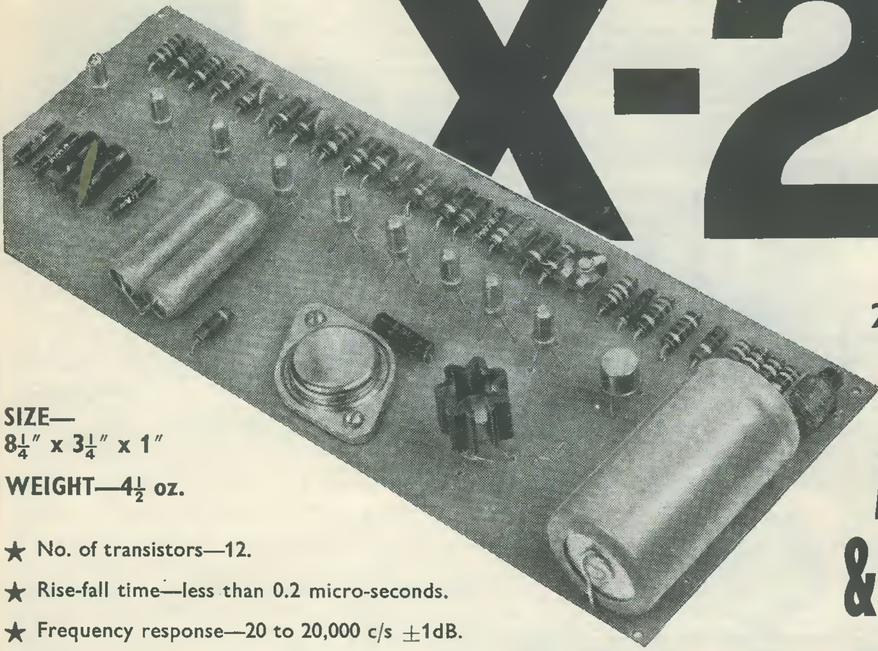
SINCLAIR X-20



20 watt combined

P.W.M. AMPLIFIER & PRE-AMP

SIZE—
$8\frac{1}{4}$" x $3\frac{1}{4}$" x 1"

WEIGHT—$4\frac{1}{2}$ oz.

- ★ No. of transistors—12.
- ★ Rise-fall time—less than 0.2 micro-seconds.
- ★ Frequency response—20 to 20,000 c/s ±1dB.
- ★ Total harmonic distortion 0.1% at 10 watts R.M.S.
- ★ Input sensitivity—1mV into 5K ohms.
- ★ Signal to noise ratio better than 70dB.
- ★ Output into 7.5 ohms—20 watts R.M.S. music power; 15 watts R.M.S. continuous; into 15 ohms—15 watts R.M.S. music power; 12 watts R.M.S. continuous.

X-10 P.M.W. AMPLIFIER

WHERE LESS POWER IS REQUIRED

Although the X-10 has been superseded in power by the X-20, this superb Sinclair integrated P.W.M. amplifier and pre-amp gives you all the advantages of quality and efficiency which makes these Sinclair designs so outstanding in every way. It is the ideal hi-fi amplifier where superb quality is wanted, with a more moderate output.

£5.19.6 Ready built **£6.19.6** X-10 power supply unit, £2.14.0

For 12–15V operation. Tone control system is added to choice.

New design—New power!

Here is proof positive of the power and quality that a Sinclair Pulse Width Modulated Amplifier can give you. The new X-20 which is complete with integrated pre-amplifier uses silicon epitaxial planars in the output stage, better than anything ever before offered to constructors in transistorised equipment. Many other refinements have been introduced into this latest Sinclair design. For example, absolute constant amplitude is maintained in the output square wave form irrespective of the extent of the modulation applied. Building this amplifier is unusually easy and the results to be obtained from it are completely rewarding. Unlike many hi-fi amplifiers, the X-20 has power and power to spare. It has superb quality, too, all from a unit measuring only $8\frac{1}{4}$" x $3\frac{1}{4}$" x 1"—dimensions which will inspire constructors to build to entirely new concepts of design and layout.

Complete kit of parts and X-20 manual **£7.19.6**

Ready built and tested **£9.19.6**
X-20 Power Unit **£4.19.6**

SINCLAIR RADIONICS LTD.,
COMBERTON, CAMBRIDGE Telephone: COMBERTON 682

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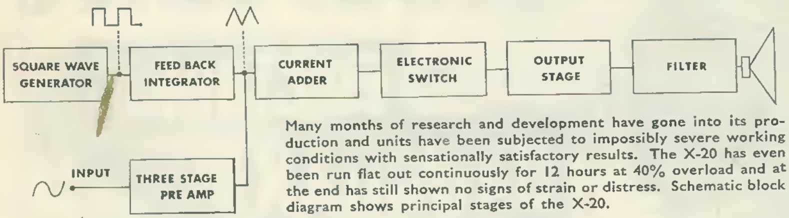
WHAT YOU SHOULD KNOW ABOUT THIS BRILLIANT NEW SINCLAIR DESIGN



Many months of research and development have gone into its production and units have been subjected to impossibly severe working conditions with sensationally satisfactory results. The X-20 has even been run flat out continuously for 12 hours at 40% overload and at the end has still shown no signs of strain or distress. Schematic block diagram shows principal stages of the X-20.

CONSTANT AMPLITUDE

Pulse Width Modulation requires a perfectly formed square wave to carry the audio signal and it must be of a frequency well above the highest level of the audio spectrum. In the X-20, the peak-to-peak amplitude of the square wave is constant at all times, no matter to what extent it is modulated by the A.F. The result is that distortion figures are lower than ever.

PULSE REPETITION FREQUENCY

In the interests of quality, the P.R.F. must be as high as possible without extending into the region of radio frequencies. In the X-20, the pulse repetition frequency is between 65 and 75 kc/s, a value which is found to satisfy the most stringent demands likely to be made upon it in terms of uncompromising quality. This frequency is generated within the circuitry of the X-20 itself and the output has rise-fall times of less than 0.2 micro-seconds.

OUTPUT STAGE — 95% EFFICIENT

Rise and fall times of less than 0.2 micro-seconds are achieved by using silicon epitaxial planar output transistors which makes the efficiency of the output stage at least 95%. Thus only 1 watt is dissipated in the output stage when the amplifier is giving an output of 20 watts R.M.S. The complete linearity of the integrater and careful modulator design ensure absolutely negligible distortion right up to the maximum output.

LOW-PASS FILTER

A low-pass filter cutting off above 20 kc/s built into the output of the X-20 ensures that the output transistors always "see" a high impedance at the P.R.F., making the amplifier widely tolerant of the type of load to which it is connected.

PRE-AMPLIFIER

This consists of three transistors with two negative feedback loops which define the gain and ensure an absolutely flat frequency response. The sensitivity is sufficient for all types of pick-ups. Provision is also made for connecting high-output devices such as F.M. Tuners and Tape Pre-amps.

TONE CONTROL SYSTEMS

The Manual included with the X-20 Amplifier details a variety of tone and volume control systems, any one of which may be added to the amplifier for very little outlay. Full information on stereo operation is also provided, of course.

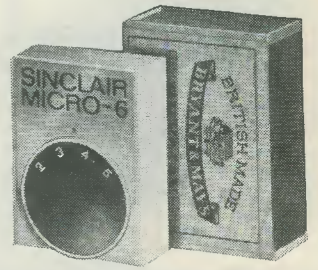
POWER SUPPLY

A special A.C. Mains operated power supply unit is available for the X-20, delivering 36 volts D.C. Full wave rectification is used and the unit will power up to two X-20's. The power unit is supplied ready built in a completely enclosed steel case.

OTHER SPECIAL FEATURES

Because of the high energy conversion factor of the X-20, it requires no heat sink in the output stage. Connected to a 7.5 ohms loudspeaker, the power output is 20 watts R.M.S. music power. Using a 15 ohms loudspeaker, the output is 15 watts R.M.S. music power.

OTHER SINCLAIR DESIGNS



MICRO-6

THE SMALLEST ON EARTH

Smaller than a matchbox, this world-famous receiver brings in stations from all over Europe. It performs with fantastic efficiency in cars, buses, trains and steel-framed buildings, yet measures only $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$. The highly stable six-stage circuit provides A.G.C. and band-spread for easy Luxemburg reception. Tunes over medium waveband. Building this smart minute set is easy. Its performance is wonderful.

All parts inc. 3 M.A.T. transistors, case, light-weight earpiece and instructions come to **59/6**

MALLORY MERCURY CELL
ZM.312 (2 required), each 1/11
Pack of six, 10/6

TR.750 POWER AMP

MEASURES ONLY 2" x 2"

With built-in switch and volume control. Output 750mW for feeding into standard 25 to 35 ohm speaker. Input 10mV into 2kΩ. Operates from 9V d.c.

All parts and instructions **39/6** *Ready built and tested* **45/-**

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for which I enclose Cash/Cheque/Money Order value £..........s..........d.

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Should you not be completely satisfied with your purchase when you receive it from us, your money will be refunded in full and at once without question. Please quote R.C.5 should you prefer to write your order instead of cutting out this coupon.

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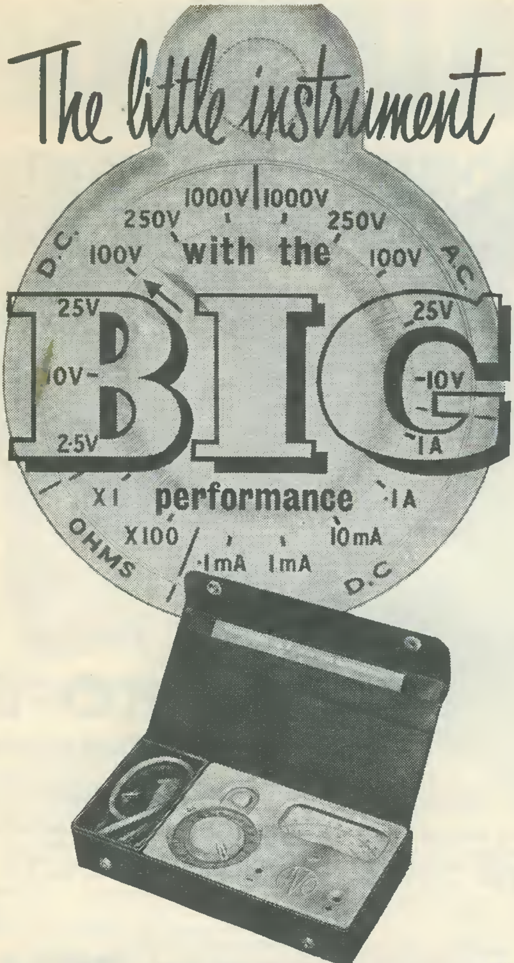
The little instrument with the BIG performance



MULTIMINOR *Mk 4*

The newly improved model of this famous AVO pocket size multi-range instrument has been enthusiastically acclaimed in all parts of the world for its high standards of accuracy and dependability as well as for its modern styling, its highly efficient internal assemblies, and its resistance to extremes of climatic conditions.

It is simple to use, one rotary switch for instant range selection, only one pair of sockets for all measurements, and a 2¾ inch clearly-marked scale-plate. It is supplied in an attractive black carrying case complete with interchangeable test prods and clips, and a multi-lingual instruction booklet.

RESISTANCE: 0-2MΩ in 2 ranges, using 1.5V cell
SENSITIVITY: 10,000Ω/V on d.c. voltage ranges
1,000Ω/V on a.c. voltage ranges

Ask AVO *to send you a full specification of this great little instrument. It measures only 7½" × 4" × 1⅞" and and weighs only 24 oz.*

R.E.C.M.F.
EXHIBITION
May 18–21
Stand 152

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LONDON, S.W.1 *Telephone: VICtoria 3404 (12 lines)*

M GROUP

MM 19

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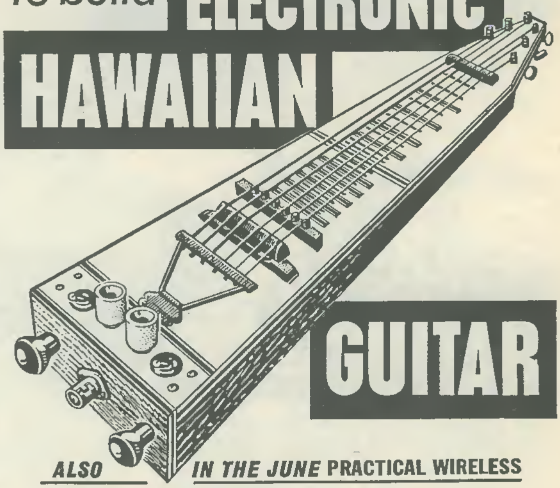

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MODIFYING THE PCR2 by adding Noise Limiter, B.F.O., Product Detector, Tuning Indicator and voltage regulated built-in power supply.

2-TRANSISTOR RECEIVER for M.W. and L.W. reception. Uses ferrite rod aerial, with provision for external aerial.

AUTOMATIC CONTROL SYSTEM FOR HAMS
Fully automatic changeover system—'Press-to-talk' switch for listening through—adjustable time delay from a few m/s to 1 sec.

PRACTICAL WIRELESS

JUNE ISSUE Out May 6th—2/-

ORDER YOUR COPY NOW!

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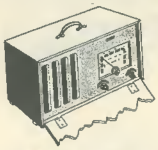
Trawler Band Transistor Receiver. A compact 4, semi-conductor receiver, complete with personal listening earpiece, that receives amateurs and maritime stations. You will be amazed at the stations that can be received on this set. Works from standard batteries. Price **49/6**, p/p 2/6.



CARAVAN RADIOS

These well made radios were designed for the Government for forces entertainment. Contains 6K8, 6K7, 6Q7, and 6V6 output. Has choke smoothing and slow motion tuning. Printed scale. 200–550 metres. In good condition. Complete with built-in 6V power back and 8" high quality speaker, all contained in a sturdy wooden cabinet. Ideal for use with your caravan or car. Will work from standard 6V car battery or easily converted for mains operation. Price **£3.19.6**, p/p 10/–.

TYPE 19 SHORT WAVE RECEIVING SET

Works straight off the mains. An excellent short wave receiver, requires only phones for immediate oreration. Price **£5.19.6**, p/p 10/–.
During an evening's testing of this excellent receiver, we optained clear reception from scores of stations, many of them thousands of miles distant, including ship stations, government transmissions, maritime broadcasts, etc., and also the short wave Radio Luxembourg broadcasts.

MORSE KEYS

Morse key assembly. Key with base, cover and terminals. Complete with lead. **6/11**, p/p 2/–. 2 Morse Keys for **12/6** post free.

CRYSTAL SET

A wonderful educational kit for all children. Provides hours of amusement while following the easy step by step instructions. It is powered entirely by wireless waves, eliminating the expense of batteries. No soldering required. Receives all main stations. Price **25/–**, p/p 2/6.

19 set Instruction Handbook 3/6 each, p/p 6d.
1155 Instruction Handbook 3/6 each, p/p 6d.
H.R.O. Instruction Handbook 3/6 each, p/p 6d.
Frequency Meter, BC 221 Instruction Handbook 3/6 each, p/p 6d.
46 Walkie Talkie Set Circuit and Notes 3/6 each, p/p 6d.
38 set A.F.V. Instruction Handbook Price 3/6 each, p/p 6d.
R.F. Unit 24 Circuit Diagram and Details Price 1/6, p/p 3d.
R.F. Unit 25 Circuit Diagram and Details Price 1/6, p/p 3d.
R.F. Unit 26 Circuit Diagram and Details Price 1/6, p/p 3d.
Receiver R1355 Circuit Diagram and Details Price 1/6, p/p 3d.
Receiver R1224A Circuit Diagram and Details Price 1/6, p/p 3d.
R.1116/A Circuit Diagram and Details Price 1/9 p/p 3d.
Wave Meter Class D Handbook, Mk. I, II III Price 3/6, P/P 6d.

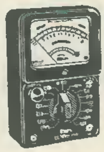
SONA

2-WAY RADIOS

A compact V.H.F. trans/rec. that can be held in the hand. Size approx. 12 x 3 x 2½." Range up to 3 miles under favourable conditions. Uses 3 miniature valves and self contained standard batteries. Easy to operate, economical to run. Ideal for fixed or mobile authorised operation. Limited number left. Price **12 gns** per pair. Post free.

High Impedance Personal Listening Earpiece. Suitable for all types of crystal sets and transistor sets. Complete with lead and plug. Price **4/11**, p/p 6d.

SENSITIVE MULTIMETER



20,000 ohm per volt, 1% resistance used throughout. Single control system for all ranges. Compact and light weight. Highly accurate. **£5.10.0**, p/p 3/6.

YORK SHOP NOW OPEN

We have just opened extensive new shop premises at **97 Walmgate, York.**

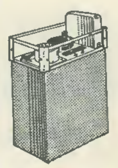
We have a large range of short wave communication equipment, audio high fidelity amplifiers and accessories, and a full range of radio components and parts. Callers welcome.

Open 9.30 a.m. to 5.30 p.m. weekdays
9.0 a.m. to 6.0 p.m. Saturdays.

Double Throat Mics. Double throat mics can be adapted for use with musical instruments. Price **5/11** each, p/p 9d.

High quality Paxolin Sheets. Strong high quality Paxolin sheets. Size 10½ x 8½ x 1/10". Three for five shillings, p/p 1/–. Six for **10/–** post free. Twelve for **18/6** post free.

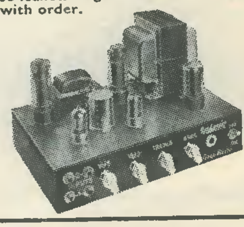
WIRELESS SET No. 38 AFV



A lightweight walkie-talkie with transmitting range 5 to 10 miles and frequency coverage 7.4 to 9 mc/s. Operates from 12V and 120V external dry batteries. Large, clearly numbered tuning control, with tuning lock. In good condition. ONLY **£4** per pair, p/p 5/–.

THE GOLDENAIR "THIRTY" HI-FI AMPLIFIER

A high quality 30-watt amplifier developed for use in large halls and clubs etc. Ideal for bass, lead or rhythm guitars, schools, dance halls, theatres and public address. Suitable for any type of mike or pick-up. Valve line-up: two EF86; one ECC83; one GZ34; two EL34. Four separate inputs are provided with two volume controls. Bass and Treble controls are incorporated. Amplifier operates on standard 50 c/s mains. 3 ohm and 15 ohm speakers may be used. Perforated cover with carrying handles can be provided if required, price now 25/–.
Customers are invited to see and hear this amplifier at our shop premises at Lambert's Arcade or our new York shop. Send S.A.E. for illustrated leaflet. **16 gns. cash.** Carriage 15/– to be sent with order.



OPERATORS UNIT

Huge purchase enables us to offer at give away price operators unit containing standard jack socket 250 mfd. electrolytic condenser, 4-way telephone socket, midget selenium rectifier, etc. Price **3/6** post free, or 2 for **6/6** post free.

RESISTOR COLOUR CODE INDICATORS

Enables you to determine value of a resistor at a glance. A must for the constructor. Saves time. Price 1/6 each, p/p 3d.

TRANSISTOR SALE

Mullard OC44. Price **3/11**, p/p 3d.
Mullard OC45. Price **3/11**, p/p 3d.
Mullard OC71. Price **2/11**, p/p 3d.
Mullard OA90. Price **1/11**, p/p 3d.
Ediswan XD202 Germanium diodes. Price **1/11**, p/p 3d.
Mullard OA79. Price **1/11**, p/p 3d.
Transistor holder 3-pin. Price **1/6** each, p/p 6d.

Valve Sale. 2/6 each, p/p 9d. 2 for 5/– post free. —6V6, 807, 6H6, 6K7, 6B8G; EF50, IL4.

M.A.T. Transistors. M.A.T. 100, 7/9; M.A.T. 120, 7/9; M.A.T. 121, 8/6. Ferrite slab aerials suitable for Transistor sets, 3/–, p/p 6d.

DYNAMOTOR

Run all your mains A.C./D.C. equipment from your car battery. 6V input gives 250V output, or 12V input gives 500V output at 30 watts. Very low battery drain. Size only 5½" x 3½". A must for the caravanner. ONLY **25/–**, p/p 3/6.

Tank Aerials. Fully interlocking copper sections one foot in length. Will make ideal dipoles, car or scooter aerials. Price 6 sections complete with canvas carrying case 3/6, p/p 1/6. Additional sections 6d. each. Please include sufficient postage.

19 set Trans/Rec. Mains Power Pack. Operate your 19 set receiver straight off the mains. Ready built power unit, complete with modification and fitting instructions. Price **59/6** p/p 3/6. Please state Model, MK. 2 or MK. 3.

Postage rates apply U.K. only. S.A.E. with all enquiries
New walk round store open in Lambert's Arcade, Lower Briggate, Leeds 1, next to Halfords Cycle Shop. Open all day Saturday.
All mail orders to our Briggate House address.

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From time to time we have shown you pages from our Components Catalogue, to whet your appetite! We usually pick out pages that we consider photogenic or particularly interesting. This month we show one of the Resistor pages—after all, resistors are a basic requirement of any electronic circuit. If we tell you that our Resistor section runs to six pages, and that we list, and stock, some 22 different types and some 890 different values—are you interested? You are? Then send in 6s. (5s. plus 1s. p. and p.) and we will send you a copy by return. Incidentally in the catalogue you will find five coupons, each worth 1s. if used as directed.

RESISTORS

Metal Oxide High Stability Resistors

The general rating of these resistors is 1 watt at 70° C. At the maximum working load the drift figures are 2% and 4% for 2,000 and 25,000 hours operation respectively. Derating to ½ watt at 70° C will improve the stability to 1% and 2%, and still further derating to ¼ watt at 70° C will bring these resistors into the Laboratory Standard with a stability rating of 0.5% and 1% for the operation periods mentioned.

The temperature coefficient is within the limits ± 150 parts in 10^6 over the range −55° C to + 150° C.
The noise is less than 0.1µV. per volt.

R9M Metal oxide resistors 1 watt 2% HSY. 2*s.* 3*d.* each.

RANGE AS BELOW:—

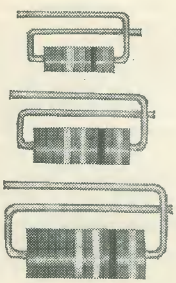
68Ω	200Ω	560Ω	2 K	5.6K	18 K	47 K	150 K	390 K
75Ω	220Ω	680Ω	2.2 K	6.8 K	20 K	56 K	180 K	470 K
82Ω	270Ω	820Ω	2.7 K	7.5 K	22 K	68 K	200 K	560 K
100Ω	300Ω	1 K	3 K	8.2 K	27 K	75 K	220 K	680 K
120Ω	330Ω	1.2 K	3.3 K	10 K	30 K	82 K	270 K	750 K±5%
150Ω	390Ω	1.5 K	3.9 K	12 K	33 K	100 K	300 K	820 K±5%
180Ω	470Ω	1.8 K	4.7 K	15 K	39 K	120 K	330 K	1 M±5%

Miniature Resistors

R1A. ±10% 8*d.* each (Make as available). $\frac{1}{10}$in x ¼in. $\frac{1}{10}$ watt. Tolerance 10%. 8*d.* each.

RANGE AS BELOW:—

10	33	100	330	1 K	3.3 K	10 K	33 K	100 K	330 K	1 M	3.3 M	10 M
12	39	120	390	1.2 K	3.9 K	12 K	39 K	120 K	390 K	1.2 M	3.9 M	
15	47	150	470	1.5 K	4.7 K	15 K	47 K	150 K	470 K	1.5 M	4.7 M	
18	56	180	560	1.8 K	5.6 K	18 K	56 K	180 K	560 K	1.8 M	5.6 M	
22	68	220	680	2.2 K	6.8 K	22 K	68 K	220 K	680 K	2.2 M	6.8 M	
27	82	270	820	2.7 K	8.2 K	27 K	82 K	270 K	820 K	2.7 M	8.2 M	



CARBON RESISTORS

R5. RS. ⅜in x ⅛in. ½ watt. Tolerance 10%. 4*d.* each.
R6. RS. ⅜in x ¼in. 1 ,, ,, ,, 6*d.* ,,
R7. RS. ¾in x ¼in. 2 ,, ,, ,, 9*d.* ,,

RANGE AS BELOW:—

In addition to the ranges set out below R5 and R6 have the following additional values:—
4.7, 5.6, 6.8, 8.2 ohms.
But the price is R5 7*d.* and R6 8*d.* in these particular values.

10	39	120	430	1.5 K	4.7 K	18 K	56 K	220 K	680 K	2.7 M	8.2 M
12	43	150	470	1.8 K	5.6 K	22 K	68 K	270 K	820 K	3.3 M	10 M
15	47	180	560	2.2 K	6.8 K	27 K	82 K	330 K	1 M	3.9 M	12 M
18	56	220	680	2.7 K	8.2 K	33 K	100 K	390 K	1.2 M	4.3 M	15 M
22	68	270	820	3.3 K	10 K	39 K	120 K	430 K	1.5 M	4.7 M	18 M
27	82	330	1 K	3.9 K	12 K	43 K	150 K	470 K	1.8 M	5.6 M	22 M
33	100	390	1.2 K	4.3 K	15 K	47 K	180 K	560 K	2.2 M	6.8 M	

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FREQUENCY SUB-STANDARD

By CRAIG MACKAY

This article describes a 100 kc/s sub-standard frequency generator which may be set up against standard frequency transmissions. Optional extras are multivibrators offering outputs at 10 kc/s and 1 kc/s, these being locked to the basic 100 kc/s signal

ALL MEASUREMENT MUST HAVE AS ITS BASIS A unit (usually arbitrary) in terms of which the quantity to be measured is expressed. It must be possible, also, to have some sub-standard which bears a certain relation to the standard unit, and which can be used for comparison with the quantity to be measured.

Clearly, the accuracy with which the quantity can be measured is directly dependent upon the accuracy of the sub-standard.

For the person concerned with electronics in its widest sense, time or frequency is a most important quantity, and the accuracy of the sub-standard which is used will largely determine the accuracy and value of any work which might be done.

This article is intended to describe the construction of a frequency sub-standard which has a basic long-term accuracy of 0.002%, and a short-term stability of one part in 250,000 (over any half-hour period) or better.

The General Circuit

The sub-standard oscillator circuit (see Fig. 1) uses a crystal mounted in an evacuated envelope with a B7G base, this oscillating at 100 kc/s in a modified Colpitts oscillator circuit. Such a crystal is marketed by the Quartz Crystal Company, and is known as crystal unit type Q7/100. Provision is made for slight adjustment of the frequency of oscillation by means of C_2.

V_2 is a buffer amplifier stage to isolate the oscillator from succeeding stages, and, like V_1, is an EF91.

V_3 is a double triode type ECC83 connected in the familiar multivibrator configuration and synchronised with the 100 kc/s oscillator to operate at 10 kc/s. The signal thus produced has exactly the same accuracy as the original 100 kc/s signal.

Fig. 2 shows the output stages. V_4 amplifies the 100 kc/s signal, or amplifies and limits the 10 kc/s signal. This produces a square wave for the 10 kc/s

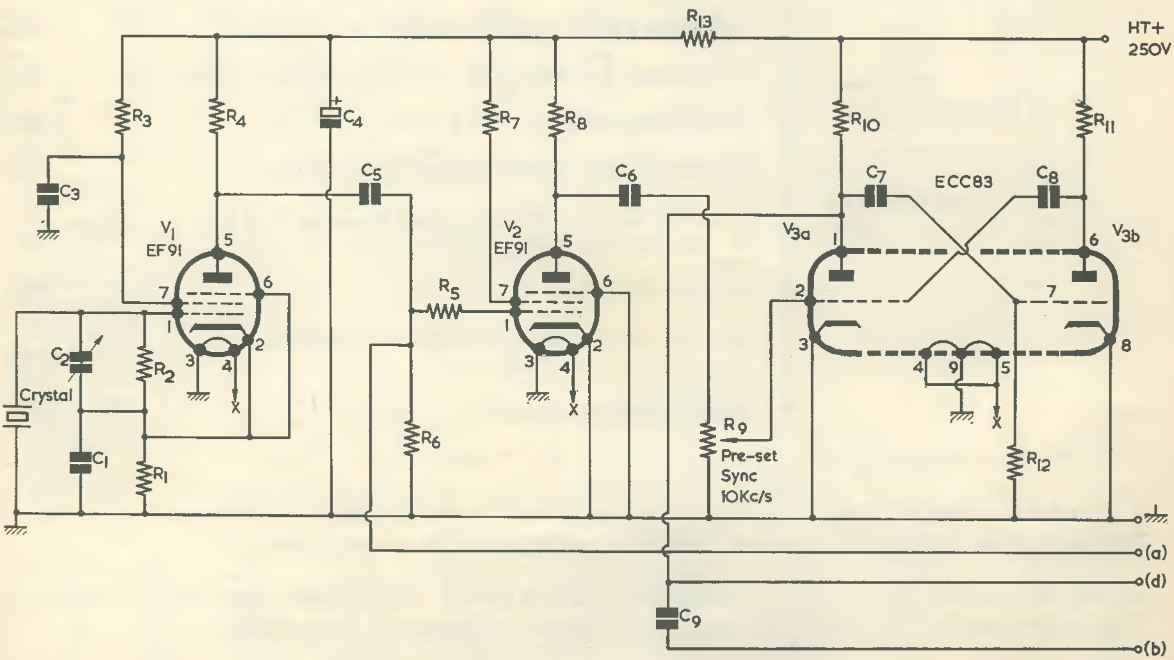

Fig. 1. The 100 kc/s sub-standard crystal oscillator, together with the buffer amplifier and 10 kc/s multivibrator

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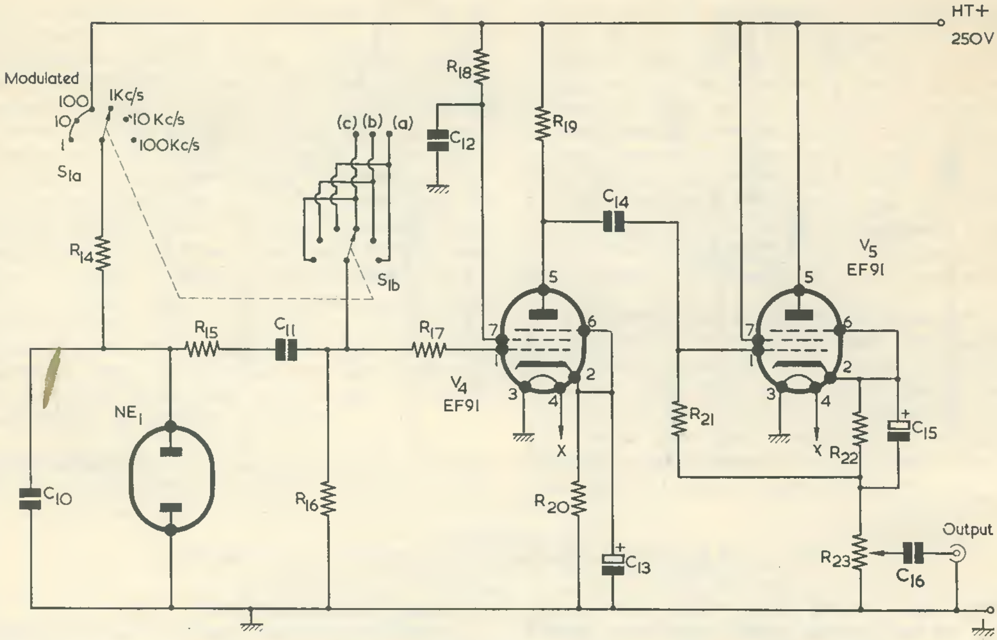

Fig. 2. The output amplifier, cathode follower and neon modulator stages

signal. The output from V_4 is fed to V_5, which is connected as a cathode follower giving a relatively low impedance output. Both V_4 and V_5 are type EF91.

It is often necessary to be able to pick out the signal from the chaos present these days in the amateur bands and a neon modulator is incorporated which produces a most distinct "bleeping" note which is very easy to recognise. The modulation on-off switch $S_{1(a)}$ is incorporated in the frequency selector switch.

V_6 is a power rectifier type EZ80. The power supply circuit is given in Fig. 3.

Additions

Different people will obviously have varying requirements for an instrument of this type. If the 10 kc/s facility is not required, then V_3 and V_4 (with their associated circuitry) may be omitted. The grid of V_5 is then connected, through a 100pF capacitor, to the anode of V_2. This, of course, considerably simplifies the instrument.

However if, in addition to the 10 kc/s facility, a signal at 1 kc/s is required with the same very high accuracy, then the circuit of Fig. 4 may be added. This consists of a buffer stage V_7, and a synchronised multivibrator operating at 1 kc/s (V_8). V_7 is type EF91, and V_8 is type ECC81.*

The switching circuit shown in Fig. 2 assumes that both 10 kc/s and 1 kc/s multivibrators are employed. When only the 10 kc/s multivibrator is used, a 2-pole 4-way switch may be fitted instead of the 6-way component shown.

If more than one additional output channel is required, the circuit of Fig. 2 may be duplicated as necessary. In this way, more than one frequency may be made available at the same time.

If different sub-multiples of the synchronising frequency are required then the value of the multivibrator coupling capacitors between the anode and "opposite" grid of V_8 will have to be altered. This can easily be done as the frequency of oscillation is inversely proportional to the values of these

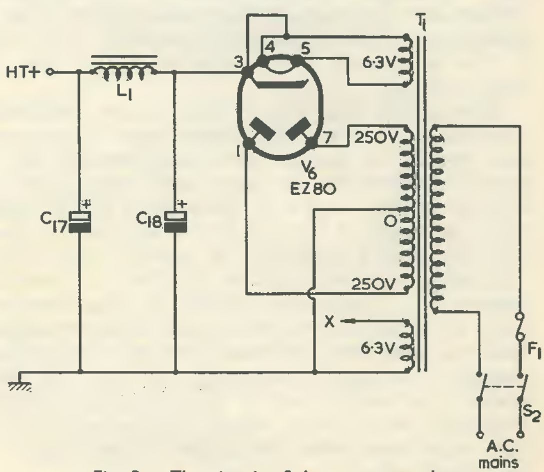

Fig. 3. The circuit of the power supply

* In the multivibrator circuits shown in Figs. 1 and 4, the sync level controls (R_9 and R_{28}) serve also as frequency controls, in that they vary the grid leak values of the associated triodes. In consequence, these controls may vary the mark/space ratio of the square wave. The circuit is, however, designed to give approximately 50:50 square waves when the controls are set to the position at which synchronising occurs.—EDITOR.

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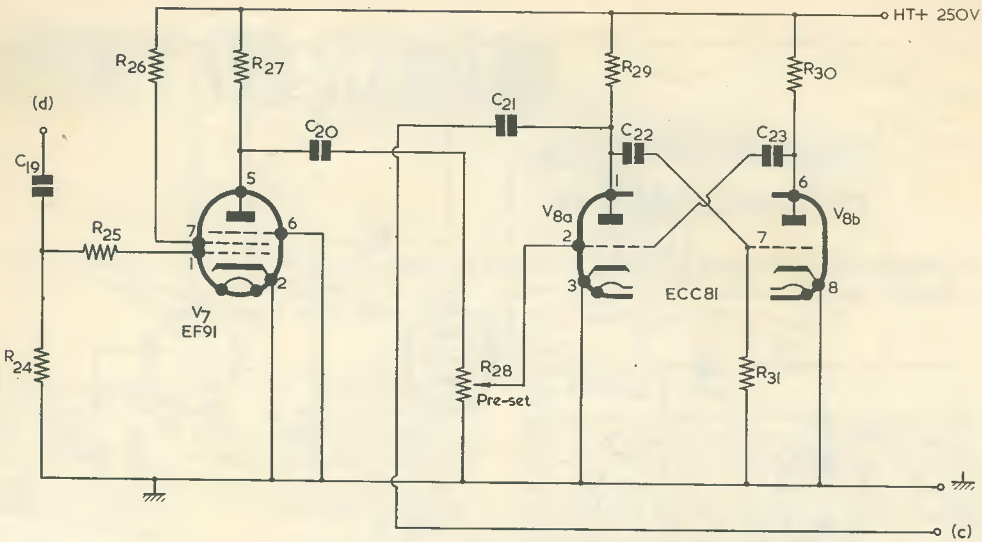

Fig. 4. The 1kc/s synchronised multivibrator, preceded by its buffer stage

capacitors, e.g. halving their value doubles the frequency of oscillation. Both capacitors should have, of course, the same value.

Building the Instrument

The constructor must first make up his mind exactly what his requirements are, or are likely to be in the future, and build accordingly.

Because of the large number of variations possible, no definite layout will be given, and only a few "rules" will be mentioned.

The final layout depends to some extent on the size of the mains transformer, which must be chosen to deliver the required currents. The basic circuit, with the 1 kc/s frequency divider requires an h.t. current of 55mA.

The chassis to be used is very much a matter of personal preference. The author used one of the "Universal Chassis" sold by Home Radio (Mitcham) Ltd., which can be supplied with a baseplate as well as the usual top plate. This, with a few ventilation holes suitably drilled, met all requirements.

The crystal has a low temperature coefficient (less than 2 parts per million per degree C temperature change at normal room temperature), but it should nevertheless be kept well away from all sources of heat. As it is mounted in a B7G glass valve envelope, it helps if a screening can is used, and this should preferably be polished aluminium. The can considerably reduces the effect of valve heat generation. The valves should be mounted well away from the crystal, and should be positioned so that no unwanted feedback occurs. Use under-chassis screening, if necessary. If feedback does occur, it is unlikely that it will affect the oscillator frequency very much, but it will certainly cause some confusion when the output signals come to be sorted out.

Setting Up the Instrument

Once the instrument has been built and thoroughly tested, it will require to be adjusted for correct operation.

First, set S_1 to 100 kc/s and couple the oscillator to a receiver receiving one of the standard frequency transmissions. In Britain, the most convenient station is the B.B.C. Light Programme 200 kc/s transmitter, which is maintained very accurately at this frequency. Elsewhere, one of the WWV transmissions could be employed.

Coupling may take the form of a lead from the sub-standard output loosely wound around the aerial lead to the receiver. This will give enough signal, and the two signals should be heard beating against each other. If they are not heard, adjust C_2 until they are. C_2 is then adjusted so that the beat frequency is reduced to a minimum, this being done, preferably, after the instrument has reached its working temperature after, say, 45 minutes.

It is easier to "see" the beat frequency by measuring the receiver a.g.c. voltage and watching it vary. Do not try to make the beat frequency zero; this will be very difficult to achieve and will only be maintained for a matter of a few seconds.

Once the crystal oscillator has been adjusted it will be necessary to set up the multivibrators (if they are included). For the 10 kc/s multivibrators, first set S_1 to 100 kc/s with modulation on and, with the output coupled to a receiver working this time, on the medium waveband, vary the receiver tuning control until two adjacent points are found where the "bleeps" are coming through loud and clear. Then switch to 10 kc/s, modulation on, and count the number of points where the bleeps are heard between, but not including, the two chosen end-points. Adjust R_9 until they are nine in number and evenly spaced between the two 100 kc/s end-points.

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The 1 kc/s multivibrator is not quite as easy to set up because, unless a very narrow band communications receiver is available, the above method (scaled down by 10) will be of little use. Probably the easiest method is to feed the output of the instrument into an audio amplifier and compare the frequency with either a piano or some other source whose frequency is known within about 5%.

If the sync control for this multivibrator, R_{28}, is varied, the oscillator may be heard to switch from one sub-multiple of the basic frequency (in this case 10 kc/s) to another; i.e. from 833 c/s to 909 c/s to 1,000 c/s to 1,111 c/s to 1,250 c/s, etc., as the sync level is adjusted.

The multivibrators should stick to their frequency permanently, but it is advisable to carry out the above procedure from time to time just to check that everything is working correctly.

Using the Instrument

The three oscillators will produce a signal which is very rich in harmonics. The 2,000th harmonic (200 Mc/s) of the 100 kc/s oscillator has been detected with the prototype, and it will produce signals at 100 kc/s intervals which will be readily found at least up to 30 Mc/s. By using these harmonics it is possible to calibrate receivers, signal generators, etc., with very high accuracy. The 100 kc/s and 10 kc/s harmonics may be used as standard markers throughout the commonly used radio frequency spectrum for precision calibration, while the 10 kc/s and 1 kc/s oscillators may be used for precision calibration of audio generators.

For really good stability it is necessary to put the completed instrument on a quiet shelf in the workshop where it can be used without being moved or bumped. The final adjustments should be carried out on this shelf, and the instrument should be left in peace and never nechanically disturbed. It should, nevertheless, be periodically checked for drift in the manner described above.

Components List

(NOTE.—As explained in the text, some components are not required if one or both of the multivibrators are omitted.)

Resistors

(All fixed resistors are ¼ watt 10% unless otherwise specified)

R_1	10kΩ	R_{18}	470kΩ
R_2	470kΩ	R_{19}	100kΩ
R_3	100kΩ	R_{20}	150Ω
R_4	22kΩ ½ watt	R_{21}	1MΩ
R_5	470kΩ	R_{22}	150Ω
$R_{6,7}$	100kΩ	R_{23}	10kΩ potentiometer
R_8	22kΩ ½ watt	R_{24}	100kΩ
R_9	20kΩ pre-set	R_{25}	470kΩ
$R_{10,11}$	10kΩ	R_{26}	100kΩ
R_{12}	5.6kΩ	R_{27}	22kΩ ½ watt
R_{13}	4.7kΩ 20%	R_{28}	20kΩ pre-set
R_{14}	10MΩ	$R_{29,30}$	10kΩ
R_{15}	18kΩ	R_{31}	22kΩ
$R_{16,17}$	1MΩ		

Capacitors

C_1	1,000pF		
C_2	100pF air-spaced variable		
C_3	0.1μF		
C_4	8μF electrolytic 300V wkg		
C_5	100pF		
C_6	1,000pF		
$C_{7,8}$	5,600pF	C_{20}	22,000pF
C_9	100pF	C_{21}	1,000pF
C_{10}	0.1μF	$C_{22,23}$	56,000pF
C_{11}	1,000pF		
C_{12}	0.1μF		
C_{13}	25μF electrolytic 25V wkg.		
C_{14}	0.01μF		
C_{15}	25μF electrolytic 25V wkg.		
C_{16}	0.1μF		
C_{17}	16μF electrolytic 300V wkg.		
C_{18}	32μF electrolytic 300V wkg.		
C_{19}	1,000pF		

Inductors

L_1 Smoothing choke, 10H 60mA

T_1 Mains transformer. Secondaries (all currents minimum rating required when both divider circuits are incorporated) 250–0–250V at 55mA; 6.3V at 0.6A; 6.3V at 2.1A

Valves

$V_{1,2}$	EF91, 6AM6, Z77
V_3	ECC83, 12AX7
$V_{4,5}$	EF91, 6AM6, Z77
V_6	EZ80
V_7	EF91, 6AM6, Z77
V_8	ECC81, 12AT7

Crystal

100 kc/s crystal type Q7/100 (Quartz Crystal Co., Wellington Crescent, New Malden, Surrey)

Switches

$S_{1(a),(b)}$ 2-pole 6-way (see text)

S_2 d.p.s.t. toggle

Fuse

½ amp cartridge fuse

Neon

Neon bulb, MES (Radiospares)

Sockets

6 B7G valveholders (one with screen, see text)
3 B9A valveholders
1 coaxial output socket
1 cartridge fuse holder
1 socket for neon bulb

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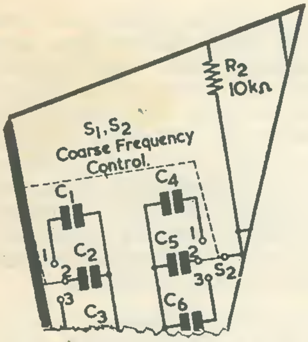

PILOT LAMP TUNING INDICATOR

for

TRANSISTOR RADIOS

SUGGESTED CIRCUIT No. 174

By G. A. FRENCH

In the preceding article in this series (published in last month's issue of *The Radio Constructor*) the writer discussed several simple methods of employing moving-coil meters as add-on tuning indicators for conventional medium and long wave a.m. transistor superhets. He also stated that he had devised a somewhat more complex circuit which enabled tuning indication to be given by varying illumination in a small m.e.s. bulb, but that considerations of space necessitated that this be described in the following article. In consequence, the present "Suggested Circuit" describes the bulb tuning indicator referred to.

Before proceeding further, it should be pointed out that the circuit described this month is of an experimental nature. This is for two reasons. Firstly, the circuit may, in some cases, necessitate the selection of transistors to obtain satisfactory results. Secondly, the circuit is intended to be added to existing receivers whose individual performances cannot be accurately assessed, with the result that success may not always be achieved. The circuit requires a basic knowledge of transistor operation and its assembly should preferably be tackled by constructors who understand the principles involved. The writer suggests that the circuit be initially checked in a temporary experimental manner with the particular transistor receiver with which it will be employed before any permanent installation is carried out.

A.M. Receiver A.G.C. Circuits

To understand how the tuning indicator circuit functions it is first of all necessary to examine the a.g.c. circuits employed in conventional a.m. transistor superhets. As was checked by the writer (who examined a large number of commercial receiver circuits to verify the point) it is conventional practice, with medium and long wave transistor superhets, to connect the diode detector following the last i.f. transformer in such a manner that the non-earthy end of the diode load goes positive as signal strength increases. This positive-going voltage is applied, as an a.g.c. potential, to a potentiometer which provides bias for the first i.f. transistor. The potentiometer is shown, in Fig. 1, as R_1, R_2. In the absence of signal, R_1 and R_2 bias the i.f. transistor such that maximum i.f. amplification is given. When a signal is received the positive-going voltage from the diode load causes the transistor base to go positive also, thereby reducing its gain. Thus, an a.g.c. loop is set up.

A small standing forward current flows through the diode detector, with the result that the a.g.c. potential from its load is slightly negative of chassis in the absence of signal, and only swings positive of chassis on reception of a signal of sufficient strength. The small forward bias can result in an apparent delay in the a.g.c. characteristic of the receiver, since very weak signals can be detected and reproduced at acceptable loudspeaker strength without causing any appreciable positive excursion of the a.g.c. voltage. This effect (which will vary in degree between receivers of different manufacture and design) prevents any tuning indicator operated by a.g.c. potential from giving indications with very weak signals, and represents a limitation in performance which has to be accepted if simple circuits are to be used for coupling the indicator to the receiver.

These points summarise the receiver features which are applicable to the present circuit. They were dealt with in greater detail in last month's "Suggested Circuit", and readers requiring further information should turn to that article.

Adding A Tuning Indicator

The preceding article also gave details of several methods in which a meter could be employed as a tuning indicator. However, such a meter cannot be mounted on the restricted panel space available with the smaller transistor radios, and an alternative means of indication is required. The lack of a suitable h.t. supply makes it impossible to fit a conventional type of tuning indicator (as is employed with valve receivers), and it was this which prompted the writer to investigate the possibilities of a tuning indicator employing a small m.e.s. bulb

The result is shown in Fig. 2. In this diagram the input emitter of a pair of directly coupled transistors, TR_1, TR_2, is connected, via the contacts of press-switch S_1, to the junction of R_1 and R_2 of Fig. 1. A low-consumption pilot lamp appears in the collector circuit of TR_2. The remaining contacts of S_1 cause the receiver battery supply to be applied to TR_1 and TR_2 when it is depressed, with the result that these transistors are only connected to the receiver battery when it is required to use the tuning indicator. Additional battery consumption is, in consequence, kept at a low level. A 9 volt supply is assumed in Fig. 2, but the circuit could be readily adapted to operate from a 12 volt supply.

The functioning of the circuit is quite simple. In the absence of signal, maximum negative voltage appears at the junction of R_1 and R_2. In addition to providing bias

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for the i.f. transistor, this condition allows sufficient current to flow in the base circuit of TR_1 to cause the bulb in the collector circuit of TR_2 to be fully illuminated. On reception of a signal the junction of R_1 and R_2 goes positive, this resulting in a reduction in the base current for TR_1 and the dimming of the lamp. Receiver tuning is, therefore, carried out for minimum illumination in the bulb. Checks of the circuit made by the writer with a standard 6-transistor medium and long wave superhet gave quite impressive results, the bulb illumination changing from full brilliance in the absence of signal to almost complete extinction on reception of local stations. Signals of intermediate strength (apart from very weak signals, which did not cause the appearance of a.g.c. voltage) gave corresponding amounts of dimming in the bulb.

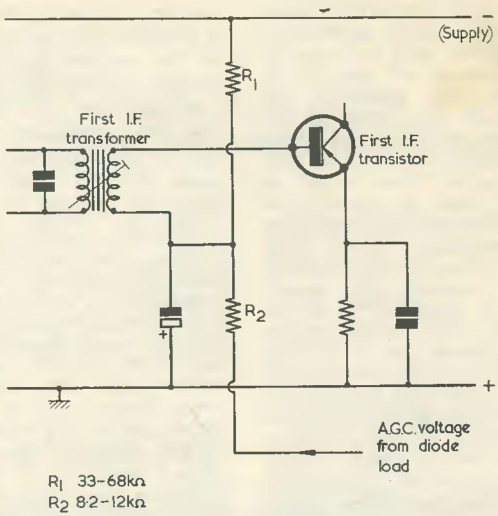

Fig. 1. The basic a.g.c. circuit in a conventional a.m. transistor superhet. The values shown for R_1 and R_2 represent the range most likely to be encountered in conventional receivers

Component Details

Despite the simple manner of circuit operation, there are a number of points which have now to be dealt with in detail, and these can be conveniently approached by discussing the individual components specified in Fig. 2.

TR_2 is an ACY18. This is a small wire-ended transistor which is readily available, and it is capable of controlling the bulb illumination for short periods, as is anticipated in the present application, without distress. It should be pointed out, nevertheless, that the circuit causes it to be operated at a fairly high dissipation figure, and it would be advisable to fit it with a well-coupled cooling fin if the indicator is to be switched on for anything longer than occasional short periods.

The remaining transistor in the direct-coupled pair, TR_1, may be any small transistor having a reasonably high gain. Under correct operating conditions, a direct-coupled pair such as is given by TR_1 and TR_2 can offer an overall gain which is equal to the product of the gains in each transistor. Thus, very high overall gain figures are feasible. To give an idea of what may be given, the writer initially checked the direct-coupled pair in the prototype circuit (with R_3 set to zero resistance) by the delightfully simple process of holding the unconnected base lead-out of TR_1 between thumb and forefinger, and touching a finger of the other hand to the negative terminal of the battery. The small base current which then flowed was more than sufficient to cause the bulb to become fully illuminated!

The transistor chosen for the TR_1 position can be any small p.n.p. type whose maximum V_{ce} is greater than 9 volts. It may, however, be necessary to select this transistor for adequate gain. The operating current available from the receiver for the direct-coupled pair depends upon conditions in the first i.f. transistor base circuit and, in particular, upon the value of R_1. As shown in Fig. 1, the value of R_1 in most receivers likely to be encountered ranges from 33 to 68kΩ. In the receiver used with the prototype circuit it

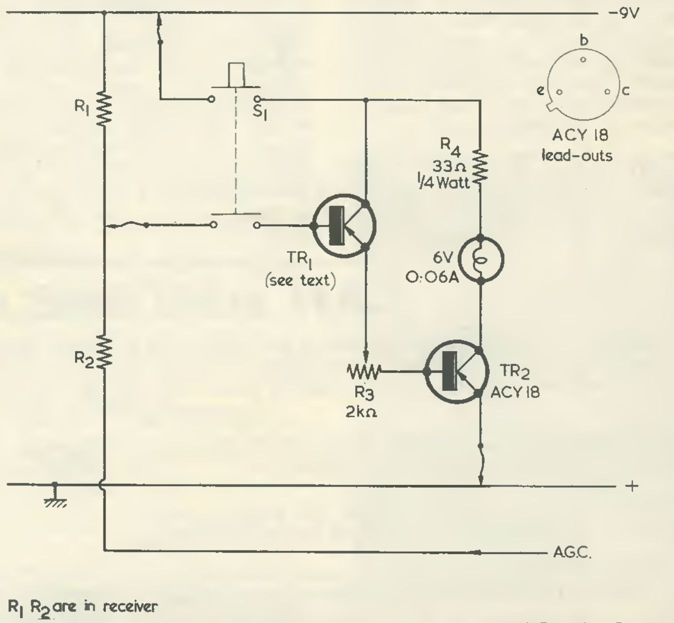

Fig. 2. Adding the tuning indicator to the basic circuit of Fig. 1. S_1 is a two-pole press-switch, one pole of which connects the negative supply to TR_1 collector and R_4 whilst the other pole connects the junction of R_1 and R_2 to the base of TR_1

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was 39kΩ, and the writer found that he could obtain satisfactory operation of the bulb with any of several transistors of the OC71 class in the TR_1 position. He then increased the value of R_1 in the receiver to 75kΩ (this representing a slightly worse case than the maximum of 68kΩ shown in Fig. 1) and found it necessary to select transistors for gain in order to obtain satisfactory results. This selection gave rise to little trouble in practice, however, and several OC44's which happened to be on hand all gave the desired results in the TR_1 position.

It is the fact that selection of transistors for gain may be required, and that it is impossible to predict circuit conditions in the particular receiver to be modified, which puts this circuit in the experimental category. As was mentioned above, it should be tried out experimentally before making a permanent installation.

The changes in TR_1 carried out by the author assumed, of course, adequate gain in TR_2, and a low gain transistor in the latter position will naturally require a higher gain transistor in the TR_1 position to compensate. However, the writer felt that there was little point in going to exceptional lengths in investigating gain requirements because of the inability to predict receiver circuit conditions. It should be added that, in all cases checked, connecting up the indicator circuit (with R_3 correctly adjusted) caused no significant drop in the negative voltage at the junction of R_1 and R_2.

Since carrying out his experiments, the writer has encountered a commercial receiver circuit having a value of 120kΩ in the R_1 position. If a value as high as this is employed in the receiver it is intended to modify, more careful selection of transistors in the direct-coupled pair may be needed. The writer has not checked the circuit for a value, in R_1, above the 75kΩ figure just referred to.

Variable resistor R_3 is inserted between TR_1 and TR_2 to provide a sensitivity control. An alternative position for such a sensitivity control would be given by a variable resistor in series with the input connection to TR_1 base, but the writer found that indications for weak signals appeared to be marginally better with the sensitivity control inserted between TR_1 and TR_2, as shown.

The press-switch, S_1, requires two sets of contacts, since it is necessary to disconnect the direct-coupled pair from R_1 and R_2 when its supply circuit is broken. If this is not done, the base-emitter junctions of TR_1 and TR_2 operate as diodes, and draw the junction of R_1 and R_2 towards chassis potential when their collector supplies are removed. The switch may be any spring-loaded rotary or toggle type having two poles.

The lamp is a Radiospares 6 volt 0.06 amp m.e.s. type, and its low current consumption makes it particularly useful in the present application. Resistor R_4 limits the voltage across the bulb to approximately 6 volts when TR_2 is fully conductive. If it is intended to use the circuit with a 12 volt supply, R_4 should be increased to 82Ω, ½ watt. In this instance, TR_1 should be a transistor having a maximum V_{ce} greater than 12 volts.

Setting Up

After the circuit has been assembled in experimental fashion it should be coupled up to the receiver. At this stage it may prove helpful to use a separate battery for the tuning indicator circuit proper and to dispense with S_1, connecting the base of TR_1 direct to the point in the receiver corresponding to the junction of R_1 and R_2 in Fig. 1. The fact that this point is bypassed by a large value capacitor (see Fig. 1) allows the connecting lead to be routed through any section of the receiver without undue risk of instability. R_3 should be set to insert maximum resistance.

The receiver should then be switched on and tuned to a blank section of the dial. If there is sufficient gain in TR_1 and TR_2, and if the receiver circuit permits sufficient input base current for the direct-coupled pair, the lamp should reach full brilliance as the resistance inserted by R_3 is decreased. R_3 should be initially left at the setting at which the lamp just reaches full brilliance under no-signal conditions, and the receiver tuning control adjusted to check the performance of the indicator with various received signals. If necessary, R_3 should then be given a final slight readjustment to give optimum performance with all signal strengths received.

As has already been mentioned, results with the prototype were very satisfactory for values in R_1 of 39kΩ and 75kΩ, the bulb illumination responding to all signals which caused the appearance of an a.g.c. potential. In the writer's case, the most powerful local station caused the bulb to be very nearly completely extinguished whilst, under no-signal conditions, it glowed at full brilliance.

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.

Smith Radiomobile Model 4220.—I. H. Wand, 49 Derwent Road, Scunthorpe, Lincs.—any information.

* * *

Verdik S1 Tape Recorder.—R. Bruce, 123 East Parade, York—service sheet, circuit diagram or any information.

* * *

Verdik S1 Tape Recorder.—S. C. Kinnoo, Goodlands, Mauritius—service sheet, circuit diagram or any information.

* * *

Hallicrafters S38 Receiver.—P. E. Stone, 25 Swallowfields, Totnes, S. Devon—purchase or borrow circuit or manual.

"Faraday Challenge" Receiver.—W. Fancourt, 20 Knightcott, Banwell, Weston-Super-Mare, Somerset—circuit or any details.

* * *

American IFF Units.—I. G. Mant, 28 Welbourne Road, Childwall, Liverpool, 16—any information on CZR-43-AAY (part of ABK-5); CZR-43-AAX (part of ABK-4) or BC-966 believed to be part of SCR-695. Also, any information on modifying Indicator Type 62 to an oscilloscope.

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NEWS AND COMMENT . . .

Oscar III

Attention was drawn to the Orbital Satellite Carrying Amateur Radio projects in "News and Comment", in our February 1964 issue. Oscar III was successfully launched from a rocket launching site in California on 9th March last at 18.30 G.M.T.

This satellite is a far more ambitious project than the previous two. It is designed so that it can receive amateur radio signals directed at it and then re-transmit them, in much the same manner as the relay satellites of the Telstar type. This type of satellite is known as a translator satellite. It receives amateur transmissions in the approximate range 144.1 Mc/s, amplifies them and then re-transmits them at approximately 145.9 Mc/s. It also carries normal beacon transmitters similar to those in previous satellites; one on 145.85 Mc/s sending the Morse signal "HI" and the other a continuous signal for tracking purposes on 145.95 Mc/s. The satellite measures approximately 18 x 12 x 6in and weighs about 30 pounds. It has four aerials, one for receiving and three for transmitting, and extensive use is made of transistors. Solar cells provide part of the power supply.

The successful launching naturally produced much excitement in the amateur radio world, particularly amongst v.h.f. enthusiasts. Its characteristic "HI" signal was being reported, within an orbit or two, from amateur stations all over the world. The orbit time was found to be 103½ minutes and the orbit path, from pole to pole, almost circular; its height was about 575 miles.

Reports soon came in, too, of the reception of amateur radio signals from it. Experience so far has shown that whilst it is comparatively easy to pick up amateur signals from it, two way communication is extremely difficult, and we will watch with keen interest for the official reports on this use of the satellite to appear.

May we add our congratulations to the many which have already been extended to the band of enthusiasts in the U.S.A. who saw this project through to success. We hope they will go on to even more ambitious projects in the future. The success of Oscar III speaks very highly indeed for the scientific and technical ability which is to be found within the sphere of amateur radio, and shows, once again, in a new field this time, that amateur radio can still play a part in promoting technical advances.

Quote

"If the Drury Lane Theatre were filled for eight performances a week, it would take 27 years to reach the audience which *Steptoe and Son* attracted in one night."—Lord Willis, during a debate in the House of Lords on television.

Radio Energy from Distant Galaxy

Radio energy which originated more than 300 million years ago was harnessed to open a curtain during the dedication ceremonies in the United States of, it is claimed, the world's most sensitive radio aerial.

The aerial, known as the Haystack Radar Facility, stands on a hill near Tyngsboro, Massachusetts. The aerial is designed for tracking spacecraft and for exploring radio waves spontaneously emanating from still little-understood sources in the universe.

During the dedication ceremonies, the aerial was focused on the Cygnus A galaxy, one of the "brightest"—most powerful—radio sources in the universe, which few optical telescopes can observe.

Cygnus A is believed to have originated from the collision of two galaxies at about the same time the earth was in its early stages of development. The collision sparked radio energy which has been travelling ever since towards the earth and is only now arriving after traversing 300 million light years.

(A light year is the distance over which light—moving at a speed of about 186,000 miles a second—travels in a year's time—about six million million miles.)

The radio energy picked up by the aerial was translated into static noise which was broadcast over the public address system for the audience at the ceremony. The noise then triggered a relay which slowly opened a curtain on the stage, unveiling the dedication plaque for the Haystack facility.

The aerial is so sensitive that it can track an object the size of a needle orbiting 500 miles above the earth!

Solder Remover

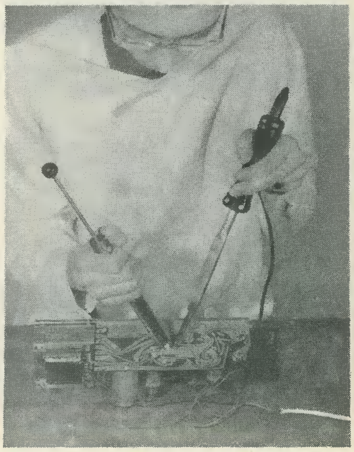
An effective solder remover is an invaluable aid to the radio and electronic engineer enabling speedy and efficient repairs or replacements of components to be carried out.

W. Greenwood Electronic Limited has introduced a precision tool for the instant removal of solder from printed circuits and all other solder joints.

The tool is an invaluable aid to the radio and electronic engineer. It enables much quicker and more efficient repair or replacement to be carried out and completely eliminates the risk of damage to either unit or component.

The nozzle of the tool is placed adjacent to the solder joint and on depression of the release button the hot solder is immediately and completely sucked into the nozzle. Re-loading is easily carried out by pressing the piston knob and the tool is then ready for the next operation.

This new and patented device costs 79s. 6d.



Removing solder from a printed circuit with this new solder remover.

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Improving the Performance of the AR88

By J. HOLLINGWORTH

Improve signal-noise ratio by fitting a frame-grid pentode in the aerial stage

As a general purpose communications receiver, the AR88 is excellent in most respects, but by present-day standards the signal/noise ratio and sensitivity leave much to be desired. It was therefore decided to attempt a modification to improve the performance in this respect.

Design Considerations

At this stage, a few words about the basic design considerations for an r.f. amplifier may not be amiss (with apologies to any readers who are already familiar with these).

The first point to consider is noise. Any receiving system generates some noise, and unless the wanted signal is stronger than this noise, no amount of amplification will make it audible. Sources of noise are the aerial system, the components in the grid circuit of the first stage, the first amplifier valve itself and, to some extent, the second r.f. amplifier or mixer stage.

There is, for all practical purposes, little that can be done about the first two sources of noise. The last can be taken care of by ensuring that the gain of the first r.f. stage is sufficiently high to make its noise output large compared with the noise generated by the next stage.

The noise generated by the valve itself is due to a number of effects, generally lumped together as a factor "R_{eq}" which is simply the value of resistance which would generate the same value of noise as the valve, under the conditions specified. This value of "R_{eq}" should ideally be as small as possible.

A second matter to consider is a.g.c. and its application. The method of applying a.g.c. to an r.f. stage is extremely important. Consider for example a receiver tuned to a weak signal, and giving a reasonable signal-to-noise ratio. With a high gain receiver, it is possible to generate quite large a.g.c. voltages for comparatively small input signals. Thus, if our weak signal is slightly increased, the a.g.c. could bias back the r.f. stage to a point on its characteristic which gives a low value of gm and hence a low gain. Under these circumstances it would be possible for the noise generated by the second r.f. stage or mixer to be significant compared to the noise output of the first r.f. stage, leading to a deterioration in signal/noise ratio as the input signal is increased.

The solution to this problem is to delay the application of a.g.c. to the first r.f. stage until the input signal is sufficiently strong to overcome the effect, relying on i.f. gain control alone up to this point.

Lastly, the problem of stability must be considered. This is most important, since even if actual oscillation does not take place, feedback may cause undesirable effects on the tracking of the grid and anode tuned circuits. Apart from reducing anode-to-grid capacitance by the choice of a valve with low C_{a-g}, and careful screening, it is necessary to avoid having impedances common to input and output circuits. For example, a.g.c. lines, heater lines, portions of the chassis carrying currents from tuned circuit or bypass components, cathode circuit components and even the shafts of variable capacitors can all contribute to this type of coupling between input and output circuits.

Modifications

Considering, now, the AR88 itself, the r.f. stage uses a 6SG7 variable-mu r.f. pentode. This has the following approximate characteristics: R_{eq}=3,000Ω, gm=3.5mA/V and C_{a-g}=3 mpF. The EF183, a readily obtainable modern pentode, has R_{eq}=490Ω, gm=12–15mA/V,

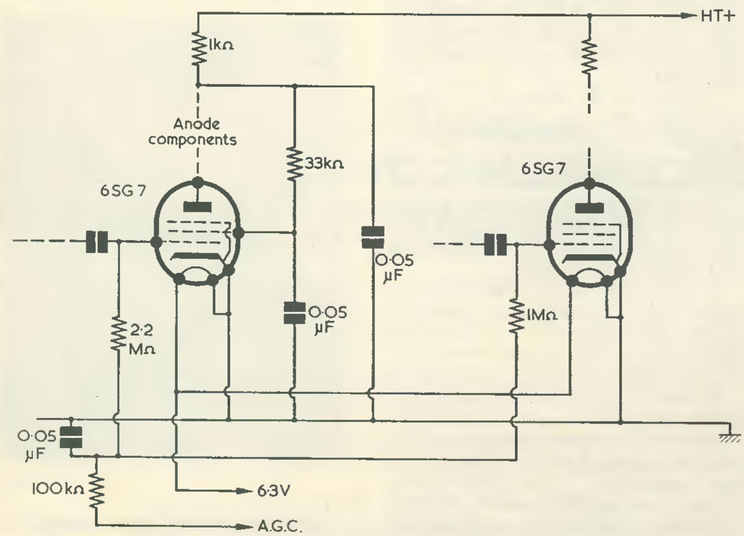

Fig. 1. The existing aerial r.f. amplifier stage in the AR88

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and C_{a-g}=5.5 mpF.

As the actual noise *voltage* generated is roughly proportional to R_{eq} an improvement of about 2.5:1 can be obtained using the EF183. The stability however will be reduced, due to the increase in gain of around four times and the almost doubled C_{a-g}. It would be possible to operate the EF183 at reduced gm but, as the noise has been reduced, an increase in gain is desirable to take full advantage of this. It is simpler to provide this gain in the r.f. stage, as part of the modification, than elsewhere.

Fig. 1 shows the original circuit and Fig. 2 the modified version. As can be seen, the a.g.c. and heater supplies have been rearranged, and the decoupling components and cathode circuit rewired to reduce feedback.

The un-bypassed cathode resistors serve to keep the input capacitance more constant with a.g.c. voltage variations, thus preventing detuning. With the layout shown in Fig. 3, and the adaptor plate and screen shown in Figs. 4 and 5, the amplifier remains stable at all frequencies for

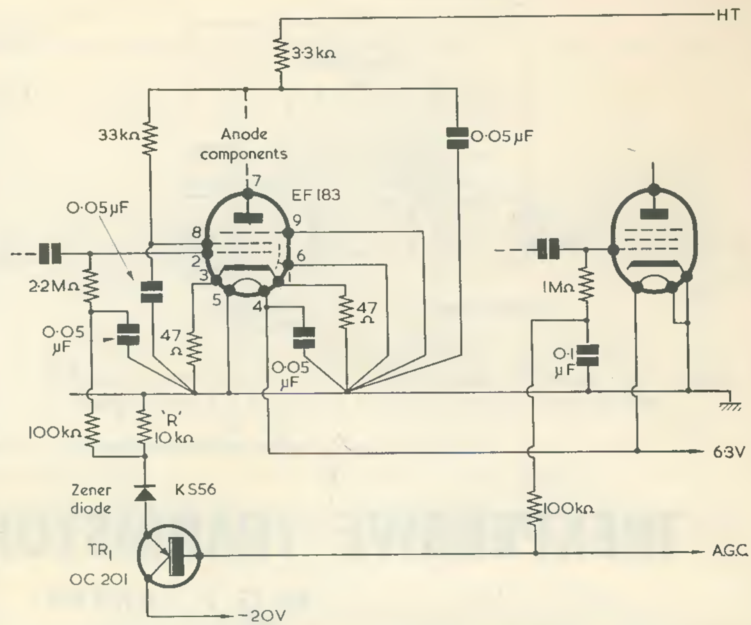

Fig. 2. *The modified circuit incorporating an EF183*

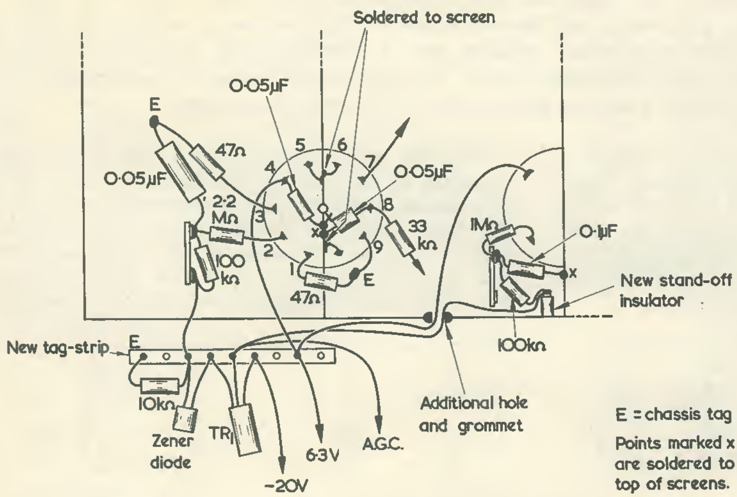

Fig. 3. *The new layout around the EF183 valveholder*

C_{a-g} up to 25 mpF, thus retaining a good margin of safety when C_{a-g} is 5.5 mpF.

The operation of the transistorised a.g.c. delay circuit is as follows. For low a.g.c. voltages TR_1 is cut off, the valve grid being returned to earth via the 10kΩ resistor, R. As the a.g.c. voltage increases TR_1 conducts, the emitter following the base, with V_{be} in the order of 0.6 volts. Most of the voltage between emitter and earth is dropped across the zener diode, which exhibits a high reverse resistance up to the zener voltage. After this point, the drop across the zener diode remains substantially constant, any further increase in emitter voltage appearing across R. Thus, when a.g.c. is applied progressively, very little bias is applied to the r.f. stage until a voltage (determined by the zener voltage) is reached. The −20V supply is derived from a convenient point in the receiver bias circuit (at the junction of R_{43} and R_{44}).

The zener diode is a Ferranti KS56 having a nominal zener voltage of 5.6.*

Realignment

The only adjustment necessary is the re-trimming of the pre-set capacitors in the first r.f. anode circuit. This is best done at the correct frequencies using a signal generator, but can be carried out quite successfully on received signals at the high frequency end of each range.

Performance

Accurate measurements of noise performance require a correctly matched noise generator and an output meter capable of reading r.m.s. noise, preferably before the

* An OAZ202, with a zener voltage of 5.6 at 1mA, should provide a satisfactory alternative.—EDITOR.

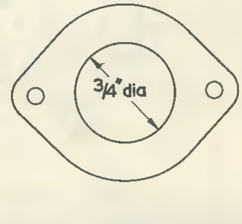

Fig. 4. *The valveholder adaptor plate which takes the new B9A valveholder. The dimensions are the same as for the octal adaptor removed, and the B9A valveholder is sweated to the plate*

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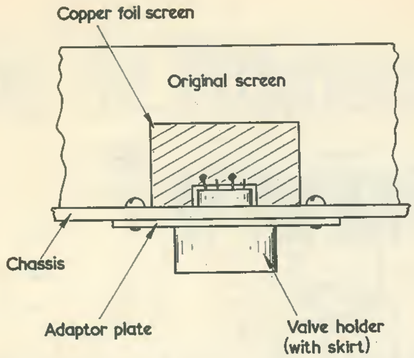

Fig. 5. Side view of the screen assembly. The copper foil screen is cut to fit and sweated to the original screen and to pins 5, 6 and the spigot

detector. As only a 70Ω generator and an ordinary valve voltmeter were available, no absolute measurements could be easily made, but some indication of the degree of improvement is given by measured noise factors of 5.5 before modification, and 2.2 afterwards, taken under otherwise similar conditions.

Conclusion

In conclusion it may be stated that a worthwhile improvement in performance can be obtained by using a modern low-noise r.f. pentode in the first r.f. stage of the AR88. The performance after modification then compares favourably with most modern receivers.

INEXPENSIVE TRANSISTOR SUPERHET

By G. F. PARKER

How does one build a transistor superhet **really** *cheaply? In this article our contributor approaches the ultimate because not only are most component values not critical but all inductors, including the i.f. transformers, are home-wound! A further saving is given by the use of a complementary output stage which requires no a.f. transformers. The result is a medium wave receiver which gives excellent results on local stations and on Luxembourg, combined with quite an adequate performance with other transmitters*

THE RADIO TO BE DESCRIBED IN THIS ARTICLE IS A 7-transistor portable giving good quality sound with adequate volume on the medium waveband. A large 3Ω speaker, 5in diameter, is used, and the reproduction compares favourably, both in volume and quality, with that of commercial types costing many times as much as the original.

The first aim in construction was to produce at superhet at the *absolute* minimum of cost. In fact the author built the prototype with parts found in the spares box, and bought no compononts specific ally for this set. This was possible because most of the parts, except the coils and the components associated with the tuned circuits, are not critical.

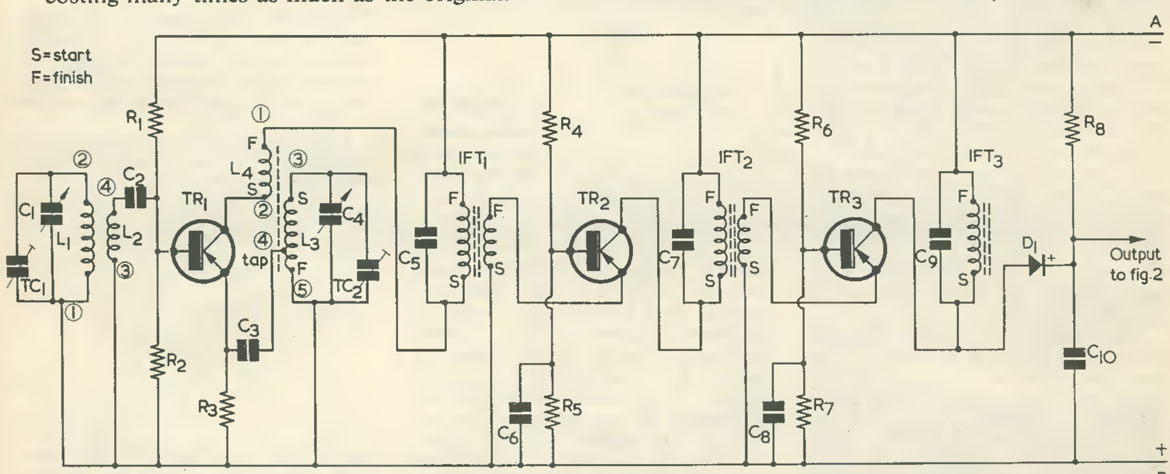

Fig. 1. The r.f. and i.f. section of the receiver. The numbers on L_1 to L_4 indicate the leads identified in the layout diagram of Fig. 5. Also indicated are the start (S) and finish (F) of each winding. It is most important that the oscillator coil, in particular, be connected as shown here

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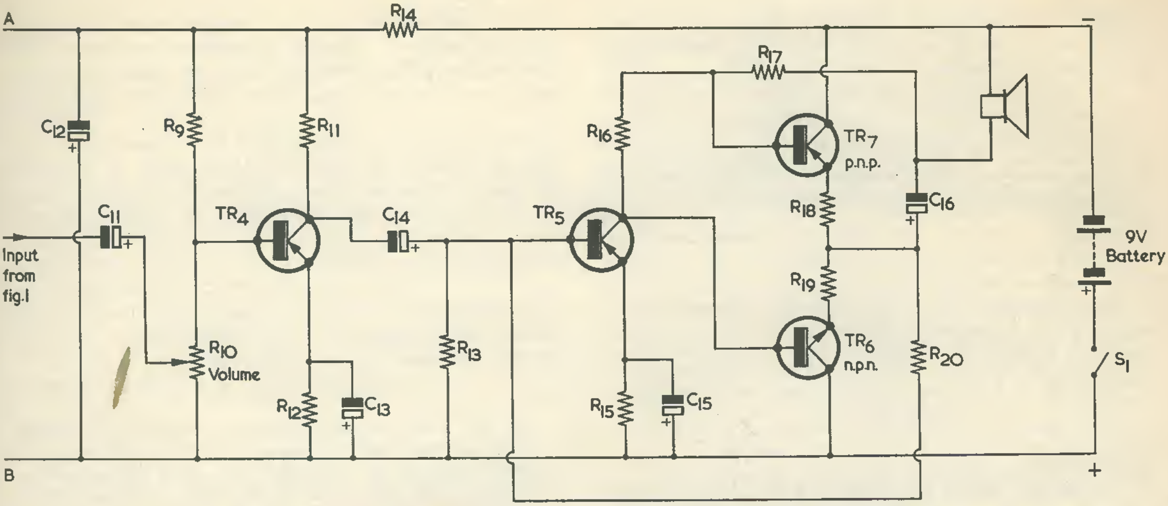

Fig. 2. The a.f. section of the receiver. The output stage employs a complementary pair of transistors

Components List
(Figs. 1 and 2)

Resistors

(All fixed values 20% ¼ watt)

R_1	68kΩ
R_2	10kΩ
R_3	3.9kΩ
R_4	100kΩ
R_5	4.7kΩ
R_6	100kΩ
R_7	4.7kΩ
R_8	22kΩ
R_9	100kΩ
R_{10}	10 or 20kΩ potentiometer, log track
R_{11}	2.2kΩ
R_{12}	1kΩ
R_{13}	10kΩ
R_{14}	100Ω
R_{15}	1kΩ
R_{16}	100Ω
R_{17}	1kΩ
R_{18}	4.3Ω
R_{19}	4.3Ω
R_{20}	10kΩ

Capacitors

(Electrolytics may be sub-miniature types. Working voltages should be at least 12)

C_1,C_4	500+500pF variable (air-spaced)
C_2	0.01μF
C_3	0.01μF
C_5	200pF silver mica
C_6	0.01μF
C_7	200pF silver mica
C_8	0.01μF
C_9	200pF silver mica
C_{10}	0.01μF
C_{11}	10μF, electrolytic
C_{12}	100μF, electrolytic
C_{13}	30 to 100μF, electrolytic
C_{14}	10μF, electrolytic
C_{15}	30 to 100μF, electrolytic
C_{16}	100μF, electrolytic
TC_1	500pF trimmer
TC_2	50pF trimmer

Semiconductors

(Alternative transistors are discussed in the text)

TR_1	OC44, SB305, AF115, surplus r.f. transistors
$TR_{2,3}$	OC45, AF117, surplus r.f. or i.f. transistors
TR_4	OC71, GET113, surplus a.f. transistors
TR_5	OC71, GET113, OC81D, surplus a.f. transistors
TR_6	XA701, OC140, OC139
TR_7	OC72, OC81, surplus a.f. transistors

Loudspeaker

See text

Inductors

(All inductors are home-wound, and construction is described in the text)

$L_{1,2}$	Ferrite rod aerial
$L_{3,4}$	Oscillator coil
$IFT_{1,2,3}$	I.F. transformers

Switch

S_1 s.p.s.t. (may be ganged with R_{10})

Battery

9V type PP9 or similar

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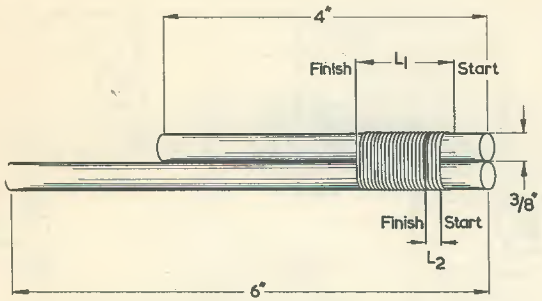

Fig. 3. Details of the ferrite aerial. L_1 consists of 35 turns of 30 or 32 s.w.g. cotton-covered or enamelled wire. L_2 is 1 turn of the same wire wound at the earthy end of L_1

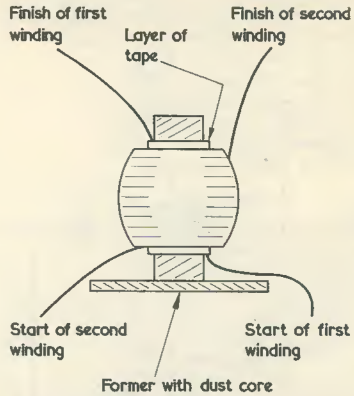

Fig. 4. The first and second i.f. transformers. The first winding has 33 turns of 30 to 32 s.w.g. cotton-covered or enamelled wire, and the second winding has 330 turns of 36 s.w.g. enamelled or cotton-covered wire. The third i.f. transformer has a single 330 turn coil

The Circuit

The circuit, which is shown in Figs. 1 and 2, was evolved after considerable experiment towards obtaining good results with the materials to hand at the time. It was essential, therefore, to hand-wind the i.f. and oscillator coils. The a.f. amplifier was also constructed with little expenditure. It does not contain the usual push-pull output stage having two transformers and a matched pair of transistors, but the less common complementary circuit. In this the p.n.p. transistor, TR_7, conducts for the negative half, and the n.p.n. transistor, TR_6, for the positive half of the signal. A matched pair of transistors is not required in this circuit. The main drawback of this circuit, so far as the home constructor is concerned, is the fact that an n.p.n. transistor is used. Most constructors will probably not have one of these in their spares box, and it will have to be purchased. Any n.p.n. transistor, such as the Ediswan XA701, OC139 or OC140, should be suitable in this position. The author used an XA701.

TR_1 is the frequency changer, oscillation being achieved by coupling the emitter of this transistor to the collector by means of L_4. Any r.f. transistor will work in this position. The author has tried OC44, SB305, surplus white spot and various surplus Ediswan transistors, and all were found to be satisfactory. However, new transistors, as would be expected, gave slightly better results than surplus types. The 3.9kΩ bias resistor, R_3, is shunted by the 0.01μF capacitor, C_3, this being tapped into the earthy end of L_3 (the emitter impedance of TR_1 is very low). The bias resistors for the first transistor are R_1 and R_2, and these are not critical.

The intermediate frequency resulting from mixing the oscillator and signal frequencies is selected by the tuned i.f. circuit represented by the primary of IFT_1 and C_5. It should be noted that the values of C_5, C_7 and C_9 are critical. The intermediate frequency is then fed into the emitter of TR_2 by a low impedance coupling coil. TR_2 is connected in the common base mode rather than in the more usual common emitter circuit, even though it gives slightly less gain as a result. It was thought, however, that some gain could be spared in the interest of stability.

TR_3 amplifies the i.f. signal in similar manner. The signal at the collector of TR_3 is demodulated by diode D_1, which may be of any type (even surplus) and it is then fed via C_{11} to the slider of the 10 or 20kΩ volume control R_{10}. This potentiometer forms part of the potential divider supplying the base of TR_4 and its value is not very critical. The bypass capacitors in the emitter leads of TR_4 and TR_5 need to be fairly large, about 30 to 100μF.

TR_4 and TR_5 amplify the a.f. signal, this appearing at the collector of TR_5. TR_6 and TR_7 provide further amplification, these transistors being connected in the common-collector mode. This arrangement gives a high current gain and faithful reproduction of the signal.

For TR_4 and TR_5, OC71, GET113 and various surplus transistors have been found to be satisfactory. An OC81D would probably be satisfactory for TR_5, with an OC72 or OC81 for TR_7. In the original, TR_7 was a surplus Ediswan transistor selected for its high gain and low leakage.

R_{14} (100Ω) and C_{12} (100μF) form the decoupling circuit for the receiver. If decoupling is found to be unsatisfactory, R_{14} may be increased to, say, 300Ω.

The loudspeaker may be any type, preferably of slightly higher impedance than the 2–3Ω employed in the prototype. Smaller speakers than the 5in diameter unit used in the original may be employed, but quality of reproduction will, however, suffer.

The Ferrite Aerial

Details of the ferrite aerial are given in Fig. 3. This was wound on two pieces of ferrite rod ⅜in in diameter, the complete assembly being approximately 6in in length. The size is not critical, and any available piece of rod of reasonable size may be used, the larger the better. If rods of different

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dimensions are used the number of turns on L_1 may have to be changed slightly. In the original, the two pieces of ferrite were bound together with Sellotape, and the coils were wound over this material.

L_1 consisted of 35 turns of 30 or 32 s.w.g. cotton covered or enamelled wire, slightly spaced at one end. L_2 was one turn of the same wire wound in the same sense at the earthy end of L_1.

The coils should not be fixed permanently in place yet, as they may have to be adjusted when alignment is commenced.

If a smaller rod than that used by the author is to hand, several more turns may have to be added to L_1. If a larger diameter rod is available, several turns may need to be removed from L_1.

The Coils

The coils comprise the three i.f. transformers and the oscillator coil, and these are all wound on coil formers having an approximate diameter of ¼in. In one version of this radio made by the author, small TV i.f. coil formers were used. Some further notes on these formers are given at the end of this article.

The oscillator coil L_3,L_4, consists of two windings. The first, L_4, has 30 turns of 30 s.w.g. enamelled or cotton-covered wire, close-wound on the ¼in former. This winding is covered with Sellotape, and the second winding, L_3, which consists of 80 turns of a thinner wire, around 36 s.w.g. enamelled or cotton-covered, and tapped at 70 turns, is wound in the same sense over this. The winding should be done neatly, but does not have to be close-wound. When the coil is finished, L_3 should be sealed in place with Sellotape, or polystyrene cement.

The first and second i.f. transformers come next. (See Fig. 4.) Each of these, again, consists of two separate windings. The first has 33 turns of 30 to 32 s.w.g. cotton-covered or enamelled wire close-wound on the former. This is then covered with a layer of Sellotape, and the second winding is started. The second winding consists of 330 turns of 36 s.w.g. enamelled or cotton-covered wire random-wound, and is fixed with a second layer of adhesive tape. Both windings must be in the same sense. The 330 turn winding is that which is tuned.

The third i.f. transformer has a single tuned winding only. This consists of 330 turns of 36 s.w.g. enamelled or cotton-covered wire wound directly on to the former in the same manner as the other i.f. transformers. The windings are sealed in place with adhesive tape or cement.

Construction

The original was built for convenience in two parts, these being the r.f. and i.f. section, and the a.f. section. The r.f. and i.f. section (Figs. 1 and 5) was constructed on a piece of ⅛in plywood. Four holes were drilled in the wood to take four bolts which held solder tags in place. To these tags were soldered parallel bus-bars of 20 s.w.g. tinned copper wire. Components were then soldered to these bus-bars, using the layout shown. If some alterna-

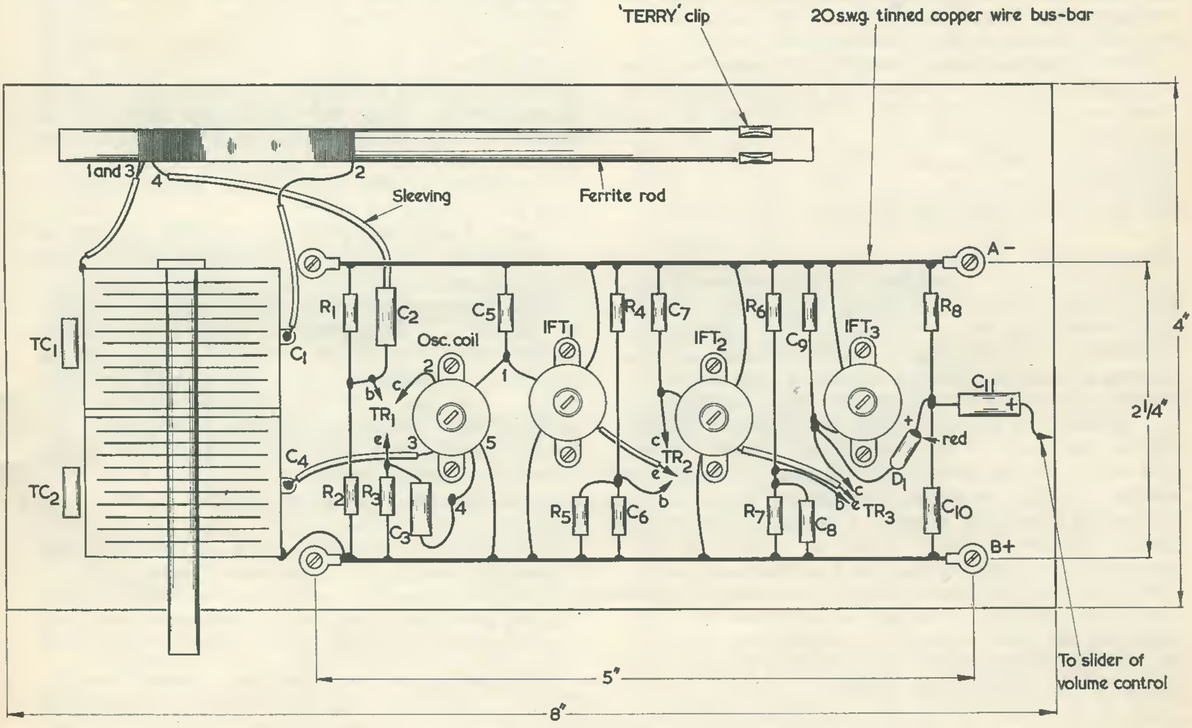

Fig. 5. Layout (not to scale) of the r.f. and i.f. section

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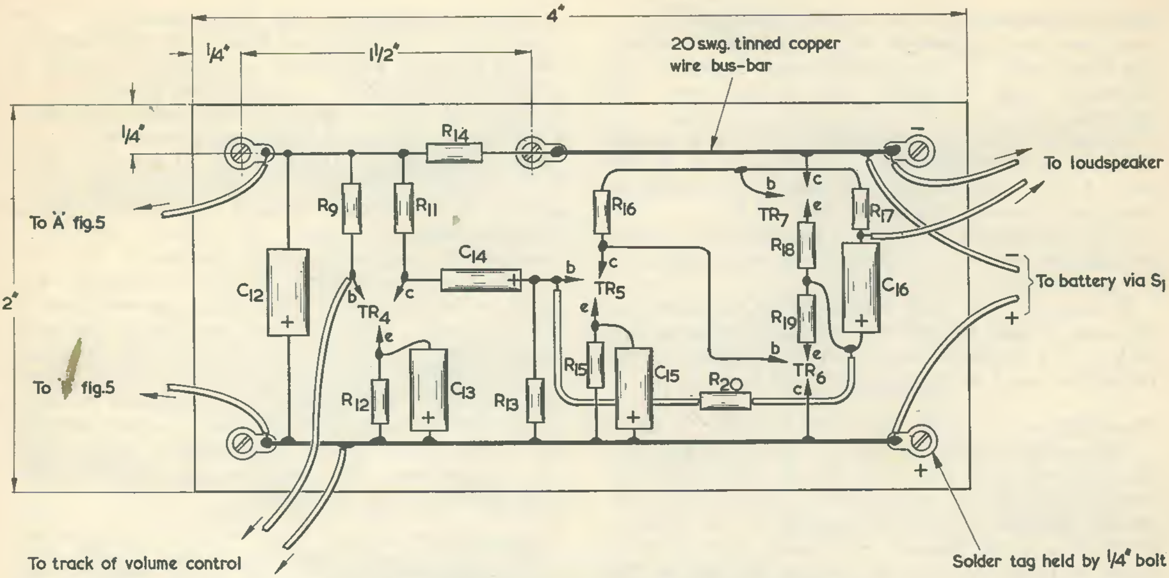

Fig. 6. Layout of the a.f. section. Again, this is not to scale

tive arrangement of the components is preferred by the constructor, he must ensure that the coils are not too close together or the connecting wires too long, as instability may occur in the form of oscillations when stations are tuned in.

It is important to note that, for correct results, the oscillator coil and i.f. transformers *must* be connected as shown in Fig. 1. This indicates the start (S) and finish (F) of each winding.

The a.f. section (Figs. 2 and 6) is built in the same way as the i.f. section, a piece of ⅛in plywood, with bus-bars, again being used. The layout of this section is shown in Fig. 6.

With both sections, care should be taken, when soldering transistors and other delicate components, to use heat shunts on the lead-out wires.

Alignment and Testing

Before the set is switched on for the first time, the circuit should be checked to ensure correct connections of the transistors, the electrolytic capacitors and the diode. The polarity of the battery should be double-checked, as reversal of the battery connections could damage the transistors.

If possible, a meter reading up to 50 or 100mA should be inserted in one of the battery leads, whereupon the set should be switched on. If a high current passes (above 20mA) switch off immediately and again check the circuit. Current consumption should be about 10mA with no signal. If the consumption is more than 5mA greater, or about 3mA less than this, something is probably wrong. If the set goes into violent oscillation when it is switched on, the decoupling components C_{12} and R_{14} should be suspected. If necessary, increase the value of R_{14} as mentioned above.[1]

If all is satisfactory so far the tuning capacitor should be rotated throughout its range, whereupon some stations may be heard faintly. If nothing is heard, an aerial should be connected temporarily via a 50pF capacitor to the non-earthy end of L_1. At least the local station should now be heard, even if only at low level. The cores of the i.f. transformers are then adjusted for best results. These adjustments should preferably be made with an insulated tool. The cores of the transformers should not be fully in nor fully out. During final adjustments the volume control should be turned up, the signal level being kept down by tuning in to a weak station or by using the directional effect of the aerial. Small increases in signal strength during alignment can then be checked more easily.

Alignment of the aerial and oscillator sections may next be carried out.

Radio Luxembourg on 208 metres should be tuned in, and TC_1 and TC_2 adjusted so that this station is received at almost minimum capacitance of the two-gang capacitor. If the tuning capacitor is then rotated throughout its entire range, several stations should be heard. Select a station near the maximum capacitance end of the tuning capacitor range. The core of the oscillator coil is then adjusted for maximum volume, readjusting the tuning capacitor as necessary to keep the station tuned in. Spacing the turns of L_1, the tuned coil, may have a similar effect at this end of the tuning range. At the high frequency end of the scale results will now probably have deteriorated, and adjustment of TC_2 will again be necessary.

By repeating this procedure several times—varying the trimming at the high frequency end, and the inductances at the low frequency end—good

[1] If instability is particularly troublesome, it may prove helpful to insert a further 100Ω resistor in the negative supply line. This can be inserted between R_4 and the primary of IFT_1, it being bypassed on its left hand side to the positive line by a 0.5μF capacitor. —EDITOR.

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results should be obtained over the whole tuning scale.

Results

Although the hand-wound coils used in this set must necessarily be less efficient than the manufactured article, the original gave very good results. Selectivity was excellent. During the daytime, about five or six stations were received at good volume, and after dark many more, about thirty, were picked up. At full volume, several stations were too loud to listen to in comfort.

Battery consumption at normal volume was about 15mA, but at maximum volume went up to about 50mA. A PP9 9-volt battery was used by the author and this can be expected to last about a month, depending obviously upon the amount of use. Smaller batteries can be used if miniaturisation is attempted, but these cannot be expected to last as long as the PP9.

Further Details

Before concluding, some further details are now given to clear up any points not fully covered earlier in this article.

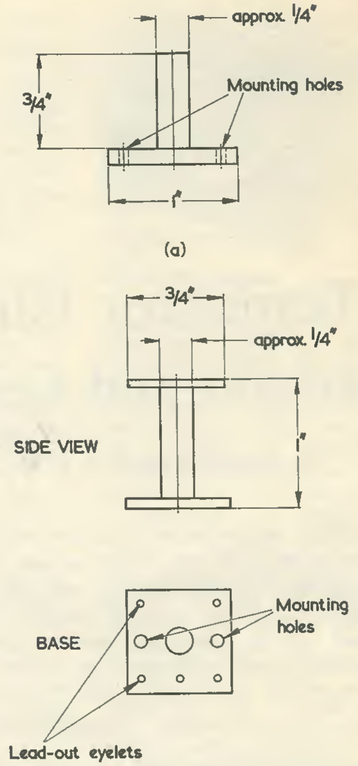
It will be noticed that no a.g.c. circuit is employed. A number of circuits were tried, but the complication introduced in what is intended to be a simple receiver for local station reception did not make their inclusion attractive.

As was mentioned earlier, several versions of the receiver have been made up using different types of former for the oscillator coil and i.f. transformers. The great advantage of this radio is the fact that components are not critical, and that latitude is possible in almost all sections. Almost any former with a diameter of approximately ¼in and having a dust core may be employed, provided that the number of turns specified is closely observed. In one version, small formers of the type shown in Fig. 7 (*a*) were used and it was even found possible to employ them without screening cans. In another version, TV i.f. coil formers, as in Fig. 7 (*b*), were employed, these using screening cans.[2]

The intermediate frequency is about 300 kc/s.

The tuning capacitor specified for C_1,C_4, has a value of 500+500pF. Normally, a 208+176pF tuning capacitor is used in transistor circuits but the writer has found that the 500+500pF component offers wider coverage and includes all stations on the medium waveband.[3]

The author has also tried transistors type AF115 in the TR_1 position and transistors type AF117 in the TR_2 and TR_3 positions. These gave extremely good results. There was, however, a tendency to squegging which was completely cured by inserting a 39Ω resistor between C_3 and the tap in the oscillator coil.



(b)

Fig. 7. Coil former dimensions are not critical. As a guide, both the types shown in (a) and in (b) have been used successfully. The coil former assemblies of (b) were taken from a TV set and a readily-obtainable alternative is discussed in the text

[2] The coils and i.f. transformers will have a fairly low Q and the risk of instability resulting from the absence of screening cans may not be high. Nevertheless, we would definitely advise the use of screening cans. A readily obtainable version of the former shown in Fig. 7 (*b*) is the Denco type 5000A/4PL, which may be used with the Denco screening can Ref. 1.—EDITOR.

[3] This is probably due to a high self-capacitance in the home-wound coils. If adequate tracking is difficult to obtain with the 500+500pF capacitor, a fixed silver mica padding capacitor of around 700pF could be connected in series with the fixed vanes of C_4.—EDITOR.

REDESIGNED STUDIOS TO HAVE MARCONI MARK V CAMERAS

Granada Television Network Ltd., one of the largest of the British independent programme contractors, is to be among the first users of the Marconi Mark V camera.

The Marconi Company are engineering consultants for a major re-development of the principal Granada Centre at Quay Street, Manchester. The new studios will provide Granada with the most up-to-date production facilities, including full 625-line capability. Marconi's, acting on behalf of Granada, will undertake all aspects of the work involved in providing Granada with this entirely new installation.

The Mark V camera, smallest and lightest 4½in image orthicon camera available in the world, is as simple to operate as an ordinary amateur photographic camera. With its integrated zoom lens, it brings a new degree of freedom to television production, by eliminating the restriction of having a number of lenses of fixed focal length on each camera. The zoom lens can frame each scene accurately at the producers direction, and either manual or servo control can be provided. With the servo control, up to four zoom positions can be pre-set.

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SUPER-REGENERATIVE

Transistor Circuit for Medium and Long Waves

Sir Douglas Hall, K.C.M.G., B.A. Oxon

Daylight reception on medium and long waves can be considerably enhanced by the use of super-regenerative detection. In this article our contributor describes a complete receiver, based on his "Spontaflex" circuit, which offers super-regenerative reception during the day and normal reception after dark. An additional feature is that one transistor serves the dual function of a.f. amplifier and quench oscillator

Super-regeneration is a means of obtaining a very high degree of radio flequency amplication with the minimum of components and power. The processes involved are complicated, but basically the system can be described as a means of quenching oscillation so that regeneration can be used far beyond the point which would otherwise be possible. A regenerative detector or radio frequency amplifier is taken beyond the point where oscillation starts, and an external oscillation at a frequency of about 10 kc/s is injected into its circuit. This quenches the radio frequency oscillation so that the amplified signal is available without the distortion which would otherwise render it useless. The radio frequency amplifier or detector is moved in and out of oscillation, the resistance of the tuned circuit becoming alternatively positive and negative at the frequency of the quench oscillation.

If the radio frequency oscillations are allowed to reach the highest point made possible by the circuit constants and direct voltage before they are quenched, the output will be logarithmically proportional to the input and so no use for the reception of speech or music. But if they are quenched before the maximum is reached the output will be arithmetically proportional to the input, and all will be well. Whether the one set of circumstances or the other prevails depends on the frequency and amplitude of the quench oscillation. It should be as far removed from the radio signal, in frequency, as possible; and design should allow for the amplitude to be adjusted, once and for all, when the receiver is set up.[1]

Producing the Quench Oscillation

There are various ways in which the quench oscillation can be produced. The simplest is to make use of the time constant of a capacitor and resistor so that the quench frequency is produced by the detector or radio frequency oscillator, the quench oscillation being caused by the capacitor charging up and discharging through the resistor. This is attractive, as (assuming transistors instead of valves) one transistor can be used to do both jobs. But in the author's experience the result is logarithmic in nature and therefore unsatisfactory. A second method is to use a tuned circuit resonant at 10 kc/s and by means of a feedback coil produce the necessary oscillation, again using the radio frequency transistor. But here again it is difficult, if not impossible, to obtain the maximum results which super-regneration can give. The most effective arrangement, and at the same time the easiest to set up and most stable in operation, is to use a separate transistor for quench oscillation. Experiments have shown that this need not, in practice, mean the use of an extra transistor in the overall circuit, as it is possible to use an audio frequency amplifier to double up as quench oscillator without any loss in efficiency or quality.

The gain which can be obtained is very great. It is proportional to the frequency of the signal being received, and at very high frequencies can only be described as phenomenal. On the medium wave band the extra gain is such as to increase the output from a station which can only just be received with normal regeneration at the critical point to an output which is ample for a large room. Even on the long wave band reception of the Light programme can be stepped up from being too quiet for comfortable listening to a point where a simple Class A output transistor is overloaded.

If this were the whole of the story, there might be no need for any other circuits. But super-regeneration has its snags. Background noise on weak stations is very loud—though the stations might be inaudible without super regeneration—and there is a 10 kc/s whistle which, oddly enough, is not nearly such a nuisance as it might appear, and on some loudspeakers may be inaudible! There is also radiation if an aerial is used. However an aerial is not necessary and with a frame or rod aerial, the receiver described in this article can be used within a few feet of another without any interference being caused.

The most serious fault is lack of selectivity. This is not as bad as often described, since it is seldom that two programmes, as such, are heard together. In fact there is less spread from a powerful station than with ordinary regeneration. But after dark, when many stronger signals are available, there is scarcely a station on the medium waveband which can be received

[1] Notes on the linear and logarithmic modes of super-regenerative detection are given in some of the general text books, including *Radio Engineering Handbook* (K. Henney) and *Radio Engineers' Handbook* (F. E. Terman). Both of these are published by McGraw-Hill.—Editor.

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without a heterodyne whine which ruins it. For this reason the circuit is virtually useless after dark, except for powerful stations for which the extra sensitivity is not really required.

Daylight Reception

It is during the hours of daylight that the circuit excels. The really weak signals do not produce their whistles, and stations in the middle distance, which would be too weak to be of use with a normal simple receiver, can be brought up to excellent strength. In fact the circuit gives the listener a choice of several Continental stations during the day, in an area where only the local station might be receivable at anything like programme value without super-regeneration. Sensitivity becomes at least as good as that of a transistorised superhet with two i.f. stages using similar sized frame aerials.

Fortunately, it is easy to switch the circuit from super-regeneration to a straight reflex design which is almost identical to the three-transistor version of the "Spontaflex" circuit described earlier by the author in this magazine.[2] The previous circuit is switched in as soon as the sun begins to set, the full sensitivity of the super-regenerative circuit being available for the hours of daylight.

The comparative simplicity of the circuit may not represent very accurately the many hours of experimenting which went into producing an arrangement which was stable throughout the medium and long wavebands without involving any extra control or other complication in tuning. The circuit is shown in Fig. 1. In this diagram, L_1 and L_2 form the medium wave frame aerial which, in the case of the prototype, consists of a single pile of 12 turns (L_1) of 32 s.w.g. enamelled wire wound on top of 2 turns (L_2) of 38 s.w.g. enamelled wire on a 9in square frame. The long wave frame aerial is of the same size. L_3 has 3 piles of 20 turns each of 38 s.w.g. enamelled wire, each pile separated by ¼in with L_4, ¼in away consisting of one pile of 8 turns of 38 s.w.g. enamelled wire. In each case the outside ends of the windings connect to S_1. Ferrite rod aerials have been tried and can, of course, be used. On 8in rods of ⅜in diameter, 50 turns and 8 turns for L_1 and L_2 will be suitable, and 200 turns and 25 turns for L_3 and L_4. Enamelled wire of 32 s.w.g. can be used throughout for rod aerials. The frames were adopted for use in the prototype as giving rather greater sensitivity.

Circuit Operation

The signal is received by the main frame aerial winding and is amplified by TR_1 as a common collector amplifier. Oscillation takes place owing to the coupling winding in the emitter circuit, depending on the setting of VR_1 which controls the amplification given by TR_1.[3] It was found preferable for super-regeneration, to control oscillation by regulating the amplification of TR_1 rather than by varying the coupling. VR_1 can give complete attenuation, down to zero if necessary, and has the advantage of reducing the current consumption of the whole receiver when backed down for quiet bedside listening to the local station. The ratio of the windings is such as to allow considerable amplification by TR_1 before oscillation starts.

The signal is demodulated by D_1 and TR_1 amplifies again as an audio frequency common base stage with a very high output

Components List (Fig. 1)

Resistors
(All fixed resistors 10% ½ watt)

R_1	47kΩ
R_2	27Ω
R_3	75Ω
R_4	1kΩ
*R_5	100Ω
*VR_1	2MΩ potentiometer, log track

Capacitors

C_1	100μF electrolytic, 6V wkg.
C_2	0.01μF
C_3	1,000pF
C_4	0.1μF
C_5	100μF electrolytic, 6V wkg.
*C_6	0.05μF
VC_1	500pF variable
*VC_2	500pF pre-set

Inductors

$L_{1,2,3,4}$	(see text)
T_1	Output transformer. Type LT700 (Rex) or type TT5 (Repanco)
T_2	Output transformer. Type TT46 (Repanco)

Semiconductors

TR_1	MAT101
$TR_{2,3}$	OC72
D_1	OA81

Switches

S_1	3-pole 3-way
*S_2	s.p.s.t.

Speaker
3Ω moving-coil

Battery
9 volt battery

* Only these components are needed if the original three-transistor "Sportaflex" circuit is to be modified.

[2] See the article by Sir Douglas Hall in the June 1964 issue, and our note on page 56 of the August 1964 issue.—EDITOR.

[3] VR_1 varies the negative potential available for the collector of TR_1, this potential being applied via the upper winding of T_2.—EDITOR.

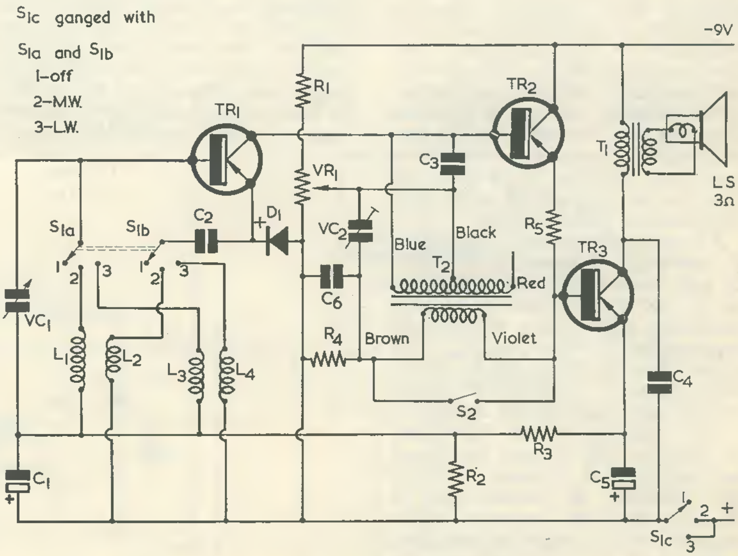

Fig. 1. The circuit of the receiver with optional super-regeneration

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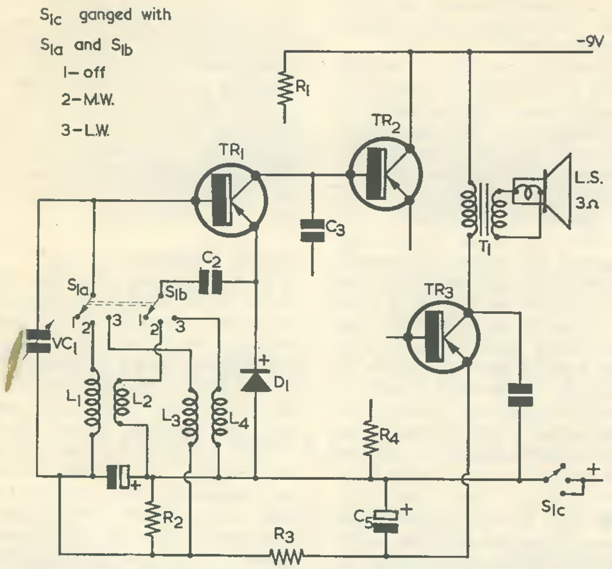

Fig. 2. First step in modifying the original receiver shown in Fig. 2 of the article published in the June 1964 issue. The circuit should take up the form shown here before the components needed for super-regeneration are added

impedance consisting of R_1 and part of VR_1. Further audio frequency amplification is given by TR_2 as a common collector amplifier. At the same time, this transistor oscillates at about 10 kc/s due to the presence of T_2. T_2 is a small output transformer with the large winding (half the primary) in the base circuit, and the small winding (the secondary) in the emitter circuit. The frequency of the oscillation is determined by the inductance of the half-primary and the capacitance of C_3. VC_2 controls the amplitude of the oscillation. It is necessary to use a variable capacitor here, though it may be preset, because of varying characteristics in different OC72's. It will be found that the correct setting with most specimens is about half-way.

R_5 prevents spurious oscillation at unwanted frequencies in TR_2. S_2 can short-circuit the secondary of T_2 and thereby prevent quench oscillation taking place when super-regeneration is not needed. The circuit then becomes a fairly normal three-transistor "Spontaflex" except for the modified volume control.

The receiver should be tested in daylight. S_2 should be closed and VC_2 turned to about the half-way position. It should then be checked that the receiver works properly without super-regeneration, tuning with VC_1 and bringing the strength up with VR_1. When this has been done S_2 should be opened and, if VC_2 is set approximately correctly, it should be found possible to advance VR_1 considerably with a great increase in volume. There will be a lot of noise between stations but this will disappear completely with a loud signal, and particularly with weaker ones.

The right setting for VC_2 should be found by trial and error, first choosing a weakish station near the low wavelength end of the medium waveband, and then a similar station near the high wavelength end. The correct setting will be fairly critical, but not exasperatingly so. Next switch to the long waveband and check that all is well. Provided L_3 and L_4 are in correct proportion there should be no difficulty, as quench oscillation amplitude is less critical on the long wave band.

As an aid to adjusting VC_2, it may be said that if the capacitance is too low there will be whistles, as VC_1 is rotated, of the kind produced by normal regenerative receivers when reaction is advanced too far. If capacitance is too high there will be a loud growling type of instability. The right position, between these two extremes, will result in good, sensitive reception, unless VR_1 is advanced too near to maximum.

Modifying the "Spontaflex"

Constructors who have built the three-transistor version of the "Spontaflex" circuit, described in the previous article and who wish to modify it will find that they can use nearly all the components specified for the earlier receiver, the original volume control, VR_1, being the only surplus item. It may prove necessary to remove a turn or two from the reaction windings of the frame aerials in order to prevent a loss of amplification resulting from the tighter coupling. The tighter coupling may cause the new VR_1 to be turned back to a point which seriously reduces the current flowing through TR_1. It may also be necessary to rearrange the switching to the method shown in this article, in order to keep the two aerials separate. As a double-pole switch was specified for wave changing, (coupled with a third pole for the battery) no new switch, apart from S_2, should be required.

Referring to Fig. 2 in the previous article, VR_1 will have to be removed,

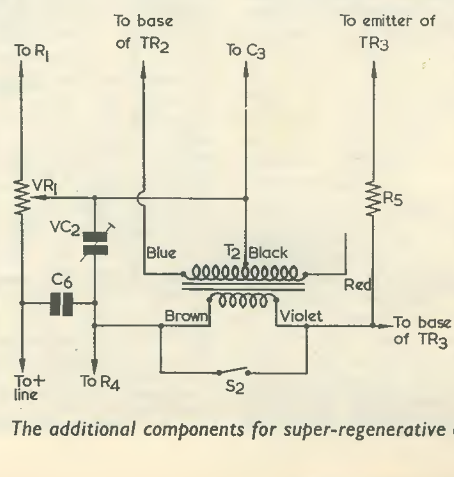

Fig. 3. The additional components for super-regenerative operation

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C_2 being taken straight to S_1. The emitter of TR_2 will need to be disconnected from R_4, C_3 disconnected from the positive line, R_1 disconnected from the base of TR_2, and the base of TR_3, the emitter of TR_2 and R_4 all disconnected from each other. VR_1 can take up the physical position occupied by its predecessor, though this and other new components will be wired up as shown in Fig. 3 of the present article. Fig. 2 shows how the original three-transistor receiver circuit should appear when modified for inclusion of the new components, whilst Fig. 3 shows the new part of the circuit required for super-regeneration.

VR_1 should be wired so that volume increases in an anti-clockwise direction, with the slider approaching the negative line. Control will then be very smooth with oscillation starting in the second half of the movement, and nearly the whole of the movement being of use with super-regeneration. VC_2 can be tucked away, as it is adjusted once and for all, but S_2 must be mounted in an accessible position.

Finally, the author would reiterate that the circuit should only be used as a super-regenerator during daylight, as it will give disappointing results on stations other than the locals after dark (except, possibly, in a very bad reception area). After dark plenty of programmes will be available without super-regeneration. During daylight the extra amplification available is really useful.

SIMPLE MIXER UNIT

By S. G. WOOD, G5UJ

FROM TIME TO TIME THE NEED IS FELT FOR A "fader" or mixer unit, and the circuit described here may be of interest.

As will be evident from the diagram, few components are required. In fact, most of the parts needed may be found in the junk box. The main item, the valve, can be of the 6SN7 or 12AU7 class, which is well suited to this particular application.

The two potentiometers are of the small carbon variety and the fixed resistors are standard $\frac{1}{4}$ watt types. The bias capacitor in shunt with the 1.2kΩ biasing resistor is of 25μF 10 volt rating.

Little is needed in the way of power supplies, and 6.3V at 0.6 amp (6SN7) or 0.3 amp (12AU7) together with around 200 volts h.t. are the total requirements here. In most cases the main amplifier power unit could provide the power required. In any case, neither the cost of building, nor the running of this little unit can be regarded as expensive.

The construction of the unit should not raise any difficulties, owing to the small number of components required. The two input circuits are shown in the diagram as being screened. Such screening will be necessary in most instances to obviate hum.

Components List

Resistors
(All fixed resistors $\frac{1}{4}$ watt 10%)

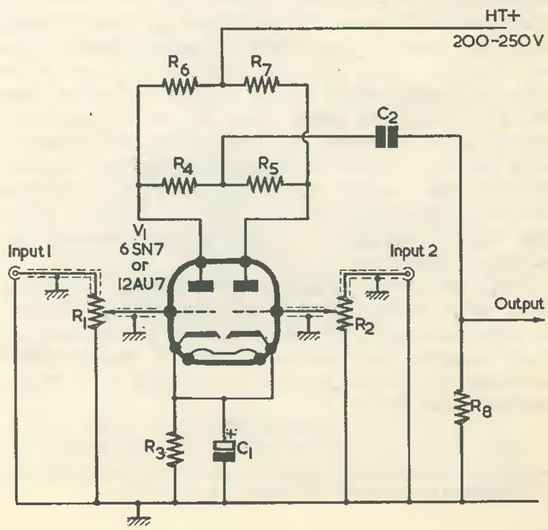
$R_{1,2}$	250kΩ potentiometer, log track
R_3	1.2kΩ
$R_{4,5}$	1MΩ
$R_{6,7}$	100kΩ
R_8	1MΩ

Capacitors

C_1	25μF electrolytic 10V wkg.
C_2	0.05μF paper

Valve

V_1	6SN7 or 12AU7



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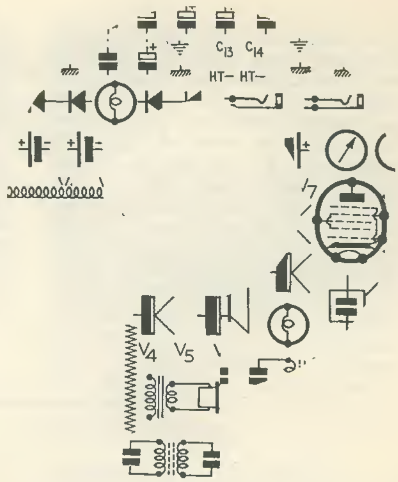

AMPLITUDE MODULATION AND THE DIODE DETECTOR

By W. G. Morley

radio

IN LAST MONTH'S ISSUE WE CONCLUDED OUR consideration of the diode when employed as a rectifier for power supply circuits. We shall now carry on to its use as a detector of amplitude modulated signals.

It is interesting to note, in the discourse which follows, that we shall be calling on a wide range of subjects which were covered in previous "Understanding Radio" articles, these including such things as audio and radio frequencies, r.f. transformers and tuned circuits, and sound reproducing devices.

Transmitting Information

In an earlier article in this series[1] we saw that radio waves may be assumed to travel from a transmitter to a receiver by way of the "ether" (a medium which pervades all space and matter) and that they may be described as *radio frequency* (or *r.f.*) signals. Also that it is difficult, in practice, to transmit radio waves having frequencies lower than 10 kc/s, with the result that the radio frequency range may, in general, be assumed to commence at this figure. So far as domestic equipment is concerned, the highest frequency currently envisaged for radio reception in the U.K. is 854 Mc/s, this being the highest frequency in the range allocated for 625-line television.

Another point noted in the previous article is that, since radio waves travel through the "ether" at almost exactly 300,000,000 metres per second, we may obtain the following simple relationships between the frequency and *wavelength* of a transmitted radio signal:

$$f=\frac{300{,}000}{\lambda}$$

where f is frequency in kc/s; and

$$f=\frac{300}{\lambda}$$

where f is frequency in Mc/s. In both cases, λ is wavelength in metres.

Thus, the "medium waveband" of about 200 to 600 metres may also be expressed as 1,500 to 500 kc/s, and the "long waveband" of about 1,000 to 2,000 metres as 300 to 150 kc/s. Some domestic sound receivers have a short wave range of about 20 to 60 metres, this corresponding, in terms of frequency, to 15 to 5 Mc/s.

Also transmitted in this country are the v.h.f. sound-only signals in Band II. Band II extends from 87.5 to 100 Mc/s and it is common practice to refer to Band II signals in terms of their frequency rather than their wavelength, as is our custom on medium and long waves.

The previous article also referred to *audio frequency* (or *a.f.*) signals, these being signals which may be heard by the human ear when the air is set in vibration. The audio frequencies range from some 30 c/s to 20 kc/s[2].

Let us now turn our attention to the manner in which a radio signal may be used to transmit information from the transmitter to the receiver.

The easiest method of passing such information is by connecting a *Morse key* to the transmitter in such a manner that the latter only gives an output when the key is depressed. (See Fig. 276 (*a*).) If the Morse key is operated to send the letter "L" (· — · ·) the resultant signal from the transmitter may then look like that shown in Fig. 276 (*b*). At the receiver, it is normal practice to employ a circuit

[1] Published in the March 1963 issue.

[2] The upper and lower limits in the audible range vary slightly for different individuals.

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which enables an audible a.f. tone to be heard from a loudspeaker or pair of headphones when the transmitter signal is present, with the result that this tone is given when the key at the transmitter is pressed. The overall effect, therefore, is that depressing the key at the transmitter causes an audible tone to be heard at the receiver, whereupon a workable system for sending a signal in Morse code is set up. In the instance shown in Fig. 276 (*b*), the a.f. tone at the receiver will follow the . — . . sequence sent from the transmitter.

The circuit at the receiver which causes an audible tone to be heard on reception of the transmitted signal is desirable because the transmitted signal is not otherwise capable of being readily understood. The operator at the receiver could not "listen" to the r.f. cycles in the transmitted radio signal because these will have a frequency which is much higher than the upper limit of human hearing.

This explanation ignores the possibility that the transmitted signal may have a frequency lower than 20 kc/s and be, therefore, within the audible range. However, unless he is undertaking specialised work, it is extremely unlikely that the amateur will encounter transmissions below about 100 kc/s, whereupon all the transmitted signals he works with will be well above the upper limits of audibility. It should be added that, for purposes of illustration, Fig. 276 (*b*) shows the r.f. cycles as having a much lower apparent frequency than would in actual fact be possible. In practice there would be so many cycles in each section of the Morse character that the lines representing them in the diagram would merge together and could not be reproduced. (In the diagrams which follow, the r.f. cycles will similarly be shown as representing a much lower frequency than would actually be the case.)

The transmitted wave shown in Fig. 276 (*b*) is quite satisfactory for the transmission of Morse code signals because it can be controlled by a Morse key. But this is only a "switching on and off" process, and it is obvious that a different approach is needed if we want to transmit speech and music by way of a radio frequency signal. The r.f. signal is itself inaudible, but we can employ it for the transmission of a.f. signals in a manner which is very easy to understand.

Modulation

Fig. 277 (*a*) shows the radio frequency signal as it appears when the transmitter is continually switched on. At the same time, Fig. 277 (*b*) shows a cycle of an audio frequency signal which we wish to transmit. In order to transmit this audio frequency signal we now apply it to the transmitter in such a way that it regulates the amplitude of the radio frequency signal. This process is known as *modulation*, and the result is shown in Fig. 277 (*c*). As may be seen, the radio frequency signal now has greatest amplitude when the audio frequency waveform is at its uppermost peak, and has lowest amplitude when the audio frequency waveform is at its lowermost trough. The modulation process has allowed the transmitted radio frequency signal to convey audio frequency signals to a receiver.

Since the audio frequency signals imposed on the radio frequency signal vary its amplitude, the process is known as *amplitude modulation* (or *a.m.*). It is usual to show an amplitude modulated wave in the manner shown in Fig. 277 (*d*), in which lines are drawn along the outside of the waveform joining the peaks of the r.f. signal, and these lines constitute the *modulation envelope*. (In practice, there would be far more radio frequency cycles than are shown in Fig. 277 (*d*), with the result that the distance between peaks would be almost negligibly small when compared with the length of a single cycle of the modulating audio frequency signal.)

The process of modulation causes the maximum peak-to-peak amplitude of the radio frequency signal to be greater than occurs in the unmodulated state, resulting in the effect shown in Fig. 278 (*a*). In this diagram a modulating audio frequency signal is applied, starting at line XY, to a previously unmodulated radio frequency signal. The degree of modulation is referred to as *modulation depth*, and is equal to the ratio of dimension P or dimension Q to dimension R. In Fig. 278 (*a*) dimensions P and Q are one-half of dimension R, and so the modulation depth is 50%. If no modulation were applied there would be no dimensions P and Q, and modulation depth would be zero. Fig. 278 (*b*) shows the case where dimensions P and Q are equal to R, giving 100% modulation depth. This is the maximum modulation depth which may be employed without introducing serious distortion of the modulating signal. The effect of *over-modulation*, given by too great a modulating audio frequency signal, is shown in Fig. 278 (*c*). As may be seen, the radio frequency signal now disappears completely during part of the audio frequency cycle.

The modulated radio frequency signal is described as the *carrier*, this being a well-chosen term since

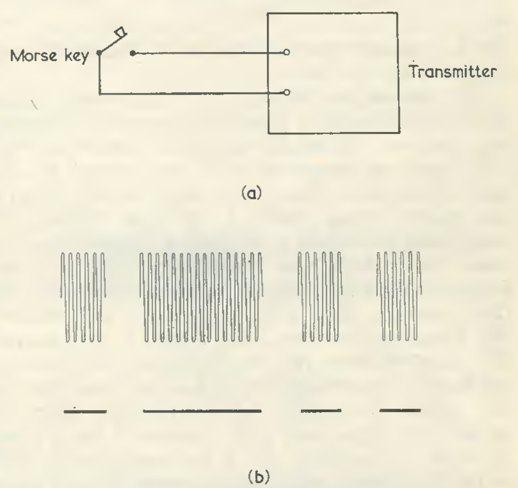

Fig. 276. By suitably connecting a Morse key to a transmitter, (a), so that it controls the output, Morse characters may be transmitted. The transmitter output for the letter "L" is shown in (b)

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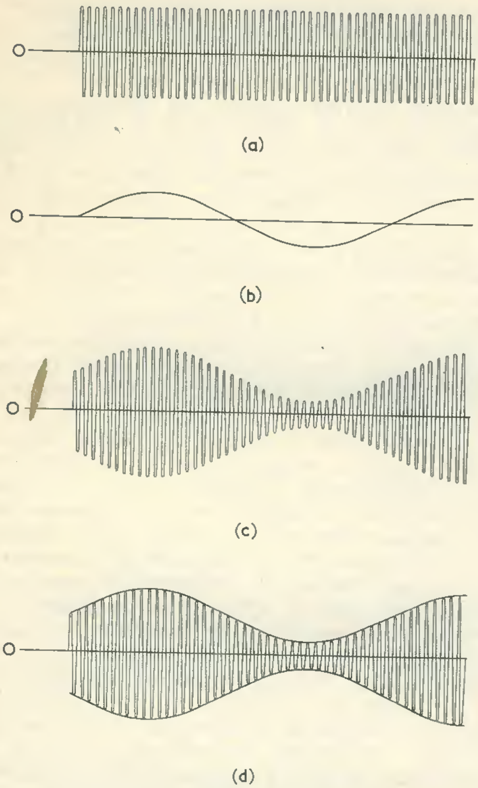

Fig. 277 (a). The output of an unmodulated radio transmitter
(b). An audio frequency waveform
(c). The r.f. signal of (a) modulated in amplitude by the a.f. waveform of (b)
(d). Two outside lines joining the peaks of the modulated waveform constitute the "modulation envelope"

the r.f. signal "carries" the audio frequency signal imposed on it.

We should, at this stage, briefly note another factor which results from the process of amplitude modulation. If an r.f. signal is modulated by an a.f. signal of frequency xc/s, two new r.f. signals appear on either side of the original r.f. signal and are spaced away from it by xc/s. Thus, if we amplitude modulate a 500 kc/s r.f. signal by an a.f. signal of 1 kc/s, the transmitter will provide an output consisting of the original 500 kc/s signal (the carrier), plus a new signal 1 kc/s below at 499 kc/s, and another new signal 1 kc/s above at 501 kc/s. These two new signals are known as *sidebands*. Speech and music are more complex than the single frequency a.f. signals we have been considering here, and they contain a large number of audio frequencies. So, if we modulate the carrier signal by speech and music signals, we will cause a correspondingly large number of sideband frequencies to appear on either side of the carrier.

Amplitude modulation represents only one method of transmitting audio frequencies by way of a radio frequency signal. Other types of modulation are *frequency modulation* (or *f.m.*), and *phase modulation* (or *p.m.*). With frequency modulation, it is the *frequency* of the carrier which is varied by the audio frequency signal, and with phase modulation it is the *phase* which is so varied. We shall not, however, go into any further detail with these two alternative types of modulation at the present stage.

Both amplitude and frequency modulated signals are encountered with domestic radio equipment. Sound transmissions on the medium and long wavebands are amplitude modulated, whilst those in Band II are frequency modulated. At the same time, the sound channel accompanying the 405-line television signal is amplitude modulated, whilst that accompanying the 625-line signal is frequency modulated.

Reverting to our Morse signal of Fig. 276 (*b*) we may now add that this is described as a *continuous wave* (or *c.w.*) transmission. This is because, being unmodulated, it is "continuous" in amplitude and frequency.

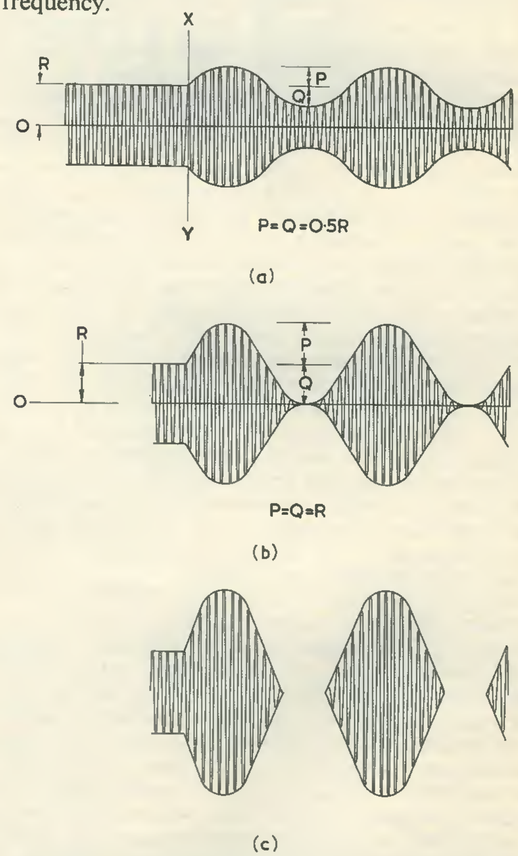

Fig. 278 (a). The waveform given by 50% modulation depth
(b). An example of 100% modulation depth
(c). Serious distortion results from over-modulation, which causes the complete disappearance of the r.f. signal during part of the a.f. cycle

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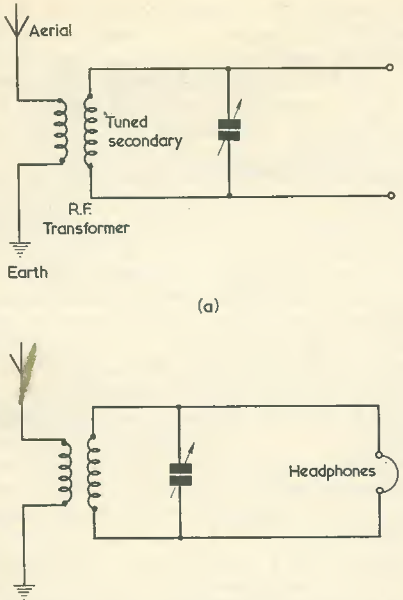
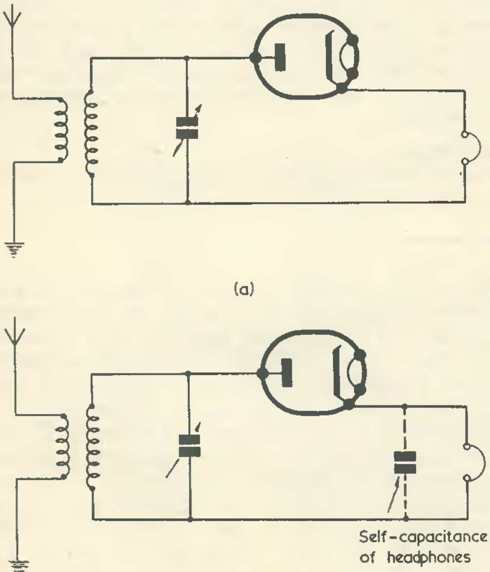


(a)

(b)

Fig. 279 (a). Coupling an aerial and earth to an r.f. transformer whose secondary is tuned to a station in the medium wave band
(b). Attempting, unsuccessfully, to hear the transmitter modulation by adding a pair of headphones



(a)

(b)

Fig. 280. The modulation of the signal selected by the tuned circuit of Fig. 279 becomes audible if we insert a diode, as in (a). But it is necessary to add the self-capacitance of the headphones to the overall circuit, (b), if the functioning of the diode is to be fully understood

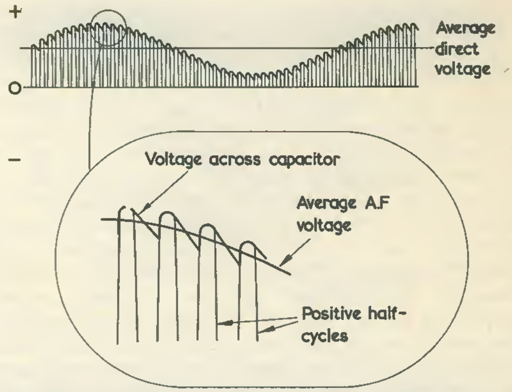


Fig. 281. The effect of the diode of Fig. 280 (b) in terms of the voltage on the upper headphone terminal with respect to the lower terminal. The voltage across the capacitor (the self-capacitance of the headphones) is shown in heavy line, as also is the average a.f. voltage. The positive half-cycles of the carrier, shown in light line, are included to demonstrate the manner in which the voltage across the capacitor is developed

The A.M. Detector

In two other preceding articles[3] we described r.f. transformers and showed that these could be used for tuning over, for example, the medium or long waveband. We employ such an r.f. transformer in Fig. 279 (*a*), the primary winding being coupled to an aerial and an earth connection.[4] The secondary has an inductance such that, when a variable capacitor of suitable value is connected across it, the pair may resonate at (or become "tuned to") any desired frequency in the medium waveband. The secondary tuned circuit offers maximum impedance at the frequency at which it is resonant, with the result that signals at this frequency may be passed on to a subsequent circuit at greater amplitude than other signals of different frequency.

Let us now adjust the variable capacitor of Fig. 279 (*a*) so that the secondary circuit is tuned to an amplitude modulated transmitter in the medium waveband. The result is that a wave-form similar to that of Fig. 277 (*d*) appears at the output terminals. How are we to make the modulating signal audible to us?

[3] In the September and October 1963 issues.

[4] This diagram also introduces us to the circuit symbol for an aerial.

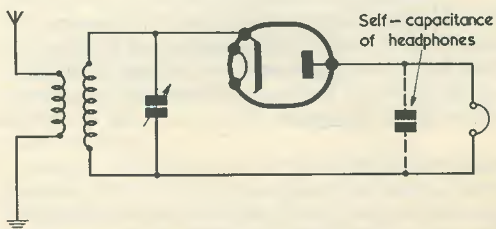


Fig. 282. Reversing the Diade

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We could commence by experimentally connecting a pair of headphones across the output terminals, as in Fig. 279 (*b*). We should, preferably, use high-resistance headphones, (say 2,000Ω for earphones[5]) because the secondary tuned circuit offers a signal at high impedance. But, however acutely we listened, we would hear nothing. It is obvious, of course, that the headphones cannot respond to the high frequency of the r.f. carrier, but we could at least expect them to respond to variations in the average value of the waveform if these occurred at an audible frequency. As is evident from Fig. 277 (*d*), however, the sections of the waveform which appear on either side of the central zero voltage line are, at all points along the waveform, equal and opposite; with the result that the average value of the waveform remains constant at zero volts and does not vary. Thus, our headphones will not reproduce any audible signal.

In Fig. 280 (*a*) we introduce a diode, whereupon we at once hear, in the headphones, the modulation of the transmitted signal. The reason for this dramatic change in performance is that the diode acts as a rectifier but, before finally evaluating the manner in which it works, we must first take the intermediary step of adding the self-capacitance of the headphones to the circuit, as is done in Fig. 280 (*b*). As we may now see, the diode functions in much the same manner as the half-wave power supply rectifier with reservoir capacitor which we have discussed in the last few issues. The diode causes the capacitor to charge during peaks of the applied alternating voltage (which in this case is the carrier signal) and to discharge between these peaks. The resultant effect, and the consequent average a.f. voltage, are shown in Fig. 281. The average a.f. voltage varies in sympathy with the modulating voltage at the transmitter, and the headphones can now reproduce the sound signal which originally modulated the carrier. It should be added that, in practice, the peaks of the carrier signal will be much closer together than is shown in Fig. 281 whereupon, assuming sufficient capacitance in the capacitor, there will be only a small difference between the average a.f. voltage and the voltage appearing across the capacitor. Fig. 281 shows also the positive half-cycles which are applied to the anode of the diode, in order to illustrate the manner in which the rectified voltage is formed.

If we reverse the diode, as in Fig. 282, we will still be able to hear the original modulating signal. This is because a rectified signal once more appears, the only difference being that it has opposite polarity to the one shown in Fig. 281. It will still have an average a.f. voltage varying in sympathy with the sound signal which originally modulated the transmitter, and the headphones will once more reproduce the signal.

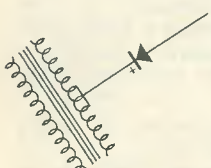
The rectified signal of Fig. 281 has an average *direct voltage* as well, this direct voltage being the average over all portions of the *audio frequency* cycle. With the circuit of Fig. 280 (*b*) the average direct voltage has a polarity such that the upper terminal of the headphones is positive relative to the lower terminal. If we reverse the diode, as we did in Fig. 282, the upper terminal of the headphones becomes negative with respect to the lower terminal. The presence of the average direct voltage will not affect operation in the simple headphone circuits we are discussing here, but it can be of considerable importance in more complex arrangements.

The diode of Figs. 280 (*b*) and 282 is normally described as a *detector*, this being a term dating from the early days of radio in which any device which enabled radio signals to be "detected" was so called. It is also, but less frequently, referred to as a *demodulator*.

Next Month

In next month's issue we shall continue to discuss the diode detector.

[5] See "Understanding Radio" in the April 1964 issue.



Simple Shorted Turns Detector

By A. C. NORMAN

THE UNIT DESCRIBED HERE WILL PROVIDE, IN conjunction with an oscilloscope, either a convincing demonstration of damped oscillations or a shorted turns indicator for air-cored coils up to 3in in diameter.

Pulse Generator

A pulse generator using two OC71's in a multivibrator circuit energises a tuned circuit consisting of L_1 and C_3. R_5 is a pre-set damping resistor. (See Fig. 1.)

The coil L_1 consists of 1,000 turns of 36 s.w.g. enamelled wire wound to a length of 2in, it being wound on one end of a 5in length of $\frac{5}{16}$in diameter ferrite rod. The remainder of the rod protrudes from the instrument. Coils being checked are then passed over the protruding section of the rod.

With R_5 set for a resistance of about 2kΩ, the oscilloscope should be adjusted to give a steady trace showing two pulses. No difficulty should be experienced from hum as the impedance of L_1 at 50 c/s is very low. R_5 is then adjusted so that the oscillations in the tuned circuit just die out by the time the next energising pulse arrives. (See Fig. 2 (*b*).)

Any increase in the damping of the tuned circuit, such as would be given by a shorted turn passed over the protruding ferrite rod, is immediately noticeable as an increase in the rate at which oscillations in the tuned circuit decay. A typical example is illustrated in Fig. 2 (*c*).

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Components List

Resistors
(All fixed resistors $\frac{1}{4}$ watt 20%)
R_1 3.3kΩ
$R_{2,3}$ 22kΩ
R_4 1kΩ
R_5 5kΩ, pre-set potentiometer, log track

Capacitors
C_1 0.02μF paper
C_2 0.1μF paper
C_3 500pF silver-mica or ceramic

Inductor
L_1 Coil on ferrite rod (see text)

Transistors
$TR_{1,2}$ OC71 (see text)

Switch
S_1 s.p.s.t. on-off switch

Battery
9-volt battery

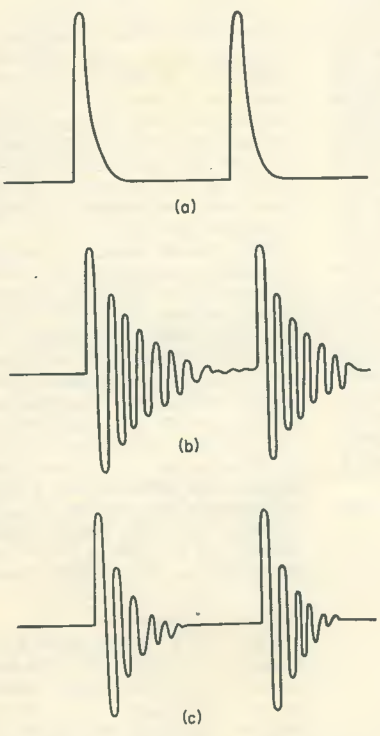

Fig. 2 (a). The output from the pulse generator
(b). The voltage across L_1 when no shorted turn is present
(c). The waveform across L_1 changes, typically, to that shown here if a shorted turn is passed over the ferrite rod

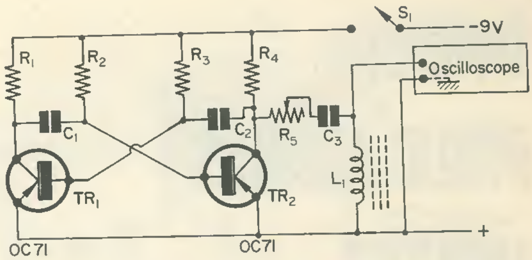

Fig. 1. The circuit of the shorted turns detector

Frequency

In the prototype the multivibrator offered 500 pulses per second but, using components of 20% tolerance, this figure could be anything between 350 and 700. As L_1 and C_3 resonate at a frequency of about 15 kc/s, 30 cycles of damped oscillations can be seen. This is enough to give a well defined envelope but not enough for individual cycles to merge with each other.

A logarithmic track in R_5 is desirable, although not essential, as it gives closer control over the damping of the tuned circuit. R_5 should be connected so that it offers minimum resistance to the circuit when adjusted fully anticlockwise.

The current drain is fairly low at 10mA, so a small battery can be used. Excluding the ferrite rod, the complete prototype was built on a chassis less than 3in square. By using miniature components it could have been considerably smaller.

Care should be taken in the construction of L_1 as it will "detect" short-circuits in itself as well as in any metallic mounting components that encircle it.

The detector is very simple to use on any air-cored coil. It will be found particularly useful when winding the bobbins for home-made transformers as the coil can be tested every 50 or so turns, thus minimising the amount of unwinding if a short-circuit is discovered.

Testing Large Coils

The detector can be used, without adjustment, to test coils with from 1 to 10,000 turns. With the larger coils it may be found that the resonant frequency of the coil being tested (given by its inductance and stray capacitance) is near the resonant frequency of L_1 and C_3. In this case a second train of damped oscillations will be set up in the coil being tested and these will beat with the oscillations in L_1. With practice it is still easy to distinguish between good and faulty coils.

In some circumstances it may be necessary to test coils which are too small to fit on the $\frac{5}{16}$in ferrite rod. For these a smaller version of L_1 could be wound on a thinner piece of rod. This would, however, be less sensitive to the larger diameter short-circuits.

Cheap, low gain surplus transistors work well in this circuit as all frequencies are low, and plenty of drive is available at the bases. If these are used, the total cost of the detector can be kept to quite a low figure.

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Transistor PUBLIC ADDRESS AMPLIFIER

A. KINLOCH

An experimental design intended for the more experienced constructor.

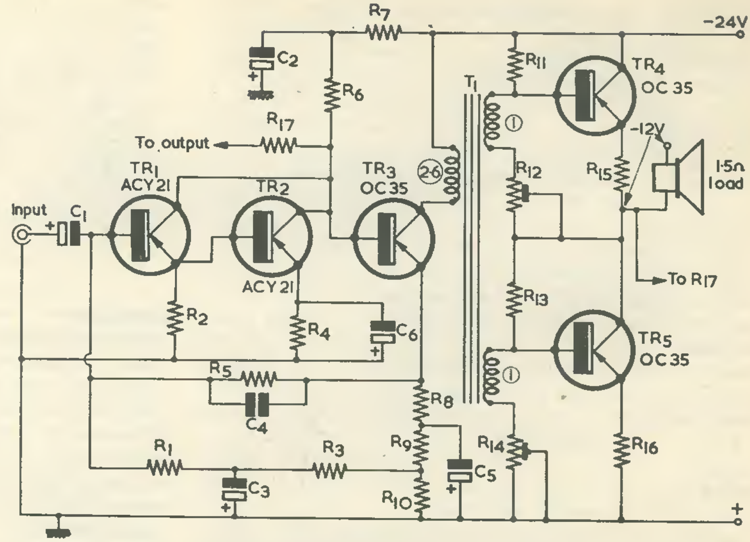

Fig. 1. The circuit of the main amplifier. The 1.5Ω load could conveniently consist of two 3Ω speakers connected in parallel

THE AMPLIFIER DESCRIBED IN THIS article was designed for public address purposes and can provide 20 watts into a 1.5Ω load or 10 watts into a 3Ω load. A suitable power supply would consist of two 12 volt accumulators connected in series to form a centre-tapped 24 volt supply. If a centre-tapped supply is not available one side of the load can be connected to the positive supply line and the other connected to the output terminal via a 5,000μF 25V wkg. electrolytic capacitor.

Output Stage

The output stage is a Class B transformerless push-pull type, the load being provided directly by the speaker or speakers. The ½Ω emitter resistors improve thermal stability and frequency response whilst lessening crossover distortion. The upper resistors of the potential dividers which bias the output transistors, R_{11}, R_{13}, are connected directly to the transistor bases so that they provide negative feedback. The 6Ω preset resistors are adjusted to set the quiescent current in the output transistors to the lowest value consistent with low crossover distortion. The voltage at the output terminal (at the collector of TR_5) should be half the supply voltage, i.e. there should be an equal voltage across each output transistor under quiescent conditions. The peak current on full drive is about 6 amps.

In the prototype amplifier the output and driver transistors were mounted with mica washers and insulating bushes on a heat sink made up of two 12 x 8in 18 s.w.g. aluminium plates. These were bolted together to give twice the thickness, and sprayed matt black. This was found to be adequate for speech and music at ordinary room temperatures (about 25° C).

The driver stage is an OC35 transistor operating in Class A at a current of 0.3 amp. It provides more power than is necessary to fully drive the output stage. It is thus possible to increase the local negative feedback in the output stage or to increase the output power by replacing the OC35 output transistors with other types having a higher current rating. The output could, of course, be increased by raising the supply voltage, but this would make it difficult to provide a "non-mains" power supply for outdoor use.

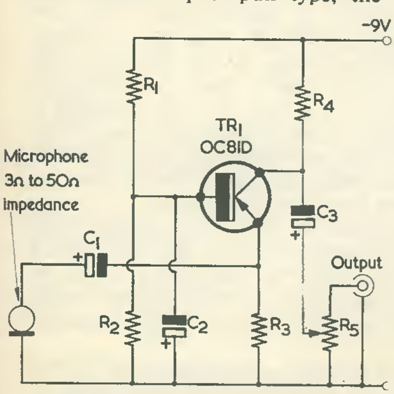

Fig. 2. The microphone pre-amplifier circuit. This may be separately powered by a PP4 battery or similar

Components List (Fig. 2)

Resistors
(All fixed values ¼ watt 10%)

R_1	68kΩ
R_2	8.2kΩ
R_3	2.2kΩ
R_4	6.8kΩ
R_5	10kΩ potentiometer, log track

Capacitors

C_1	100μF electrolytic 12V wkg.
C_2	10μF electrolytic 12V wkg.
C_3	10μF electrolytic 12V wkg.

Transistor
TR_1 OC81D

The Driver Stage

The OC35 driver transistor is directly coupled to a "compound transistor" amplifier stage consisting of two ACY21's. D.C. and a.c. negative feedback is applied from the emitter resistors of the OC35 driver to the base of the first ACY21. C_4 is included to prevent high frequency instability and is a tubular ceramic type. R_5 could be a variable 10kΩ control, and could then be used to adjust the current in the OC35 driver.

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Components List (Fig. 1)

Resistors
(All fixed values ¼ watt 10% unless otherwise stated)

R_1 2.2kΩ
R_2 1.8kΩ
R_3 220Ω
R_4 82Ω
R_5 10kΩ
R_6 470Ω
R_7 470Ω
R_8 1Ω wirewound
R_9 4Ω 1 watt wirewound
R_{10} 4Ω 1 watt wirewound
R_{11} 180Ω 1 watt wirewound
R_{12} 6Ω wirewound preset potentiometer
R_{13} 180Ω 1 watt wirewound
R_{14} 6Ω wirewound preset potentiometer
R_{15} ½Ω 5 watt wirewound
R_{16} ½Ω 5 watt wirewound
R_{17} 1.8kΩ

Capacitors

C_1 10μF electrolytic 25V wkg.
C_2 250μF electrolytic 25V wkg.
C_3 200μF electrolytic 6V wkg.
C_4 1,000pF tubular ceramic
C_5 1,000μF electrolytic 12V wkg.
C_6 500μF electrolytic 6V wkg.

Transistors

TR_1 ACY21
TR_2 ACY21
TR_3 OC35
TR_4 OC35 } matched pair
TR_5 OC35 }

Transformer

T_1 1.3+1.3:1+1, Type TT24 (Repanco)

Pre-Amplifier

The pre-amplifier stage and the gain control are separate from the main amplifier and are intended to be sited near the microphone. The writer is, at the time of writing, employing a grounded base stage as shown in Fig. 2, but this can be rearranged as a grounded emitter stage, if desired, by connecting C_1 to the positive rail and connecting the microphone between C_2 and the positive rail. An OC81D is used in the pre-amplifier because of its low cost. If noise is evident when the OC81D is used as a grounded emitter amplifier, R_1 and R_2 should be replaced by new, high stability, resistors before any blame is cast on the transistor. Noise caused by the base biasing resistors is avoided when a grounded base stage is employed.

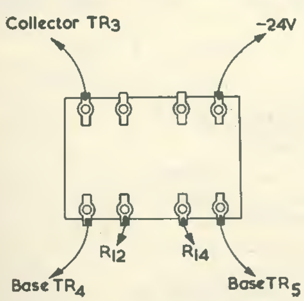
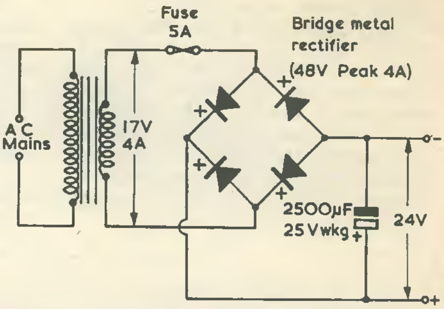


Fig. 3. Connections to the Repanco TT24 transformer

Fig. 4. A suitable power supply for operation from the mains



Construction

The main amplifier was constructed on a 26-way tagboard, with TR_1, C_1, R_1, R_2 and C_3 enclosed in a flat tin-plate box on which was mounted the coaxial input socket.

The Repanco transformer type TT24 is a 1.3+1.3:1+1 component, and is used here as a 2.6:1 transformer. As is indicated by Fig. 1, the primary offers a 2.6:1 ratio to both secondaries, i.e. the 1.3 sections of the primary are connected in series. External physical connections to the transformer, as used in the prototype, are shown in Fig. 3. If, by any chance, there is a reversal in phase in the signal fed to the output transistors, R_{17} will provide positive feedback instead of negative feedback, and this may be corrected by reversing the connections to the primary.

The transistor heat sink is mounted vertically to allow cooling by convection.

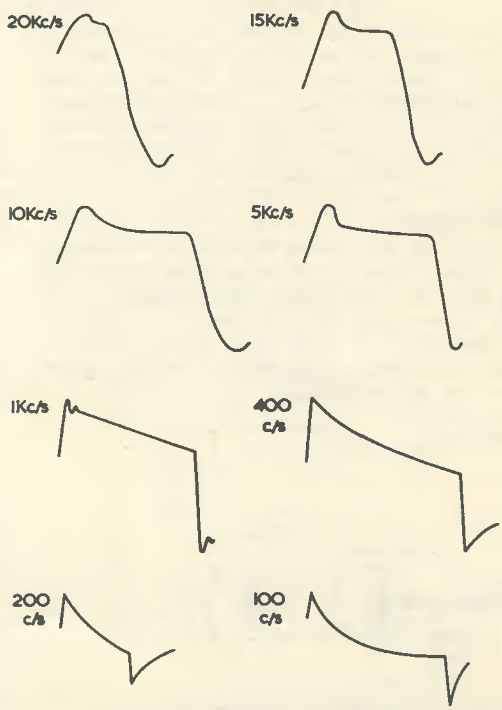


Fig. 5. Output waveforms given by square wave inputs at the frequencies indicated

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Mains Power Supply

The circuit of a suitable mains power supply is given in Fig. 4. The hum level is low with this power unit, and 20 watts of "speech and music power" are available. A 5 amp fuse is inserted between the transformer and the rectifier. There may be transient currents greater than 5 amps, but these are unlikely to blow the fuse.

With the mains power supply, the load is coupled to the output terminal via a 5,000μF capacitor, as mentioned in the opening paragraph.

Output Waveforms

A selection of output waveforms is illustrated in Fig. 5. These were taken with a 24 volt supply having no centre-tap, the load being a 3Ω speaker coupled to the output terminal via a 5,000μF capacitor. The oscilloscope was a Solarscope type CD711S.2 on the 3 volt Y range, and the generator an Advance H1. The oscilloscope was connected between the output terminal and the positive supply line. Input signals were square waves at the frequencies indicated.

2-TRANSISTOR MINIATURE A.F. AMPLIFIER

KENNETH JONES

A very simple circuit design which, at the expense of increased battery consumption, offers reproduction superior to that given by the normal Class B transistor output stage

THIS AMPLIFIER WAS DESIGNED BY THE WRITER to be reasonably small and to have a higher output quality than usual. It was decided that a transformerless circuit should be employed, using only a driver and output transistor. Direct coupling between stages, and to the speaker, was used to ensure good quality.

Power Transistor

In order that the output should be reasonably loud, a single power transistor was used. The Mullard AD140 was chosen here because of its high gain and output, but in this circuit no heat sink is required. A high gain driver using an OC44 was employed, and an OC45 was also successfully used in the prototype.

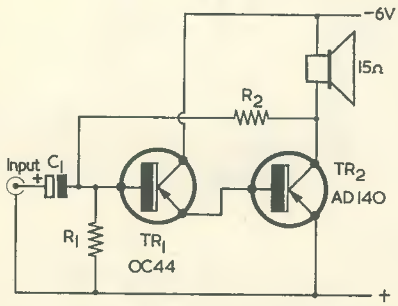

Fig. 1. The circuit of the amplifier

Connection between the amplifying stages is made via the driver's emitter, so the base of the AD140 has the correct polarity bias when using p.n.p. driver transistors. This also allows for the use of a higher impedance input than usual, because of the impedance step-down effect of a grounded collector stage. Further, the d.c. coupling reduces the number of components required for the complete circuit. Only two transistors, two resistors and one capacitor are needed, making the complete circuit inexpensive even though the output transistor may not be obtainable cheaply.

The prototype amplifier was built on a small Paxolin sheet, on to which the AD140 and remaining components were mounted, including miniature input and output sockets. If miniature components are used throughout, a really small and powerful amplifier may be constructed.

Soldering

Care must be taken when soldering in the transistors, and a heat shunt must be used. The author found a pair of fly-tying pliers extremely useful when soldering transistor leads. The pliers are spring-loaded, and may be clipped on to the leads, leaving the two hands free. They may be obtained from most large fishing tackle shops, the larger size being the best investment.

The amplifier requires a potential of 4 to 5 volts at up to 90mA, but if more output is required, at a correspondingly higher current, a 6 volt battery

Components List

Resistors
R_1 6.8kΩ ¼ watt 20%
R_2 33kΩ ¼ watt 20%

Capacitors
C_1 10μF electrolytic 3V wkg.

Transistors
TR_1 OC44 (or OC45)
TR_2 AD140

Loudspeaker
15Ω impedance

Sockets
Coaxial input socket
Output sockets
Transistor holder for TR_1 (optional)

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may be used. After 6 volts, the current consumption rises sharply.* A flat torch battery containing three single cells at 1s. 3d. should give reasonable life. The amplifier could be used as the audio and output stages following a 3-transistor superhet tuner, and will give full output straight off the diode. Such a radio may be used as a car radio in cars having 6 volt systems.

The amplifier gives an output power commensurate with a 2 x OC81 push-pull circuit, and has an excellent frequency response together with (because of the negative feedback taken from TR_2 to the base of TR_1) little distortion even at full output. The quality was much preferred to that given by two OC81's in push-pull with a similar sized speaker. There is no reason why really good quality reproduction should not be obtained, especially when a large 15Ω speaker is used.

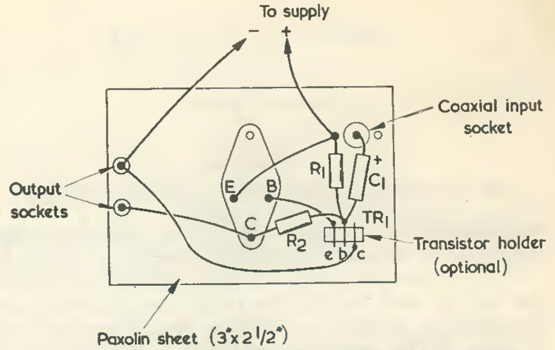

Fig. 2. A suitable layout. The transistor holder shown is optional

* Due to the d.c. flowing in the speaker and the absence of a heat sink, it would probably be preferable not to employ supplies considerably in excess of 6 volts.—EDITOR.

SIMPLE ECHO UNIT

By P. F. EXETER

An inexpensive sound delay unit employing readily obtainable parts

COMMERCIALLY MANUFACTURED ECHO UNITS ARE expensive to buy and so the writer tried to find a simpler method which could be constructed cheaply. Several attempts were made, and the most successful is described in this article. The author's unit can be easily fitted to any radio or small a.f. amplifier and, when used, gives the effect of being in a large hall.

As shown in Fig. 1, the amplifier drives the speaker in the normal way, but a portion of the output is fed into the echo unit, which is an electromechanical time delay device. This includes two 2,000Ω headphones placed approximately 15in apart with a metal spring coupling the two diaphragms together.

Construction

To commence construction, a small hook is first soldered on to the diaphragm of each headphone, as shown in Fig. 2. Before soldering it is necessary to scrape and clean the central area of the diaphragm, as this has an enamelled surface. The writer used a penknife and fine glass paper to prepare the surface and obtained a satisfactory joint with resin-cored solder. The diaphragm is then refitted to the headphone and the cap screwed on. The latter must, of course, have a hole in its centre to allow the hook to pass through.

The headphones are then fixed to the ends of a wooden box, as illustrated in Fig. 3, rubber grommets being placed between the inside surface of the box and the headphones to act as shock absorbers and prevent vibrations being transmitted along the wooden sides. The dimensions of the box used by the writer were 16 x 3 x 3in, and it was

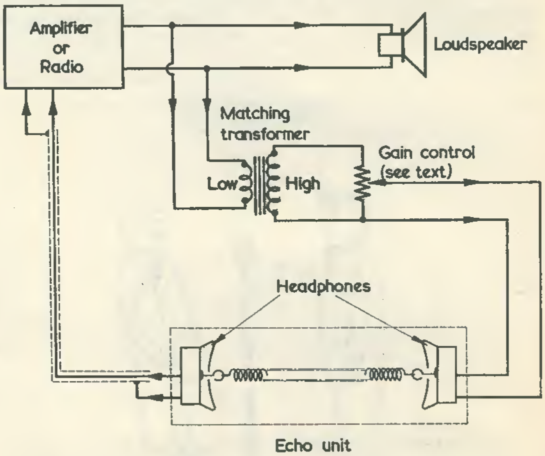

Fig. 1. The echo unit coupled up to an a.f. amplifier

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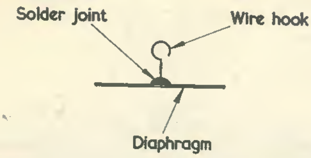

Fig. 2. Soldering a hook to the headphone diaphragm

constructed from plywood. These measurements may need to be adjusted to suit different headphones.

The component which provides the time delay is the spring, and this is attached to the hooks on the headphones at each end of the box. The size and tension of the spring depend upon the amount of time delay required. The writer obtained best results with an electric fire spiral element of the type which can be obtained from hardware and electrical shops for several shillings. Home-made springs using copper or steel wire were not as successful.

The output of the headphone at the other end of the box is then fed back into an early stage of the amplifier or, if desired, into a separate amplifier.

Operation

The echo unit operates in the following manner.

When a signal is fed from the amplifier output to the echo unit it is passed through a matching transformer to match the speaker impedance to the impedance of the headphone. This signal causes the diaphragm to vibrate in sympathy with the signal fed to the headphone. As the spring is connected to the diaphragm by the hook, the diaphragm vibrations are transmitted along the spring to the other headphone. Again, the spring is connected to the diaphragm, and vibrations in this cause an alternating voltage to develop across the coils in the second headphone, this voltage being fed back into the amplifier for further reproduction by the speaker. As there is a time delay along the spring the voltage fed back into the amplifier will appear at the speaker shortly after the original sound, giving hence the effect of an echo.

The headphones and spring are fitted in a sealed wooden box to prevent "outside" sounds being picked up.

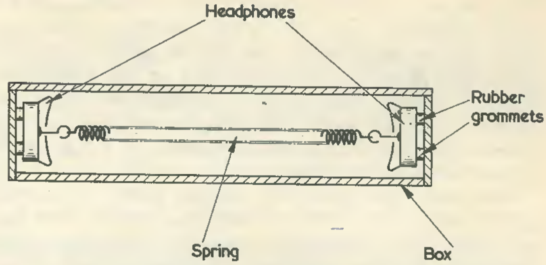

Fig. 3. The echo unit assembly. The headphones must be mounted such that direct vibrations cannot be transmitted along the wood of the box, and they can be held in place by pieces of sponge rubber or similar material

Further Points

Originally, the output of the amplifier was fed to the first headphone of the echo unit without a gain control but, as there was evidence of overloading, the control was then inserted. A standard speaker transformer with its secondary connected to the speaker and its primary to the headphone (so that it acts as a step-up transformer) should give a reasonable match. The gain control may be a $10k\Omega$ or $20k\Omega$ potentiometer and should be wire-wound. If the amplifier has a high output power, the matching transformer should be of appropriate size. Also, further resistance may need to be inserted between its high impedance winding and the gain control to prevent excessive dissipation here and in the headphone.

The output from the second headphone is at high impedance, and may be coupled directly to any grid circuit without a transformer.

Due to the simplicity of the device some distortion must be expected, but this was not found to be very noticeable with the prototype. A correct setting in the gain control helps in the reduction of distortion.

The time delay offered by the unit is fairly short but is readily discernible. An increased time delay would be given by using a longer box and a longer length of spring between the headphones, but this was not checked by the writer.

QUIZ TIME

"The trouble with you is you ask too many questions!"

TELEVISION AND RADAR

An interesting demonstration of how radar and closed circuit television can be linked as a navigational teaching aid was recently mounted at the Navigation School of Hull Trinity House.

A Marconi Marine "Radiolocator IV", with 9in P.P.I., is installed on the second floor of the School for radar training purposes, and for the demonstration the new Marconi V322 television camera was linked to a 27in receiver in the main hall two floors below. The radar "picture", enlarged from 9in in diameter to 27in, could be seen in comfort by a number of viewers at one time—an obvious boon in class teaching where a large television picture could be employed as a lecturer uses a projected lantern slide.

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Cover Feature

Dynamic Gain Transistor Tester

By D. BOLLEN

An inexpensive instrument which gives comparative tests of transistor performance at 2 Mc/s, 10 Mc/s and 30 Mc/s

IT IS WELL KNOWN THAT TRANSISTORS EXHIBIT A "spread" in their characteristics, this being especially true of the cheaper surplus types. Current gain is easy enough to check at zero frequency, but it bears little relation to the actual gain given in a grounded emitter circuit operating near the transistor's cut-off frequency. Now that r.f. transistors are readily available to the home-constructor some simple means of checking their gain at working frequency is particularly desirable in order to avoid the wasted time and inconsistent results obtained from "try it and see" methods.

Components List

Resistors

- R_1 12kΩ 10% ¼ watt
- R_2 6.8kΩ 10% ¼ watt
- R_3 2.5kΩ potentiometer, preset, linear track
- R_x Series meter resistor (see text)

Capacitors

- C_1 1,000pF ceramic or silver-mica
- C_2 120pF ceramic or silver-mica
- C_3 8μF electrolytic, 12V wkg.

Inductors

- $L_{1,2,3}$ See text

Diodes

- $D_{1,2}$ OA81

Switches

- $S_{1(a),(b)}$ 2-pole, 3-way
- S_2 s.p.s.t. on-off

Miscellaneous

- Meter (see text)
- Transistor holder
- 3 coil formers, 7/16 dia by 1⅛in (see Fig. 2)
- 3 dust cores
- Tagstrip
- Paxolin panels

The easily built tester described here has shown that surprising variations do exist between transistors in respect of gain. In some cases ordinary audio transistors will give useful gain at higher than 2 Mc/s, while types designed to operate at 10 Mc/s sometimes show only a small gain at 2 Mc/s and will not amplify much beyond that. An old XA123 drift transistor, scrapped by the writer because its beta was less than 15, was found to out-perform a new alloy-diffused transistor with a beta of 100. Subsequent "in circuit" tests confirmed its usefulness.

The Circuit

The circuit is shown in Fig. 1, and it incorporates a straightforward inductance-coupled oscillator. Switch tuning is employed for simplicity with feedback between collector and base, the transistor under test operating in the common emitter mode.

There are three ranges, chosen to suit the p.n.p. r.f. transistors which are most commonly encountered, i.e. i.f. amplifiers, m.w. r.f. amplifiers and self-oscillating mixers, and transistors operating in s.w. circuits up to 30 Mc/s. With the coils specified the transistor under test oscillates at 2 Mc/s on range 1, 10 Mc/s on range 2, and 30 Mc/s

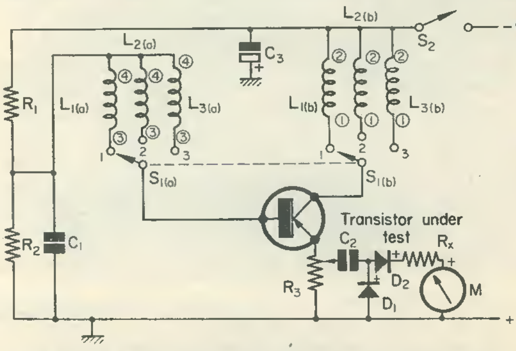

Fig. 1. The circuit of the dynamic gain tester. R_x has a value which causes full-scale deflection to be given in the meter with 1 volt applied

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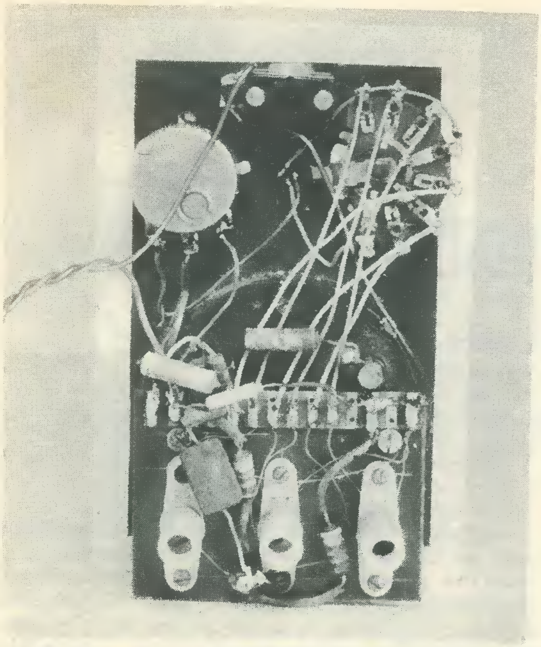


Internal view showing the three coils, the tagstrip, and associated components

on range 3. These frequencies can be varied by adjustment of the dust cores.

If the transistor under test is near its cut-off frequency on the selected range it will oscillate feebly or not at all. A transistor with a low overall dynamic gain will also give a low reading even if it is operating well within its frequency limits.

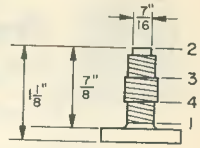
The r.f. output from the transistor is rectified and the resultant d.c. indicated by the meter. The writer used a 200μA movement, but it is possible that anything up to 1mA f.s.d. could be employed if R_x is selected to give a full scale deflection of 1 volt.

Construction

The tester was constructed on a piece of Paxolin measuring 6 x 4in. Holes were drilled to take the meter, the on-off switch, the range switch, the transistor holder, and the pre-set gain control R_3.

The three coils were wound on formers having the dimensions shown in Fig. 2. $L_{1(b)}$ consists of 60 turns of 36 s.w.g. silk-covered wire close-wound and fixed in place with polystyrene cement. Over this is wound a further 10 turns ($L_{1(a)}$) placed centrally. For L_2 the first winding ($L_{2(b)}$) is 30 turns, and the second ($L_{2(a)}$) 5 turns of the same wire. L_3 consists of 10 turns ($L_{3(b)}$) and 3 turns ($L_{3(a)}$) of the same wire. Dust cores are fitted.

Fig. 2. Details of the coils, and former dimensions. $L_{1(a)}$ and $L_{1(b)}$ are wound on a single former, as are $L_{2(a)}$ and $L_{2(b)}$, and $L_{3(a)}$ and $L_{3(b)}$. The lead-out numbers correspond to those given in Fig. 1



The coils were mounted on a smaller piece of Paxolin measuring 3 x 2in, together with a slim tagstrip sawn from Veroboard, which was then screwed to the back of the meter. The three resistors, three capacitors, and two diodes can all be soldered direct to this tagstrip.

When connecting the coil leads to the tagstrip it is important to observe the lead numbering sequence shown in Figs. 1 and 2.

As the consumption of the unit does not exceed 2.5mA, and then only for short periods, the smallest type of 9 volt battery (such as the PP4) can be used. This is clamped to the Paxolin panel by a thin strip of aluminium. The battery was removed for the photographs so that construction could be more easily seen.

Operation

Insert a transistor and check that the battery consumption does not exceed 2.5mA. Set R_3 to mid-point and insert a good high frequency transistor with the range set at 2 Mc/s. An OC171 is ideal for this purpose. Adjust R_3 until the meter reads slightly less than full-scale, then switch to the other two ranges. The meter reading should remain approximately the same if all is well. If no reading is obtained on one of the ranges check the coil connections and reverse one winding if necessary.

All that remains is to try various transistors. An OC45 should read high on range 1, with no reading at all on ranges 2 and 3, indicating that its gain has fallen steeply between 2 and 10 Mc/s. An OC44 will show a fair reading on range 2, but nothing on range 3. Transistors of the same type can be compared with one another by noting the meter reading for each one. Only the higher frequency transistors will give a reading on range 3. To increase the range frequencies unscrew the dust cores, or completely remove them. The exact frequency of oscillation can be checked by finding the fundamental on a short wave receiver, but if the coils are wound according to the instructions they should be near enough to the specified frequencies for practical purposes.

Obviously the flexibility of the instrument could be increased by extending the ranges to include 300 kc/s for audio transistors, and 100 Mc/s or more to suit the very high frequency transistors now available.

THE NEW DUAL-STANDARD TV SETS

The last of this series of articles (Part 13) has been unavoidably held over and will appear in the next issue.

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The "Athenian" 4-Band Superhet Receiver

Part 2—A Design for the Beginner, 16—2,000 Metres

By James S. Kent

In the last issue, the circuit of this receiver was fully described. In this instalment, the construction will be similarly dealt with in order that the beginner to superhet construction may build the design with the minimum of trouble

Having decided to construct the "Athenian" receiver, whose circuit was described last month, and having obtained the parts as listed in the Components List, the intending constructor will no doubt be waiting for this issue so that operations can commence.

The first step is probably the least exciting but nevertheless it must be carried out accurately if every panel and chassis mounted component is to fit in the correct place.

Drilling the Chassis and Panel

Fig. 2 (*a*) shows the front panel measurements, this having an overall size of 14 x 8in. Holes A, B, C, D, and E are all $\frac{5}{16}$in diameter. They should first be marked out with a centre-punch on the *rear* of the panel before drilling, and the dimensions double-checked. The reason for marking the rear of the panel is that any error in measurement, or false markings, will not show on the front. Hole A is for the wavechange switch; B for the b.f.o. pitch control; C for the function control; D for the audio gain control; and E for the phone jack.

Next, mark and drill holes F and G to $\frac{5}{16}$in diameter, these being the apertures for the bandset and bandspread spindles respectively. Refer to Fig. 2 (*d*) for the remaining drilling details required for holes F and G in order that the two dials may be fitted correctly, as is done at a later stage.

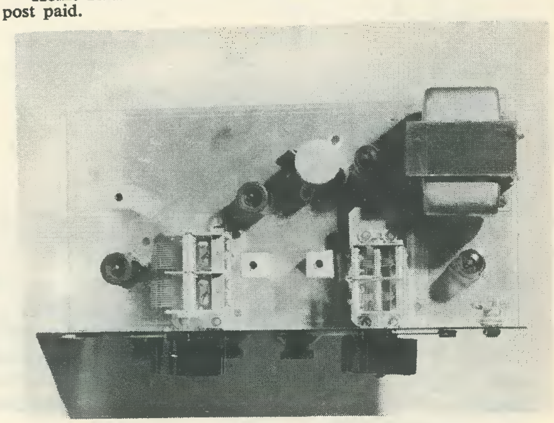
The drilling details for the pilot lamp assembly and the "Athenian" motif have not been given in Fig. 2 (*a*) as these will depend on the type of fitment obtained. In the prototype, the drilling measurements for the lamp assembly are 1in from the edge of the right-hand side of the panel (looking at the front) and $1\frac{1}{4}$in down from the top edge of the panel. Those for the medallion are exactly the same except that it is 1in from the left-hand side of the panel.

Next, place the front panel against the front apron of the chassis, and clamp (or secure by other means) these together in *exactly* their final relative position, the two edges and bottom of both panel and chassis being square and level.

Centre-punch in the *centre* of holes A to E inclusive, remove the panel and drill the same size holes as hitherto in the chassis apron. The holes in the panel and front apron of the chassis should now coincide. If not, then a small amount of filing with a round or half-round file will be necessary when these two parts are later fitted together.

Fig. 2 (*b*) shows the main details for the chassis deck. Holes H, K, M and O are for V_1, V_3, V_2 and V_4 respectively. These should be marked out first and circular holes having a diameter of $\frac{3}{4}$in made in the chassis deck. The easiest method of accomplishing this is to obtain a Q Max chassis punch complete with Allen key,[1] this tool cutting a smooth round hole in one operation after a centre hole has been initially drilled. Failing this, it will be necessary to mark out a circle of the diameter stated and to drill holes round this mark, finally removing the unwanted centre by a slight tap with a ball-pane hammer and filing clean with a half-round file. The latter is a most laborious business and the small investment involved in obtaining the Q Max tool is well worthwhile—particularly as it will last a lifetime and be constantly in use during constructional operations. Do not drill any of the valveholder mounting holes yet.

[1] Home Radio Cat. No. TL10 with key Cat. No. TL12, 17s. 9d. post paid.



Above-chassis view of the completed prototype receiver. The components, from left to right at bottom, are V_1, bandset capacitor, b.f.o. coil, IFT_2, bandspread capacitor, V_3 and pilot lamp assembly. Left to right, above, IFT_1, V_2, C_{28}, $_{29}$, V_4 and mains transformer T_2

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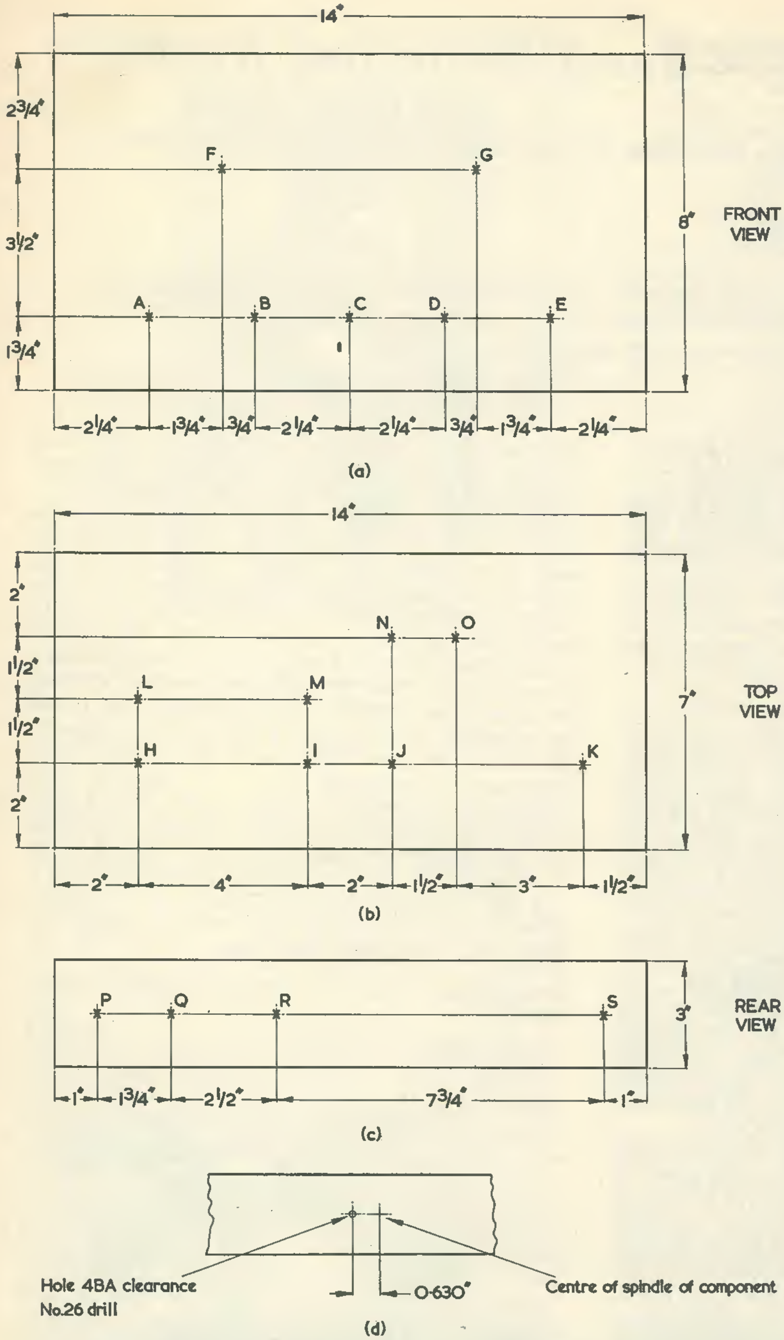

Holes I, J and L should now be marked, these being the centre points for the transformer hole groups; I being that for the b.f.o. coil, L for IFT_1 and J for IFT_2. The three centre holes should have a diameter of $\frac{5}{16}$in. Six other holes are now required at positions I, J and L, and details of these are given in Fig. 5 (*a*). Before marking and drilling, however, ensure that with IFT_1 (hole L) pins 1 and 6 are positioned nearest the rear edge of the chassis and pins 3 and 4 are nearest the front edge. (See Fig. 5 (*b*). A useful dodge here consists of marking the metal cans with a pencilled number corresponding to the various pins, this helping to ensure that the orientation of these components is correct. IFT_2 (hole J) should now be similarly drilled (see Fig. 5 (*a*).) with pins 1 and 3 nearest the rear and pins 4 and 6 nearest the front of the chassis. The b.f.o. coil is next dealt with in a similar manner, pins 1 and 3 being nearest the front and pins 4 and 6 being nearest the rear edge of the chassis.

The next task is to mark out and drill the holes required for mounting the mains transformer. These are not shown in Fig. 2 (*b*) but a glance at the accompanying illustration (above chassis) shows the location and orientation of this component. The thin red, yellow, green, black, brown and black/yellow leads, together with the two yellow heater wires, should be nearest the rear edge of the chassis. Mark and drill the four 2BA holes required to hold the transformer in position using the mounting lugs as a template. Mark and drill two $\frac{1}{2}$in holes mid-way between the fixing lugs and fit these with suitably sized rubber grommets.

Hole N should next be dealt with, and this should have a diameter of $1\frac{1}{8}$in (the same size as is required for an octal valveholder). A Q Max chassis cutter is also available for this size.[2]

Fig. 2 (a). Panel drilling details. The wavechange switch is positioned at A, the b.f.o. pitch control at B, the function switch at C, the volume control at D, the phone jack at E, the bandset capacitor at F and the bandspread capacitor at G

(b). Chassis drilling details. V_1 is fitted at H, the b.f.o. coil at I, IFT_2 at J, V_3 at K, IFT_1 at L, V_2 at M, $C_{28,29}$ at N and V_4 at O

(c). Rear chassis apron details. The mains input lead passes through P, the mains filter unit is fitted at Q, the power outlet socket at R and the aerial input socket at S

(d). Drilling details required for fitting the bandset and bandspread dials, together with their associated slow motion drives

[2] Home Radio Cat. No. TL14, with Allen key Cat. No. TL15C, 19s. 6d. post paid.

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The 9-way tagstrip should now be fitted (see illustration) and this should occupy a position midway between V_1 and IFT_1 at one end and V_2 and L_4 (b.f.o. coil) at the other end. This tagstrip has two earthed tags (tags 2 and 8) and each of these *must* be reliably secured to the chassis.

The 4-way tagstrip can now be fitted and this should occupy a position to the left of V_3 (looking from the rear of the chassis) such that tag 1 (see Fig. 13) is level with pin 9 of the valveholder.

The hole for the aerial i.f. filter unit should now be drilled, this being 1in from the left-hand edge of the chassis and 2in from the rear edge. *Do not secure any component into position as yet.*

Refer now to Fig. 2 (*c*) and mark and drill the holes P, Q, R and S. Hole P should have a diameter of ½in, and is fitted with a rubber grommet. This is for the mains input lead. Hole Q is 4BA clearance to take the mains input filter unit. Hole R is for the power outlet socket and should be 1⅛in diameter to take an octal socket. Finally, hole S is for the coaxial aerial input socket and should have a diameter of ½in.

The next task is to drill and bend the two variable capacitor mounting platforms (see Fig. 3 (*a*) and (*b*)). In each case, the components themselves may be used as templates for marking out the fixing holes, 4BA nuts, bolts and shakeproof washers being used for securing purposes. Dealing with Fig. 3 (*a*) first, it will be noted that there is a cut-out portion on the right-hand side of the metalwork, this being required to give clearance for the b.f.o. transformer, the depth of this cut-out being ¼in. Drill the platform as shown, not forgetting the two 4BA chassis securing holes and the ⅜in hole required beneath each solder tag of the capacitor (two in all); fit these two holes with small rubber grommets. Each corner of the platform should be trimmed as shown, this avoiding possible cuts on the hands at a later stage. Bend along the two lines as shown in the side view of Fig. 3 (*a*). Similarly deal with the platform shown in Fig. 3 (*b*). Here, no connections pass through the platform from the variable

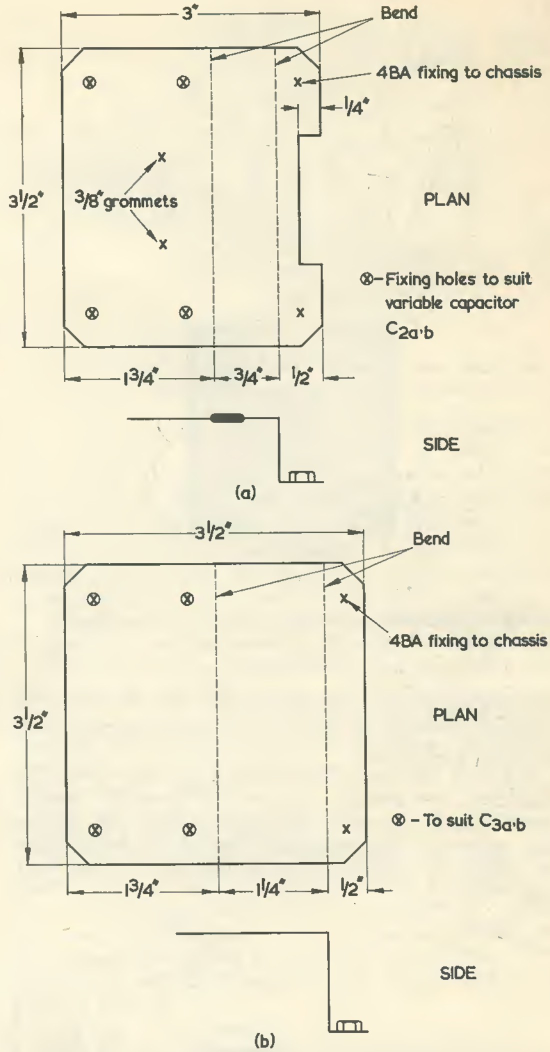

Fig. 3 (a). Plan and side view of the metal platform required for mounting the bandset two-gang capacitor to the chassis (b) the platform required for the bandspread capacitor

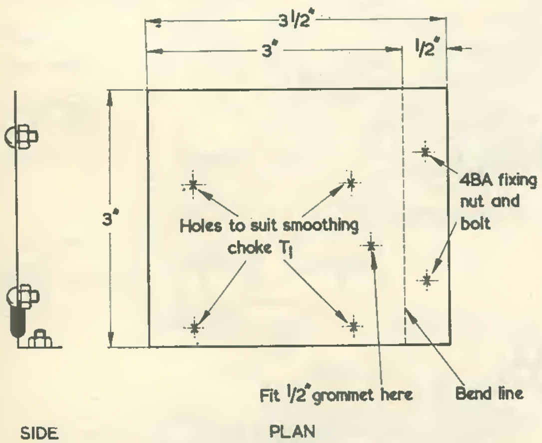

Fig. 4. Metalwork required for mounting the l.f. smoothing choke to the underside of the chassis

capacitor, and no cut-out is required in the metalwork. Having drilled the metalwork, bend along the lines as shown. Both of the capacitors should be mounted on the metalwork such that the spindles protrude as much as possible, $\frac{9}{16}$in of spindle being required to extend beyond the front panel for dial fixing purposes. Mount the capacitors to the metalwork but do not secure to the chassis as yet.

To the right-hand apron of the chassis, on the *outside*, place the output transformer T_1 into position. Mark the fixing holes with a centre-punch and drill the four holes. The position of this transformer is such that its *centre* is 3¾in from the front of the chassis and 1½in from the top of the chassis. The transformer is used as a template on

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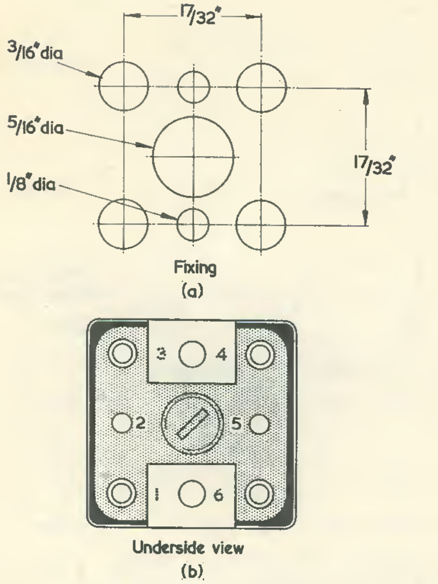

Fig. 5 (a). Drilling details for the i.f. transformers and b.f.o. coil. (b). Underside view of these components

the outside of the chassis for the reason that it is almost impossible to employ it in this manner from inside the chassis.

Midway between this transformer and the rear edge of the chassis, place the speaker output Paxolin strip upright, mark out, drill and secure into position. Mount under one of the fixing nuts an earth tag. (See below-chassis illustration and Fig. 16.)

Refer next to Fig. 4, which shows the mounting bracket for the smoothing choke. Mark out, drill and bend as shown, using the component itself as a template for its four mounting holes, then mount the choke in position on the bracket.

Returning again to the chassis deck, position V_1 valveholder (which requires a screening can) such that pins 1 and 9 are nearest the front of the chassis, drill the two fixing holes and mount into position, placing an earthed solder tag under the nut nearest the front of the chassis. With V_2 valveholder, (which also requires a screening can) place this with pins 1 and 9 nearest aperture N, and secure with a solder tag under the nut nearer the same hole. For V_3, position so that pins 4 and 5 are nearest the side of the chassis and, with V_4, so that pins 1 and 9 are nearest hole N. Secure these two valveholders and ensure that a solder tag is mounted under the nut nearer the centre of the chassis in each case. Mount the smoothing capacitors C_{28}, C_{29} into position by using the metal clip as a template, ensuring that the red tag is nearest the V_4 valveholder. Secure into position the i.f. filter unit; the aerial input socket; the international octal valveholder used as the power outlet socket, mounting an earthed solder tag under one of its nuts; the mains input filter; IFT_1 (pins 1 and 6 nearest the rear of the chassis) and the mains transformer.

Place temporarily into position firstly the bandset variable capacitor on its platform, mark on the chassis deck the two positions for feeding the two connecting leads required, remove the mounting, drill the two holes and fit two ⅜in rubber grommets. Similarly deal with the bandspread capacitor. In this case the connecting leads pass through two holes in the chassis between the bandspread capacitor bracket and IFT_2. The two platforms are now

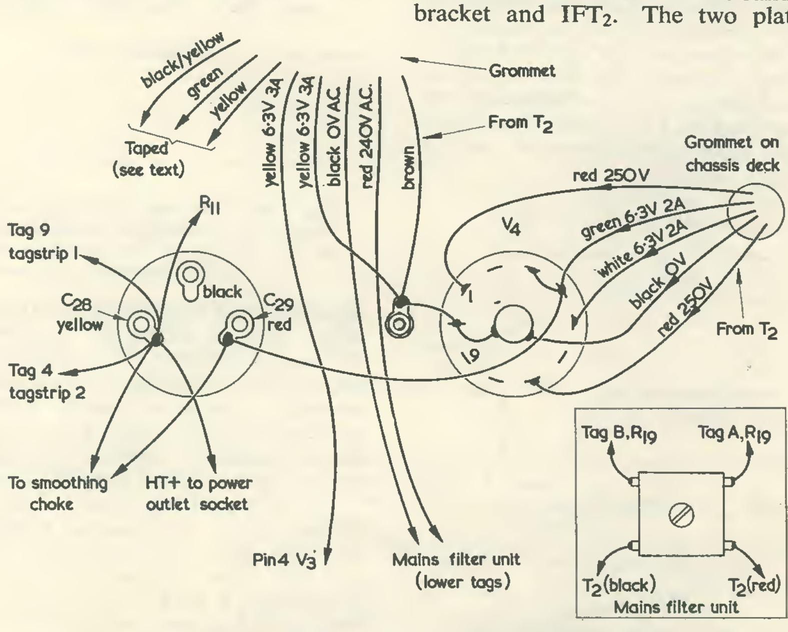

Fig. 6. Point-to-point diagram of the power stage at V_4. Note that the spigot earth tag appears between pins 1 and 9

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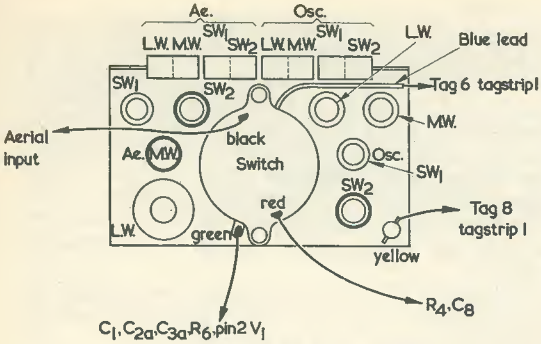

Fig. 7. Rear view of the coilpack, showing the connection points

ready for mounting but, first of all, a small soldering process is required.

When dealing with the bandset two-gang capacitor, it will be found much easier to solder to the respective tag of each fixed vane section a 3in length of p.v.c. covered wire before securing the assembly into position, feeding the two wires through the platform and the chassis prior to mounting into position. The two platforms may now be mounted.

Mount and secure into position the b.f.o. coil (pins 4 and 6 nearest the rear of the chassis) and IFT_2 (pins 1 and 3 nearest the rear edge of the chassis). Under the right-hand fixing bolt of the b.f.o. coil (that nearer IFT_2) secure an earth solder tag.

Secure into position the smoothing choke assembly using the metalwork as a template for the two fixing holes to the chassis deck. The illustration shows the position for this assembly, the screen protruding beyond hole N and being placed midway between this hole and V_2 valveholder.

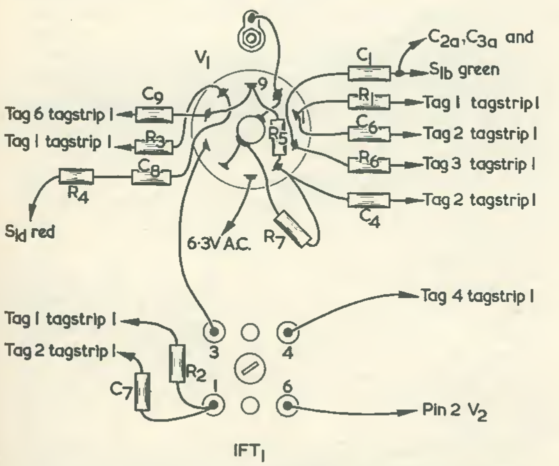

Fig. 8. Point-to-point wiring diagram of the first stage (V_1 and IFT_1). In all the point-to-point diagrams, where a resistor or capacitor is designated within a rectangle, that component should be soldered into circuit at that particular stage of construction

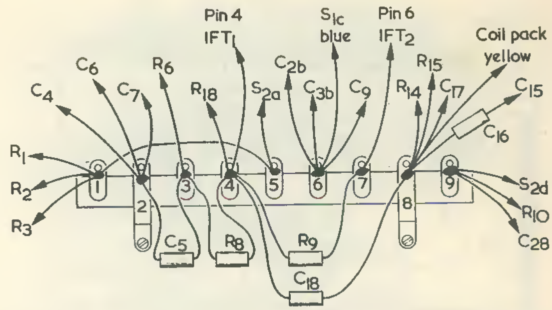

Fig. 9. Wiring-up details of the 9-way tagstrip. Note that both tags 2 and 8 must be secured to chassis

Next, fit the panel to the chassis by feeding the two variable capacitor spindles through their respective holes, and securing into position in hole A the coilpack, hole B the 25pF variable b.f.o. pitch capacitor, hole C the 4-pole, 3-way function switch, hole D the volume control and E the phone jack. Note from the below-chassis illustration the orientation of these components.

Finally, fit the pilot lamp assembly and drill through the chassis, directly underneath, a ¼in hole, which is fitted with a small rubber grommet. Secure the assembly into position. If using the medallion, drill the panel as previously described but do not fit the medallion as yet. The drilling and fixing of components is complete and wiring-up may now commence.

Wiring-up the Circuit—V_4

The best method of carrying out this task is to commence at V_4 and to follow this by connecting up all the respective valve heater supplies. In this manner, heater leads may be so positioned and routed that they do not run near tuned or "hot" leads, thereby reducing the risk of induced 50 c/s mains hum.

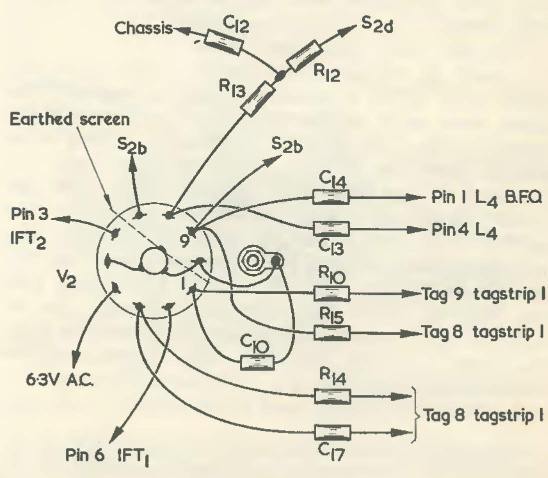

Fig. 10. Point-to-point wiring details at V_2 valveholder

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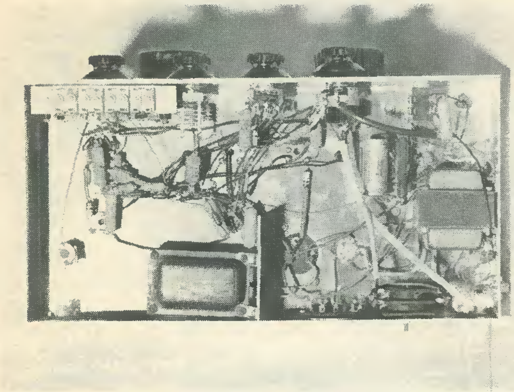

Below-chassis view of the receiver showing the positions of the main components. The l.f. smoothing choke is mounted at the rear and the output transformer at the side of the chassis. The mains filter unit and the power outlet socket are positioned on the rear chassis apron alongside the mains input wires—note the knot tied in the latter to avoid undue strain being applied to the soldered connections at the on/off switch. The aerial input socket and the i.f. filter unit L_1 appear at the lower left of the photograph

The diagram of Fig. 6 shows the required connections from the mains transformer T_2 to the rectifier V_4, the smoothing capacitors C_{28},C_{29} and the mains filter unit (shown in inset).

Commence by soldering into position the following leads connecting to V_4: red 250V to pin 1; green 6.3V to pins 3 and 4; white to pin 5; black to the centre metal spigot and from there to the spigot tag and chassis, and red 250V to pin 7. Note that both of the 6.3V leads (green and white) will have to be scraped in order to remove the protective enamel covering prior to soldering. From pin 4, a length of p.v.c. covered wire is taken to the tag of C_{29} (red). To this latter point, one of the smoothing choke leads (it does hot matter which one) is also soldered.

Dealing next with the wires from the other grommet, the black/yellow, green, yellow wires will have to be taped *separately* in such a manner that their bare ends are covered and will not make contact with each other or the chassis. These wires should now be folded, taped so that they are retained in the fold, and tucked away under the other wires once these are connected. The two yellow 6.3V wires should now be scraped and connected, one to pin 4 of V_3 (output stage) and one to the earth tag. The black 0V a.c. input wire and the red 250V a.c. input wire should now be soldered to the two lower tags of the mains filter unit (see inset to Fig. 6).[3] The brown wire is connected to the earth tag. The remaining smoothing choke wire should now be connected to the tag of C_{28} (yellow). Other connections to this tag are: a p.v.c. covered wire to pin 4 of the power outlet socket; a p.v.c. covered lead to tag 9 of tagstrip 1 (Fig. 9) and to tag 4 of tagstrip 2 (Fig. 13). The connection to R_{11} will be dealt with later. Carefully check to ensure that the correct connections have been made and constantly refer to the circuit diagram in Fig. 1, published last month.

Next connect a small length of bare wire from pin 2 of the power outlet socket to its adjacent earth tag.

From pin 4 of V_3, continue the heater supply to pins 4 of both V_2 and V_1. Place the heater lead as close to the chassis deck as possible.

The Circuit of V_1

The wiring-up details for this are shown in Figs. 7 and 8. Fig. 7 is for the coilpack but it will be found easier to commence by wiring the circuit of V_1 and make the necessary connections to the coilpack as they become necessary.

With a short length of bare wire, connect pin 5, the central metal spigot and the spigot tag to the earth tag. To pin 1, solder one end of R_1 (33kΩ, orange, orange, orange) and C_6 (0.1μF), the other end of R_1 being soldered to tag 1 and the other end of C_6 to tag 2 of tagstrip 1 (see Fig. 9). To pin 2 of V_1 connect one end of both R_6 (1MΩ, brown, black, green) and C_1 (100pF); the other end of R_6 being soldered to tag 3 of tagstrip 1 and the other end of C_1 to the green tag of the coilpack (see Fig. 7). From the green tag of the coilpack connect a length of p.v.c. covered wire to $C_{3(a)}$ (bandspread capacitor section nearest the front panel, feeding this wire through the associated rubber grommet in the chassis deck). Also to the green tag of the coilpack connect the length of p.v.c. covered wire previously connected to $C_{2(a)}$ (front section of the bandset capacitor nearest the front panel).

To pin 3 of V_1, connect one end of both R_5 (47kΩ, yellow, violet, orange) and R_7 (220Ω red, red, brown). The other end of R_5 connects to pin 9 and that of R_7 to pin 5 (chassis). C_4 (0.01μF) is also connected to pin 3, its other end connecting to tag 2 of tagstrip 1. Pin 4 has already been dealt with (6.3V a.c.). Pin 6 is connected directly to pin 3 of IFT_1.

Pin 7 of V_1 has soldered to it one end of C_9 (50pF) the other end of which is connected to tag 6 of tagstrip 1; also a short length of wire, the other end of which connects to pin 9 of V_1.

To pin 8 connect one end of both R_3 (33kΩ orange, orange, orange) and C_8 (200pF). The other end of R_3 connects to tag 1 of tagstrip 1, whilst the free end of C_8 is connected to one end of R_4 (150Ω brown, green, brown). Before soldering these two latter ends, each must be cut as short as possible and twisted together. The free end of R_4 is then connected to the red tag of the coilpack (see Fig. 7). The connections to pin 9 of V_1 have already been completed.

The next step is that of completing the wiring to IFT_1. To pin 1, connect one end of both R_2 (10kΩ brown, black, orange) and C_7 (0.1μF). The other

[3]The connections to the mains input filter unit assume a 240–250 volt a.c. mains supply, as will be in existence in most instances. For lower mains voltage supplies, the appropriate primary leads should be selected, following the circuit diagram shown last month in Fig. 1 —EDITOR.

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end of R_2 now connects to tag 1 and that of C_7 to tag 2 of tagstrip 1 (see Fig. 9). Pin 4 of IFT_1 is soldered direct to tag 4 of tagstrip 1 and pin 6 is connected to pin 2 of V_2.

Return now to the coilpack and complete the following wiring. The yellow tag (this is a stand-off pillar with wire insert, the latter being, in effect, the tag) is now connected to tag 8 of tagstrip 1. This yellow tag connection constitutes the coilpack earth and is shown in the circuit diagram of Fig. 1 (published last month) as such. The blue lead of the coilpack connects to tag 6 of tagstrip 1 and the black lead to L_1 (aerial filter unit, if included) and from that point to the aerial input. Alternatively, the black lead connects direct to the latter point if the filter unit is not included.

Fig. 7 shows, in addition to the various connections, the positions of the various coils, both aerial and oscillator, and also the trimmer capacitors for each range.

The Circuit of V_2

Before commencing with this part of the circuit, beginners should check with the foregoing instructions and the circuit of Fig. 1 to ensure that all connections have been made as described, whereupon those portions of the circuit completed may be "blacked in" on the circuit diagram with the aid of a ball-point pen. It should be noted, however, that the tags of tagstrip 1 are used as junction points and in case some confusion arises when checking and "blacking out" the circuit, a reference to Fig. 9 will assist in assuring the beginner that the correct connections have been made. For instance, R_3 in the V_1 circuit (pin 8) is shown in Fig. 8 as being connected between that pin and tag 1 of tagstrip 1 whereas in the circuit it is shown as being connected at one end to tags 2 and 3 of $S_{2(a)}$. A reference to Fig. 9 will show that it is, in fact, so connected to $S_{2(a)}$ whilst a further reference to Fig. 11 ($S_{2(a)}$, (b), (c), (d)) will show that tag 5 of the tagstrip is connected to $S_{2(a)}$.

In all the point-to-point diagrams, it has been so arranged that where a component is actually shown, i.e. designation within a rectangle, it should be wired in at that stage.

Referring to Fig. 9, complete the following wiring. Connect tag 1 of the tagstrip to tag 5 with a length of p.v.c. covered wire. To tag 2 connect one end of C_5 (0.01µF), the other end of this capacitor going to tag 3. To tag 3 connect one end of R_8 (220kΩ red, red, yellow), the other end of this being soldered to tag 4. To tag also solder one end of R_9 (2.2MΩ red, red, green) and C_{18} (0.01µF), the other end of R_9 connecting to tag 7 and that of C_{18} to tag 8. To tag 4 also connect a length of p.v.c. covered wire, the other end of which is soldered to one end of R_{18} (100Ω brown, black, brown). The free end of R_{18} is then connected to tag C of $S_{2(c)}$—see Fig. 11.

To tag 5 of tagstrip 1 solder a length of p.v.c. covered wire the other end of which connects to tags 2 and 3 of $S_{2(a)}$. To tag 6 of tagstrip 1 connect a length of p.v.c. covered wire, the other end of

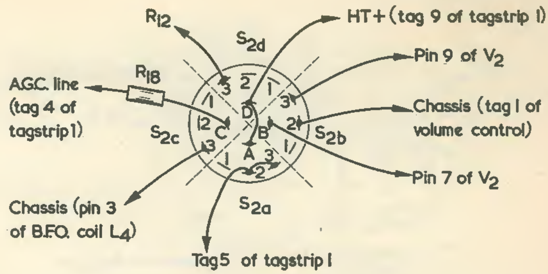

Fig. 11. Connections to the function switch $S_{2(a)}$, (b), (c), (d)

which is connected to $C_{3(b)}$ (bandspread capacitor section nearest the rear of the chassis). One end of the wire previously soldered to $C_{2(b)}$ should now also be connected to tag 6 of the tagstrip.

With a short length of p.v.c. covered wire, connect tag 7 of the tagstrip to pin 6 of IFT_2. To tag 8 of the tagstrip, connect one end of C_{16} (140pF), leaving the other end free for the moment. To tag 9 connect a length of p.v.c. covered wire, the other end of which is now connected to tag D of $S_{2(d)}$—see Fig. 11. The remaining connections to the tagstrip will be completed later as the wiring process continues.

We deal next with the connections to the valveholder of V_2. (See Fig. 10.) With a short length of bare wire, connect pin 5 to the central metal spigot and the spigot tag to the earthed tag. A small metal screen should now be soldered across the valveholder as shown by the dotted line. This screen should be soldered to both the central metal spigot and the spigot tag and care should be taken to ensure that the screen does not make contact with any other valve pin. A suitable metal screen may be made by cutting out a piece of tin from a discarded cocoa tin or similar with the aid of a pair of tinsnips, and trimming to shape.

To pin 1 of V_2 connect one end of both R_{10} (100kΩ brown, black, yellow) and C_{10} (0.1µF), the other end of R_{10} being connected to tag 9 of tagstrip 1 and that of C_{10} to the earth tag as shown. To pin 3 of V_2 solder one end of R_{14} (220Ω red, red,

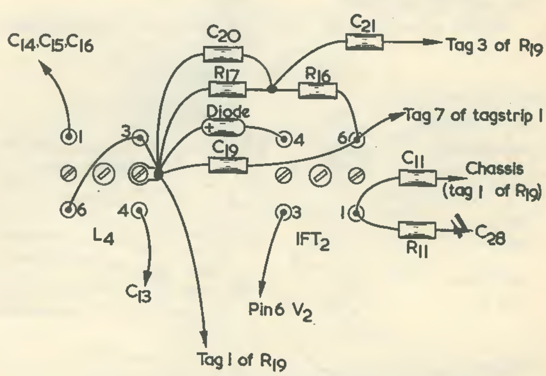

Fig. 12. Wiring-up details for IFT_2 and the b.f.o. coil L_4. Note particularly the polarity of the diode detector

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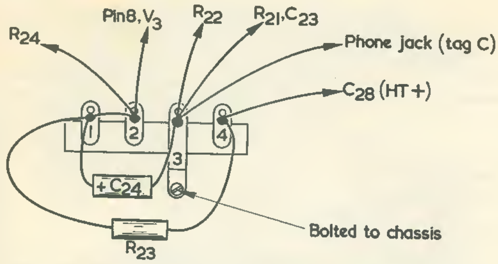

Fig. 13. The 4-way tagstrip. Tag 3 must be connected to chassis

brown) and C_{17} (0.01µF); the other end of R_{14} being soldered to tag 8 of tagstrip 1 and that of C_{17} to the same tag. To pin 6 of V_2 connect a length of p.v.c. covered wire, its other end connecting to pin 3 of IFT_2. To pin 7 of V_2 solder a length of p.v.c. covered wire connecting to tag B of $S_{2(b)}$—see Fig. 11. To pin 8 of V_2 solder one of both R_{13} (22kΩ red, red, orange) and C_{13} (50pF) the other end of the latter component being connected to pin 4 of the b.f.o. coil (L_4) and that of R_{13} to one end of both R_{12} (150kΩ brown, green, yellow) and C_{12} (0.1µF). This junction should be formed by cutting the wire ends as short as possible and twisting them together prior to soldering. The free end of C_{12} is now connected to tag 3 of $S_{2(c)}$, the other end of R_{12} being connected to tag 3 of $S_{2(d)}$—see Fig. 11 for these two latter connections. Pin 9 of V_2 should now have one end of C_{14} (100pF) connected, the other end of this component being connected to pin 1 of the b.f.o. coil L_4—see Fig. 12. A short length of p.v.c. covered wire should next be soldered to pin 9 of V_2, the other end of which is connected to tag 3 of $S_{2(b)}$.

The switch wiring should now be completed—see Fig. 11. Commence with the $S_{2(a)}$ section and join tag A to tag D of $S_{2(d)}$. Dealing with $S_{2(b)}$ section, connect tag 2 to tag 1 of the volume control. (See Fig. 15). To complete $S_{2(c)}$, connect tag 3 to pin 3 of the b.f.o. coil L_4. This completes the switch wiring.

Refer now to Fig. 12. To pin 1 of L_4 connect a short length of p.v.c. covered wire and connect the other end to the stator vanes tag of C_{15} (b.f.o. pitch control variable capacitor). With a short length of bare wire, join pins 3 and 6 of L_4 and connect these to the chassis earth tag.

Dealing next with IFT_2, connect to pin 1 one end of both R_{11} (10kΩ, brown, black, orange) and C_{11} (0.1µF), the other end of R_{11} being connected to the tag of C_{28} (32µF electrolytic) and that of C_{11} to chassis (tag 1 of the volume control R_{19}—see Fig. 15). To pin 4 of IFT_2 solder the black end of the diode, using a pair of pliers as a heat shunt. The other end of this component (red) is now soldered to the earth tag as shown (using a heat shunt). Obtain R_{17} (270kΩ, red, violet, yellow), C_{19} (100pF), C_{20} (100pF) and a length of p.v.c. wire, suitably shorten one wire end of each component and twist these and the wire together and solder. Place the pliers against the red end wire of the diode to form a heat shunt and connect the twisted ends of the components mentioned above to the earth tag as shown in Fig. 12. Connect the other end of the p.v.c. covered wire to tag 1 of the volume control, that of C_{19} to pin 6 of IFT_2, C_{20} and R_{17} to the ends of R_{16} (22kΩ, red, red, orange) and C_{21} (0.01µF), cutting the wires forming this latter junction as short as possible, twist them together and solder. The other end of R_{16} connects to pin 6 of IFT_2 and that of C_{21} to tag 3 of the volume control R_{19}.

The Circuit of V_3

This is the last stage to be dealt with and operations should commence with wiring-up tagstrip 2, as shown in Fig. 13.

Connect R_{23} (1.5kΩ 5 watts) between tags 1 and 4 of this tagstrip as shown. Solder the end of C_{24} (8µF electrolytic) which is marked with a plug sign or is coloured red to tag 1, the other end of this component being connected to tag 3. Join tags 1 and 2 of the tagstrip as shown. From tag 2 connect a length of p.v.c. covered wire and connect the other end of this wire to pin 8 of V_3. From tag 3 connect a short length of p.v.c. covered wire and connect the other end to tag C of the phone jack—see Fig. 15 (*b*). From tag 4 solder a length of p.v.c. covered wire, the other end of which connects to the tag of C_{28} (32µF electrolytic). The remaining connections will be made to this tagstrip as the wiring-up process of V_3 continues.

Refer now to Fig. 14 in which is shown the connections to V_3. With a short length of bare wire connect pin 5 to the central metal spigot, the spigot tag and the earth tag. To pin 1 connect one end of R_{24} (100kΩ, brown, black, yellow), C_{25} (0.01µF) and C_{26} (0.1µF). Connect the other end of R_{24} to tag 2 of tagstrip 2, that of C_{25} to pin 9 of V_3 and that of C_{26} to tag B of the phone jack—see Fig. 15 (*b*). Pin 2 of V_3 should now be connected to tag 2 of the volume control R_{19}—see Fig. 15 (*a*)—and this connection should be made by using a short length of coaxial cable, the metal outer braiding of which is connected to chassis by soldering to the central metal spigot of V_3 valveholder. Note

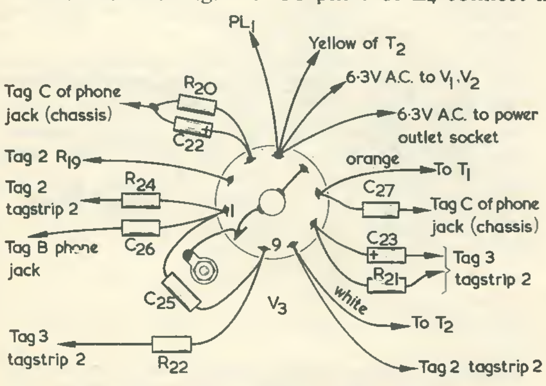

Fig. 14. Point-to-point wiring details for V_3 valveholder

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here that in the photograph of the prototype (below chassis view) this coaxial cable is shown connected incorrectly, being soldered to tag 3 of R_{19} instead of tag 2.

To pin 3 of V_3, connect one end of both R_{20} (1.8kΩ, brown, grey, red) and C_{22} (10μF electrolytic) the positive end of the capacitor being that connected to this pin. The other wires of these two components should now be cut to a suitable length, twisted together and soldered to tag C of the phone jack (chassis). To pin 4 of V_3, to which two connections have already been made when dealing with V_4, solder a length of p.v.c. covered wire, the other end of which connects to pin 7 of the power outlet socket. Next, obtain two lengths of p.v.c. covered wire of similar length (sufficient to reach from V_3 valveholder to the pilot lamp assembly via the rubber grommet *when twisted together*) and solder one end of each length of wire to a tag of the pilot lamp assembly. The other end of one length of this wire is now connected to pin 4 of V_3 and the remaining end to tag C (chassis) of the phone jack.

To pin 6 of V_3 solder one end of C_{27} (0.01μF), the other end connecting to tag C of the phone jack. Connect the orange wire of T_1 (output transformer) to pin 6 of V_3. To pin 7 of V_3 connect one end of R_{21} (470Ω, yellow, violet, brown) and the positive end of C_{23} (25μF electrolytic), the other ends of R_{21} and C_{23} being connected to tag 3 of tagstrip 2. To pin 8 of V_3 connect the white wire of T_2 and a short length of p.v.c. covered wire, the other end of which connects to tag 2 of tagstrip 2. To pin 9 connect one end of R_{22} (220kΩ, red, red, yellow) the other end being soldered to tag 3 of tagstrip 2.

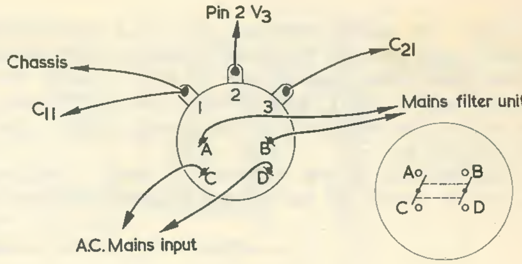
One connection now remains to be made to the volume control and that is the coupling of tag 1 to chassis. The connection may be made by connecting a length of wire to tag 3 of $S_{2(c)}$—see Fig. 11.

To tag D of the phone jack solder the black wire of T_1.

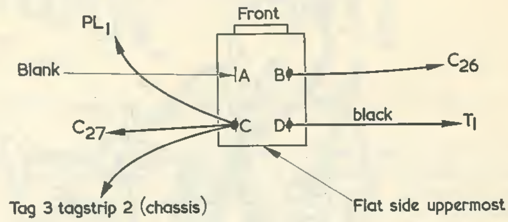
The yellow and green wires of T_1 should be taped *separately* to ensure that the wire ends do not make contact with each other or the chassis and these wires should then be tucked away. The red wire from T_1—see Fig. 16—should now be soldered to the lower tag of the speaker output socket, the upper tag of this strip being soldered to the chassis earth tag.

R_{25} (10Ω, brown, black, black) is now wired between the lower speaker output socket tag and tag D of the phone jack. To accomplish this it will be necessary for one of the resistor leads (that connecting to the phone jack) to be extended by soldering on an additional length of insulated wire, the joint being covered by sleeving. The resistor is positioned near the speaker output socket.

Finally, complete the mains input circuit. This consists of fitting the mains input lead and com-



(a)



(b)

Fig. 15 (a). Connections to the volume control R_{19}. Ensure, before soldering, that tags A, B, C and D agree with the switching circuit shown in the inset. (b). Details of the phone jack wiring

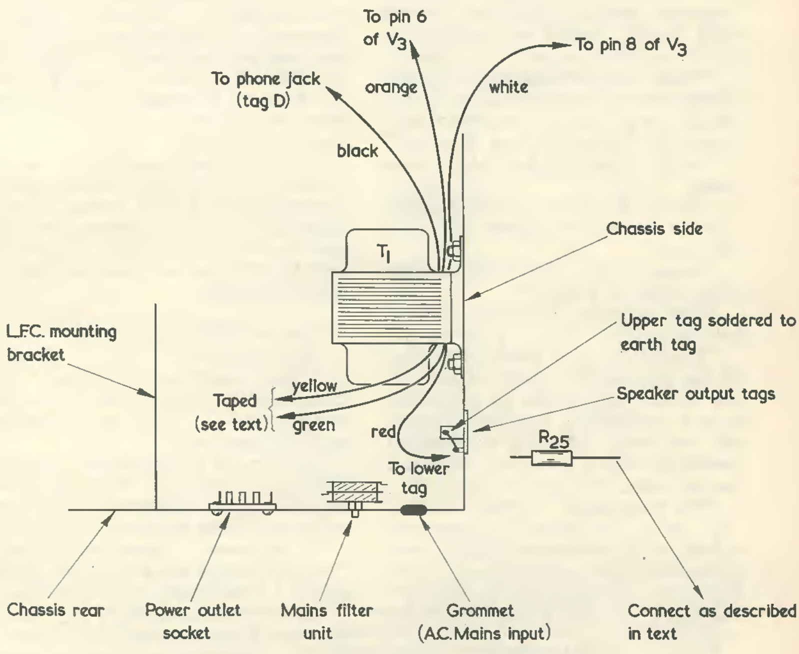


Fig. 16. Wiring details of the output transformer T_1

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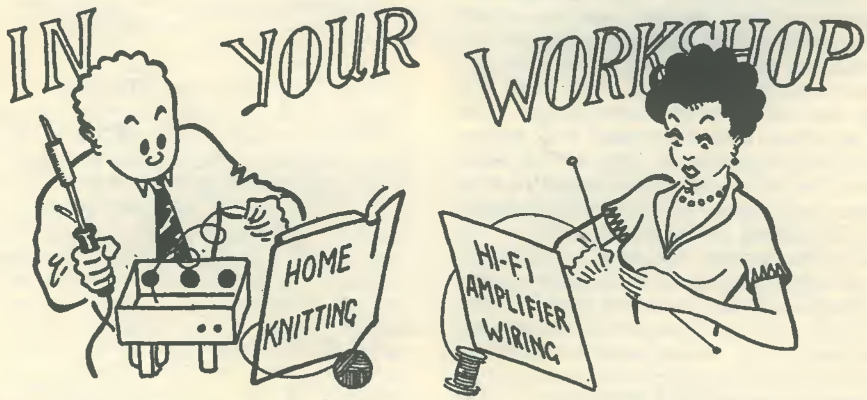
pleting the wiring between this and the on-off switch, and between the on-off switch and the mains filter unit. (See Figs. 6 and 15 (*a*).) Ensure that switch tags A, B, C and D are those which correspond to the switching circuit shown in the inset in Fig. 15 (*a*).

The wiring of the receiver is now complete. Carefully check all the wiring against the circuit diagram of Fig. 1 and the foregoing textual instructions to ensure that all connections have been made correctly.

Part 3, the conclusion of this series, is to be published next month, and will deal with treating the front panel, testing and operation of the receiver.

(*To be concluded*)



This month Smithy the Serviceman, aided as always by his able assistant, Dick, turns away from the more complex aspects of servicing to consider the simpler problems involved in meter series resistors and shunts.

"THE NOMINAL RESISTANCE PER yard," called out Smithy, "is 1.13Ω."

"Fine," declared Dick, jotting the figure down in his notebook. "That's got 22 s.w.g. Eureka wire sorted out! Now, what about 24 s.w.g. Eureka?"

Smithy consulted his tables once more.

"That," he pronounced gravely, "has a nominal resistance of 1.83Ω per yard."

"Good," said Dick enthusiastically, "and 26 s.w.g.?"

"The nominal resistance there," Smithy replied, "is 2.73Ω per yard."

"Excellent," said Dick, scribbling in his notebook. "Well, that's got *me* sorted out so far as resistance wire is concerned. Incidentally, why did you keep referring to nominal resistance values just now? Why not just say what the actual value is?"

"It's necessary," replied Smithy, "to refer to nominal resistance values with resistance wire because of the inevitable tolerances which are involved. To start off with, there's a tolerance on the diameter of the wire itself."

Smithy returned to his wire tables.

"For instance," he continued, "the diameter of 22 s.w.g. wire is nominally 0.028 inches, but it has top and bottom limits of 0.0283 and 0.0277 inches. With 24 s.w.g. wire, the nominal diameter is 0.022 inches, with top and bottom limits of 0.0222 and 0.0218 inches. Again, with 26 s.w.g. wire the nominal is 0.018 inches, with top and bottom limits of 0.0182 and 0.0178 inches. These tolerances on wire diameter are just one reason why you have to refer to resistance values in resistance wire as being nominal."

A Simple Power Unit

Dick groaned.

"This tolerance business," he complained, "doesn't half make life complicated. Why can't people make things *exact*?"

"Because it's impossible," replied Smithy. "What you have to do is make things to tolerances which are sufficiently tight for the job in hand."

"I suppose," grumbled Dick, "that tolerances are just one of those things I must learn to put up with."

"Since everyone else in any other branch of engineering," commented Smithy sarcastically, "has to work with tolerances, it would seem reasonable for you to join in as well. I assume, incidentally, that you won't need any help in working out the correct value for this meter shunt you're making up?"

Dick's jaw dropped.

"How on earth?" he gasped incredulously, "did you know I was making up a meter shunt?"

"You don't need," grinned Smithy, "to be a Sherlock Holmes to work *that* one out. Whenever anyone starts nattering about resistance wire, it's a 99.8 to 100% chance that he's going to make up a meter shunt!"

"I can see," said Dick quickly, "that even *that* chance has a ±0·1% tolerance on it!"

Smithy chuckled, and leaned back lazily against his bench.

Both he and Dick were spending a relaxed half-hour before leaving the Workshop for the evening. They had managed to clear all receivers which were in for repair, and had now assumed the postures of men who had worked well and who were very well aware they had worked well. Smithy squatted comfortably on his stool, tilting it negligently backwards towards his bench. Dis-

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daining the conventional, his youthful assistant had perched himself on the surface of his bench, taking up an attitude reminiscent of the Lotus Position in Yoga. There had been no squabbles during the day to disrupt the harmony of Workshop operations, and the pair were now in complete *rapport*.

"Are you," asked Smithy, returning to the resistance wire theme, "knocking up a multi-testmeter, or something like that?"

"Nothing so complicated," replied Dick. "I'm just finishing off a little power supply unit I've made up in my bedroom at home."

"In your bedroom?"

"There's nowhere else in the house," replied Dick mournfully, "where they'll let me do any experimenting. Anyway, all this power unit consists of is a mains transformer giving two lots of 6.3 volts and 250–0–250 volts at 70mA, together with a rectifier, a choke and a double electrolytic. I'll be using this power pack to run a few odd bits of valve equipment I'm dreaming up, and I'll be fitting a meter to it to read h.t. current and voltage."

"Hmm," commented Smithy. "All this seems nice and straightforward."

Dick fished a sheaf of papers out of an inside pocket, selected a sheet, and tossed it over to the Serviceman.

"There you are," he announced. "That's the circuit. Dead simple, isn't it?"

Smithy unfolded the paper and examined the circuit carefully. (Fig. 1.)

"Very good," he remarked. "Your meter switching is quite neat, too. On one switch position, the meter is connected across a 100mA shunt in the h.t. positive line. In the other switch position it's in series with a resistor which allows it to read h.t. voltage."

"That's right," agreed Dick. "Incidentally, I thought I'd do the current reading bit in the h.t. positive line rather than the h.t. negative line for several reasons. If I'd put the shunt in the h.t. negative line I would have had to make the power unit chassis connection to one side of it. A chassis connection at the output terminal side of the shunt (Fig. 2 (*a*)) would mean that the can of the double electrolytic in the power unit would need insulating from chassis. At the same time, a chassis connection on the transformer side (Fig. 2 (*b*)) would have meant that the power unit chassis wouldn't have been common with the h.t. negative output terminal nor, as a result, with the chassis of any gear I connected it up to. So

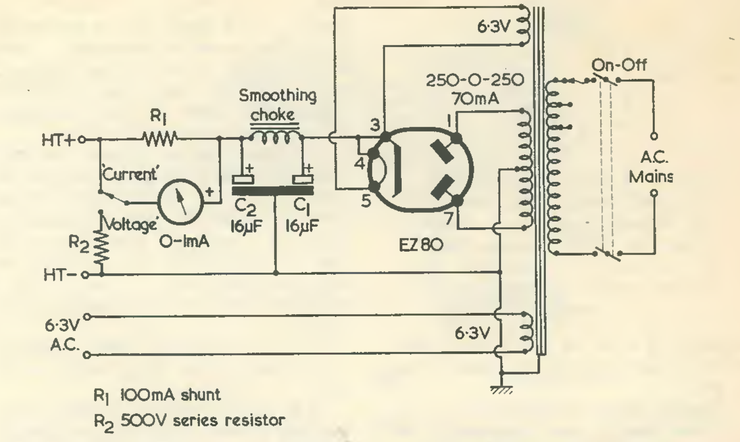

Fig. 1. The circuit of Dick's power supply unit. C_1 and C_2 are in a single can

it seemed easier in the long run to put the shunt in the h.t. positive line instead."

"Very sensible," pronounced Smithy approvingly. "I can see that you've given some consideration to this little power pack of yours."

"I'm not," said Dick modestly, "just a pretty face, you know."

"Perhaps not," replied Smithy hurriedly. "Anyway, what is the full-scale deflection of your meter?"

"It's a 0–1mA movement," said Dick, "with an internal resistance of 75Ω. It's one of those surplus 2½ inch jobs which still seem to be knocking around these days."

"Fair enough," said Smithy. "Have you worked out the value of the shunt?"

"Of course," said Dick proudly, as he ruffled through the sheaf of papers he had extracted from his pocket. "I started off by assuming that, with the shunt, I wanted the meter to give a full-scale deflection of 100mA. (Fig. 3.) This meant that 1mA would flow through the meter and 99mA would flow through the shunt. So the shunt resistance needed to be one ninety-ninth of the meter resistance, or $75 \times \frac{1}{99}$ ohms. And you don't need to be Einstein to find that that comes to 7.58Ω!"

"I would jolly well think you shouldn't," snorted Smithy, who had been scribbling out a quick calculation. "Especially when the correct answer is 0.758Ω!"

"Well, I'm dashed," said Dick mildly. "Come to think of it, my answer must have had something queer about it. I'd have needed a

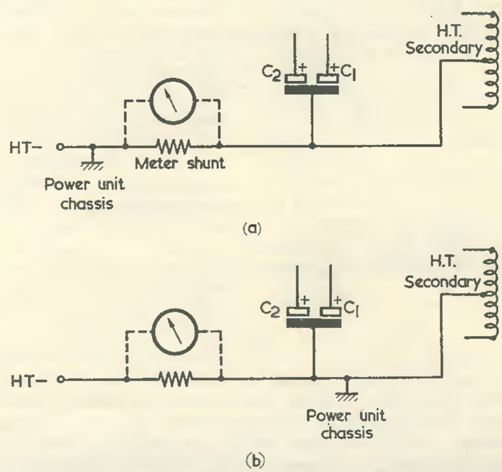

Fig. 2 (a). If the current-reading meter shunt is inserted in the h.t. negative line as shown here, the negative connection to C_1C_2 is not at chassis potential (b). Shifting the chassis connection to the transformer side of the shunt results in the h.t. negative output terminal not being at chassis potential

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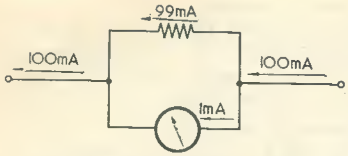

Fig. 3. A shunt which converts a 0–1mA meter to give an f.s.d. of 100mA must pass 99mA when the meter passes 1mA. Its resistance is, therefore, $\frac{1}{99}$ of the internal resistance of the meter

dickens of a lot of that Eureka wire to have made up the resistance value *I* got!"

Smithy raised an eyebrow.

"You don't," he commented reprovingly, "seem particularly worried about your calculation being wrong."

"Why should I be?" replied Dick airily. "It was only the decimal point in the wrong position. That can happen to anyone!"

Making a Shunt

"I should hate," said Smithy, "to think of you attempting any *real* design work. Anyway, hadn't you better start working out the length of resistance wire you need for the shunt?"

"I'm beginning to wonder whether it will be O.K. to work to wire length," said Dick with a frown, as an earlier cause of annoyance came to his mind. "Don't forget you told me just now that the resistance figures per yard for the resistance wire are only nominal anyway."

"Nominal or not," said Smithy, "they're more than good enough for your power unit application. I must admit, though, that in this particular instance I wouldn't bother to work out the length of wire required to any great accuracy. I'd use quite a different approach for making up the shunt."

"That," remarked Dick, "sounds interesting. How would you tackle it?"

"I'd begin," replied Smithy, "by making a very approximate calculation for the length of wire required. Let's assume we're going to use the 22 s.w.g. wire, which has a nominal resistance of 1.13Ω per yard. The present shunt requires 0.758Ω, which is a little less than three-quarters of 1.13Ω. So I'd start off by cutting myself three-quarters of a yard of the resistance wire with some four inches or so spare."

"Which," chimed in Dick, "would come to 31 inches."

"Right," confirmed Smithy. "I'd then pass a current through this wire with a standard meter in series, if possible adjusting the current by a variable series resistor so that the standard meter reads a nice round value near f.s.d. (Fig. 4 (*a*).) You could obtain this current from the power unit itself, but its maximum transformer rating of 70mA means that you'd have to choose a current which didn't exceed this value. The next process would consist of connecting one terminal of your 0–1mA meter to one end of the resistance wire, and sliding a flexible lead from the other terminal up and down the resistance wire at the other end. (Fig. 4 (*b*).) When the 0–1mA meter gave a reading corresponding to that in the standard meter, say 0.6mA to correspond with 60mA, then you'd know that the length of resistance wire across which the meter was connected was exactly that needed for the 100mA shunt."

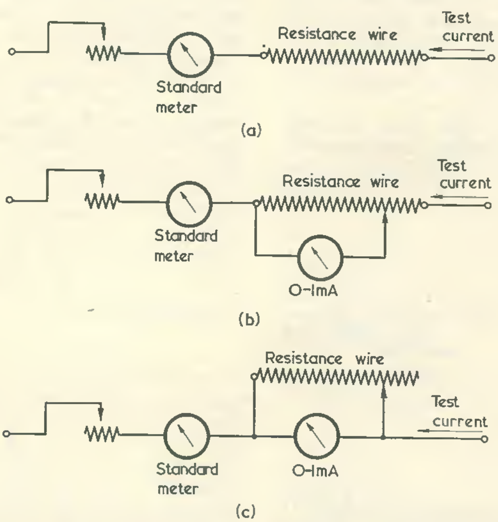

Fig. 4. Illustrating a simple method of finding the length of resistance wire required for a meter shunt. In (a) the variable resistor is set up such that a test current flows through the resistance wire, this being monitored by the standard meter. In (b) the meter to be shunted (shown here as a 0–1mA instrument) taps into the resistance wire. When the readings of the two meters agree, the correct amount of wire for the shunt has been tapped off. The alternative method of finding the requisite length of resistance wire illustrated in (c) is not recommended, as it may result in damage to the meter

"Blimey," said Dick, impressed. "That's a neat approach."

"I've used it on quite a few occasions," replied Smithy. "The main advantage is that there is no risk of damage to the meter movement because the heavy current always flows through the resistance wire. If you're going to find the length of resistance wire experimentally, the method I've described is a *far* safer idea than another that is occasionally advised, and which consists of applying the heavy current to the meter terminals with a variable length of shunt resistance wire across them. (Fig. 4 (*c*).) With such an approach, you only need a momentary open-circuit to the shunt resistance wire and the heavy current goes straight through the meter."

"Not," remarked Dick, "a very good way of tackling things."

"Indeed not," agreed Smithy. "Incidentally, finding the length of resistance wire you need with the aid of the actual meter with which it will be used offers a small but quite useful advantage. If the meter resistance varies a little from the value it's supposed to have, this error is automatically cancelled out."

"With your method," said Dick critically, "there is the disadvantage that you need a standard meter for comparison purposes."

"True enough," agreed Smithy. "But some sort of standard meter would also be desirable if you worked all the way through by calculations of resistance wire length. It would still be preferable to check the final result with another meter, if only to assure yourself that you'd got everything right. The standard meter I referred to would, normally, be a multi-testmeter which you knew to be reliable."

"I see," said Dick, "Well, having found the length of resistance wire

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needed, what's the next job?"

"Making up the shunt," replied Smithy. "Usually, this process will consist of winding the wire round a strip of Paxolin or something similar, and anchoring the ends at solder tags. (Fig. 5 (*a*).) Don't forget that the effective length of the resistance wire is that between the points at which the solder joints start. (Fig. 5 (*b*).) If you're aiming at a very high level of accuracy, it's a good plan to make this effective length very slightly longer than that you actually need. You can then 'trim' the shunt when it's finally mounted in position by extending the solder joint along the wire by the requisite amount. (Fig. 5 (*c*).) You do this, of course, whilst checking against the standard meter as before."

With these words, Smithy came to a stop. Surprised at a lack of audible response from his assistant the Serviceman glanced up, to see that Dick's face had become contorted in the scowl which signified that he was about to indulge in one of his occasional outbursts of doggerel. His heart sinking, Smithy prepared for the worst.

Suddenly Dick's face cleared.

"Here we are, Smithy," he announced proudly. "Just listen to this!

"*A serviceman living in Beckenham*
Makes meters read high without
wrecking 'em,
He's developed a stunt
Where the shunt bears the brunt
Of the current which flows when
he's checking 'em!"

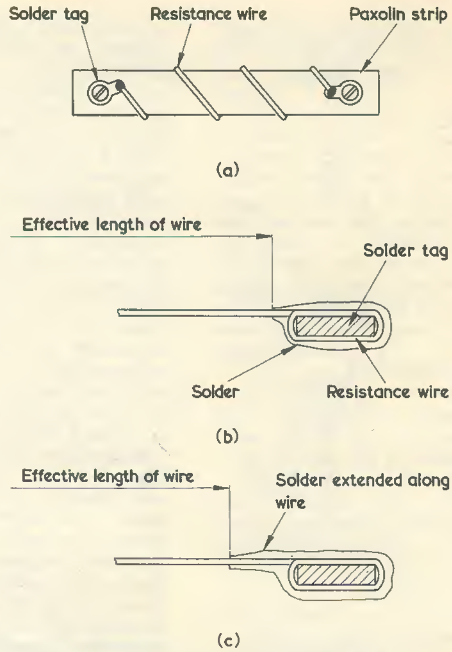

Fig. 5 (a). When the requisite length of resistance wire has been found, the shunt may be made up as shown here
(b). An enlarged cross-sectional view of one of the solder joints, illustrating that the effective length of the resistance wire extends only to the start of the solder in the joint
(c). Extending the solder from the joint along the wire reduces the effective length of the latter

Series Resistors

"Well," said Smithy after an embarrassed silence, "I can see you've achieved your old form once more."

"I'm glad you liked it," replied Dick, pleased. "It seems to be quite a long time since I last gave you one of my offerings."

"Perhaps," offered Smithy hopefully, "you're getting out of practice?"

Dick considered this question carefully.

"I don't think so," he remarked eventually. "At the same time, though, I mustn't let the old Muse get all rusty and clogged up. I think I'll try my hand at this sort of thing a little more often in the future."

"I can," commented Smithy, "hardly wait. In the meantime, I see that we've now cleared up the shunt resistor for the meter in your little power supply. What about the series resistor?"

"That's easy," said Dick promptly, as he consulted his sheaf of papers once more. "What I need there is a 1% high-stability resistor having a value of 499,925Ω!"

"You're in luck," said Smithy, with heavy irony. "It was only last week that I got in a box of resistors with just that particular value and tolerance."

"That's great," said Dick enthusiastically, taking out a pen and ticking off an item on his papers with a flourish. "If I can scrounge one of those resistors off you, then, Smithy, I can get my power pack finally completed tonight."

Smithy swallowed.

"Tell me first," he asked gently, "how you arrived at that resistance figure."

"That's easy," replied Dick. "I want the meter to read 500 volts full-scale and, since it is a 0–1mA movement, I need to connect a resistor in series with it which causes 1mA to flow when 500 volts is applied." (Fig. 6.)

"So?"

"Well," continued Dick. "A current of 1mA flows in 500kΩ when 500 volts is applied. So the series resistor will be 500kΩ minus the 75Ω internal resistance of the meter."

"And that," queried Smithy, "is 499,925Ω?"

"Isn't it?"

"Of course it is."

"Well," said Dick confidently, "there we are then."

"You thundering twit," exploded Smithy. "Where the dickens are you going to find a resistor like that? You said a tolerance of 1%, which means plus or minus 5kΩ out of 500kΩ. So, if you state a tolerance of 1%, all you need is any resistor whose actual value lies between 495 and 505kΩ."

"What about the 75Ω resistance in the meter?"

"When compared," snorted Smithy, "with resistances of the order of 500kΩ, 75Ω is just a flea-

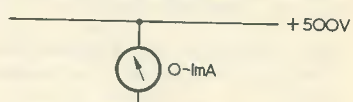

Fig. 6. Fitting a series resistor to enable a 0–1mA meter to read 500 volts full-scale

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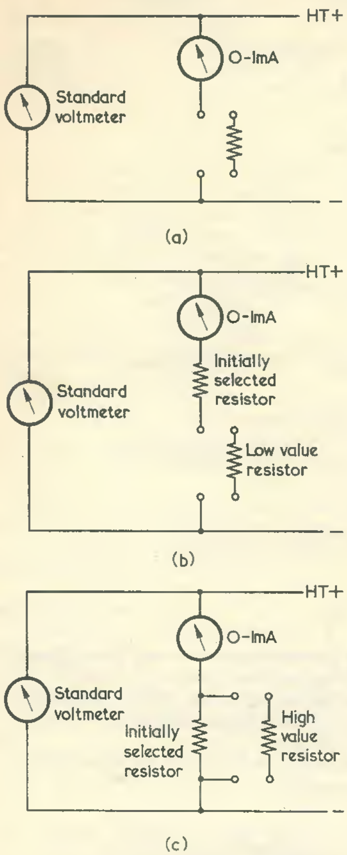

Fig. 7. Obtaining a suitable value of series resistor with low tolerance components. In (a) different resistors are experimentally connected in series with the 0–1mA meter until one is found which makes it read slightly high. Then, in (b), low value resistors are experimentally connected as shown to bring the meter reading finally correct. An alternative approach, when the required series resistor is low in value, is to find an initial value which makes the 0–1mA meter read slightly low, (c), then apply high value resistors across that initially selected

bite. 500kΩ at 1% will be more than adequate for your particular application."

"Well, can I scrounge one of those, then?"

"I'm afraid," said Smithy ungraciously, "you've had it. The resistors I keep in stock are preferred values which are intended for repairing radios and TV's, and they don't include 500kΩ at 1%!"

"Then how," wailed Dick, "am I going to get this power unit of mine finished?"

"You can always," suggested Smithy, "buy the resistor."

"What," exclaimed Dick, aghast. "*Buy* a resistor? When I work in a servicing shop!"

"I can see," said Smithy resignedly, "that you're quite definitely a product of the New Morality. Anyway, it shouldn't be too hard to fix you up from my resistor stock, even if it doesn't include 500kΩ at 1%. All that's required is to find any low tolerance high-stability resistor that's near to the value you want and trim it up a bit."

"Trim it up?"

"That's right," confirmed Smithy. "What I would do, in the present case, is to start off by connecting up a standard voltmeter across the meter and series resistor points in your power pack, and then trying a few low tolerance 470kΩ resistors in the series resistor position. (Fig. 7 (*a*).) If you're lucky you may even find a 470kΩ resistor which gives you a reading in the meter corresponding almost exactly with that in the standard voltmeter, whereupon all you do is to wire that particular resistor permanently into circuit and all your troubles are over. It is much more probable, however, that you'll be unlucky, whereupon you select a 470kΩ resistor which is just a little too low in value, so that the reading in your meter is just a wee bit high. All you then have to do is find a low value resistor which you can pop in series with the first one to bring the meter reading right. (Fig. 7 (*b*).) The low value resistor will probably be in the region of 1kΩ to 33kΩ and, provided you have a reasonable stock of such resistors on hand to choose from, you should be able to get a meter reading which agrees almost exactly with that shown by the standard voltmeter. It will be easy to select the second resistor because quite large relative changes in value here will correspond to low changes in meter reading. For instance, changing from a 10kΩ to a 15kΩ resistor will cause the meter reading to shift by about 1% only."

"That's quite a snazzy idea," remarked Dick appreciatively. "So far as I can see, the only disadvantage is that you have to fit two resistors into circuit instead of one."

"That's right," confirmed Smithy. "I've used this approach myself on stacks of occasions in the past when I couldn't get hold of close tolerance resistors. Incidentally, if the series meter resistance you require is fairly low, say around 500Ω or less, you want to try a different method. In this case you commence by finding a resistor which is a wee bit too *high* in value. You then trim it down by putting high value resistors *across* it (Fig. 7 (*c*)) starting from around 1MΩ or so and working down. You'll again find that quite a high relative change in value in the second resistor results in a small change in meter deflection whereupon, provided you have a reasonable stock of high value resistors to choose from, you should be able to obtain a final value of combined series resistor which is just about spot-on."

"That's fine," said Dick enthusiastically. "Can you let me have a few assorted resistors to take home tonight Smithy?"

"All right," agreed the Serviceman, "but you *must* bring them all back again in the morning."

"Except two?"

"Except two," conceded Smithy.

Dick's grin of pleasure was suddenly transformed, for the second time that afternoon, into the agonised grimace which accompanied the labours of metrical composition. Helplessly, Smithy waited until the attack passed over. After some moments, Dick's features relaxed.

"Now, how," he remarked grandly, "about this?"

"*That serviceman's moved now to*
Twickenham,
And makes voltmeters using a
minimum
Of close tolerance R's;
He don't need them, because
He combines 20 percenters to
stick in 'em!"

There was silence as the last echoes died away.

"That last line," commented Smithy dispassionately, "doesn't even scan."

"What d'you mean, doesn't scan?"

"It doesn't," explained Smithy, "agree with the rules of metre."

"I wouldn't know about that," commented Dick cheerfully, "I leave all that sort of thing to the professionals, like Patience Strong and John Betjeman. So long as the lines more or less rhyme at the ends they're good enough for me!"

Bypass Electrolytics

"Well, that," remarked Smithy, hastily changing the conversation, "seems to have buttoned up your little power unit. There's one thing that worries me about it, though."

"Oh yes," said Dick, "and what's that?"

"The question of limiting resistance for the rectifier. It's one of those things that so many home-constructors seem to forget about."

"You mean," queried Dick, "en-

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suring that there is sufficient resistance in each rectifier anode circuit to meet the valve manufacturer's requirements?"

"That's right."

"In that case," said Dick condescendingly, "I can set your mind at complete rest. I've been following the recent 'Understanding Radio' articles, which have been all about things like rectifier limiter resistors,* and I'm not so big-headed as to refuse to pick up a few points from some other geyser in the electronics game!"

"You're not so *what*?" spluttered Smithy.

"So big-headed."

"Blimey," gasped the Serviceman, "and it was only two months ago that you were going around upsetting G. A. French. What I can't understand is why, at that last statement of yours, the heavens didn't open up and a great streak of forked lightning come down and hit you on the bonce!"

"I can't see," said Dick carelessly, "what you're making all the fuss about. Anyway, since the rectifier anodes need a limiting resistance I checked up in the valve book. I'm using an EZ80 which, with 250–0–250 volts applied, requires minimum limiting resistances in each anode of 125Ω when the reservoir capacitor is 50μF. I measured the resistance of each half of the mains transformer h.t. secondary and these came to slightly more than 200Ω. So the effective limiting resistance in each rectifier anode must be well above the minimum of 125Ω. Also, I'm using a 16μF electrolytic instead of a 50μF component, so that makes things easier still."

"Fair enough," commented Smithy. "Although I shouldn't look upon the reduction in reservoir capacitance as necessarily arguing that limiting resistance may be reduced below the valve-manufacturer's minimum figures. One thing the limiter resistor does is to keep the current down if you switch on with the rectifier cathode hot, and at a time when the mains voltage is at a peak and the reservoir capacitor is discharged. Under these conditions, even the 16μF electrolytic will still act more or less as a dead short at the instant of switching on. The same applies also, of course, to any limiting resistor values quoted for silicon and selenium rectifiers, with the exception that these don't *require* a hot cathode to operate."

But Smithy's words fell on deaf ears, and Dick offered no reply when the Serviceman finished.

"What's up?" asked Smithy.

"There's something," said Dick pensively, "which has just occurred to me. I think I'll have to change that meter switching circuit."

"What on earth for?" asked Smithy. "It seems perfectly good to me."

"There's a snag in it," pronounced Dick. "The meter shunt resistance appears between the smoothing electrolytic and the h.t. positive terminal. This means that the h.t. lines to equipment run from the supply won't be as well bypassed as they would be if the smoothing electrolytic connected directly to the h.t. positive terminal."

"You've got a minor point there," admitted Smithy. "But I shouldn't worry too much about it, if I were you."

"Why not?"

"Because," explained Smithy, "if your power unit is going to supply any equipment which needs a well bypassed h.t. supply, I'd strongly advise you to fit another electrolytic across the h.t. lines on the equipment chassis itself."

"What's the reason for that?"

"You're bound," said Smithy in reply, "to have fairly long leads between the equipment and the power supply, and these will act as a common impedance to all h.t. circuits in your equipment, with a consequent risk of instability. It's almost always desirable to use short wiring to any h.t. bypass capacitor. So far as this particular problem is concerned, what I've usually done in the past, when making up a power unit of the type you've got here, is to omit the smoothing capacitor altogether. I've then fitted h.t. bypass electrolytics in all the pieces of equipment which are intended to connect to the supply, whereupon these also act as smoothing capacitors."

"That's a neat idea," commented Dick. "I wish I'd used it with my own power unit now. The trouble is that I can't take out the smoothing capacitor because it's in a double electrolytic with the reservoir capacitor."

"Not to worry," replied Smithy soothingly. "Every microfarad on the h.t. line makes the ripple smoother!"

Time To Go

"There's another thought that's occurred to me," said Dick, who seemed to have entered into a mood of despondency. "I haven't made any provision for discharging the electrolytics in the power pack when there's no equipment connected to it. You can get some nasty shocks from charged electrolytics, you know!"

"You've forgotten something."

"Have I?"

"You've forgotten," said Smithy, "your built-in voltmeter circuit. If the electrolytics in the power pack are charged up, and no external equipment is connected, all you've got to do is to switch in the voltmeter. You can then sit down and watch its needle go slowly down to zero as it bleeds the charge off the electrolytics."

"Of course I can," exclaimed Dick, reverting to his usual optimistic self. "I'd forgotten all about the voltmeter circuit."

He paused for a moment.

"Oh no," said Smithy, watching his assistant with the helpless fascination of a rabbit before a snake, "not *again*!"

But it was too late.

"*Our serviceman's fees are essentially*
The lowest you'll find, confidentially.
Since all his voltmeters
Work also as bleeders,
His charges reduce exponentially!"

Despite himself, Smithy couldn't help but grin at his assistant's latest excursion on the sea of verse.

"All right, boy," he chuckled. "I'll allow that that one wasn't *quite* as corny as the previous ones."

"*All* my stuff," pronounced Dick, with the air of Royalty unbending graciously to accept a small favour, "is good. Even though middle-aged Philistines such as yourself may not always understand its greater depths!"

Whereupon Smithy's assistant, seeing from the Workshop clock that it was time to leave for the day, and forgetting all about the resistors he had intended to borrow, nipped smartly through the door, leaving a wrathful Serviceman to switch off and lock up.

But Smithy's indignation soon changed into more purposeful contemplation as, later, he drove home in his car. If, he meditated, the gods that be couldn't get organised on that business of opening up the heavens for the streak of forked lightning, perhaps a little mortal assistance might not come amiss. Mentally considering the number of kilovolts he could conjure up from his stock of line output transformers, together with their possible effect on his assistant, Smithy the Serviceman drove happily away into the gentle May evening.

* See "Understanding Radio" in the February and March issues.—EDITOR.

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The Use of Heat Sinks with Power Transistors

A. FOORD, Grad. I.E.R.E.

How to calculate heat sink dimensions

FOR ALMOST EVERY TRANSISTOR THE MANUfacturer specifies a maximum junction temperature which must not be exceeded under normal operating conditions. This temperature is denoted by the symbol $T_{j\ max}$. For a silicon transistor this may be of the order of 150°C, and for a germanium transistor about 90°C.

Thermal Equilibrium

The heat generated inside a transistor is conducted away to the case and absorbed by the surroundings. When the transistor is operated continuously the device must reach a thermal equilibrium with its immediate surroundings; with the result that the collector junction remains at a steady temperature above the ambient value. Since almost all the internal heat dissipation is at the collector junction, power transistors have the collector in contact with the mounting base. Thus, conduction of heat from the semiconductor wafer to the case takes place over a large cross-section. By attaching a cooling fin to the case, or by mounting the case on a heat sink, the effective surface area is increased. This gives a considerable improvement on the speed of heat transfer to the air.

Where no potential exists on the heat sink which might affect the collector voltage, the transistor is bolted directly to the heat sink. In other instances the transistor is isolated electrically from the heat sink by means of a mica washer and two bushes. Since this washer is thin, there is very little resistance to the flow of heat. If possible, it is better to isolate the heat sink electrically from the chassis and mount the transistor directly on the heat sink, since this gives the least possible thermal resistance from the transistor mounting base to the sink.

Thermal Resistance

From the junction to the air we have a temperature gradient, this extending from junction temperature (say 90°C) to air temperature (say 25°C). The temperature gradient is shown in Fig. 1, and it will be noted that we have a temperature drop from the junction to the mounting base, from the base to the heat sink, and from the sink to the air.

The terms "air temperature" and "ambient temperature" are used as synonyms, although for equipment working in a confined space ambient temperature may be 45°C and not the 25°C normally associated with air temperature. Ambient temperature simply means the temperature of the air surrounding the heat sink. The various temperature gradients will depend on the power dissipated in the transistor, and are given as thermal resistances in degrees per watt. The symbols used for the various thermal resistances are given in Fig. 1.

Example 1

To take an example, let us suppose that the maximum rated junction temperature of a transistor is 90°C. The thermal resistance from the junction to the mounting base is quoted as 1.5°C per W. If we wish to dissipate 10W, what is the maximum temperature we can allow the mounting base to attain?

Then: $T_{jmax}=90°C$, $P_{tot}=10W$
$\theta_m=1.5°C/W$, $T_{case}=?$

If we dissipate 10W, the temperature drop from the junction to the mounting base is given by:

$$T_{jmax}-T_{case}=P_{tot}\times\theta_m$$
$$90-T_{case}=10\times1.5$$
$$T_{case}=90-15$$
$$T_{case}=75°C$$

We must, therefore, keep the mounting base temperature below 75°C.

In this example we saw how to work out the mounting base temperature for a given power dissipation and junction thermal resistance. If we wish to work out the heat sink temperature we can deal with θ_i by adding it on to θ_m in our calculations.

If a mica washer is employed θi is, typically, equal to 0.5°C/W and, with a lead washer, to 0.2°C/W. A lead washer is sometimes used between the transistor case and the heat sink since it moulds itself to the contours of the two surfaces and causes good thermal contact between them. With a mica washer the transistor mounting base is sometimes smeared with high thermal conductivity silicone grease before mounting in order to minimise any air gaps due to surface irregularities.

Up to now we have considered the thermal resistance to the case, and the thermal resistance

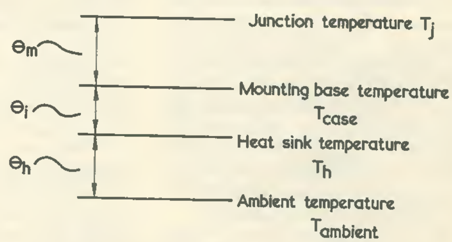

Fig. 1. The thermal resistances associated with a power transistor

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of the lead or mica washer (if used). These two values are fixed by the manufacturer, and are beyond our control. We therefore only have control over one part of the system—the heat sink or cooling fin.

Heat Sink Design for Natural Air Cooling

The thermal resistance of a flat heat sink or fin supported in free air depends on its thickness, shape, orientation, surface area, temperature, material, nature of its surface, and the temperature of the cooling air. The curve given in Fig. 2 may be used to determine the fin area required for a given value of θ_h.[1] This curve applies under the following conditions:

(1) The fin is vertically mounted.
(2) It is made of bright aluminium or copper $\frac{1}{16}$in. thick or thicker.
(3) The ratio of length to breadth should be less than 2:1.
(4) The hottest point is at least 25°C above the surrounding air temperature.
(5) The transistor is mounted near the centre of the fin.

In the curve the heat dissipated due to radiation is neglected since the surface is assumed to be bright. If appreciable radiation occurs, the fin area can be reduced. For a single fin with a matt black surface, the area can be reduced to 0.7 times the value calculated from Fig. 2.

Our heat sink must, then, have a thermal resistance given by:

$$\theta_h = \frac{T_{case} - T_{ambient}}{P_{tot}} - \theta_i \text{ °C/W}$$

or, if we work from the heat sink temperature, then:

$$\theta_h = \frac{T_h - T_{ambient}}{P_{tot}} \text{ °C/W}$$

If we work directly from the junction temperature, we have:

$$\theta = \frac{T_{j\,max} - T_{ambient}}{P_{tot}} \text{ °C/W}$$

where θ is the total thermal resistance from the junction to air, and is given by:

$$\theta = \theta_m + \theta_j + \theta_h$$

Thus:

$$\theta_h = \frac{T_{j\,max} - T_{ambient}}{P_{tot}} - \theta_m - \theta_j \text{ °C/W}$$

Example 2

If $T_{j\,max} = 90$°C, $\theta_h = 2.2$°C/W, $P_{tot} = 10$W, $\theta_i = 0.5$°C/W, $\theta_m = 1.5$°C/W,

Calculate T_{case}, T_h and $T_{ambient}$.[2]

From the junction to the case the temperature drops by:

$$T_{j\,max} - T_{case} = P_{tot} \times \theta_m$$
$$T_{case} = T_j - P_{tot} \times \theta_m$$
$$= 90 - 10 \times 1.5$$
$$T_{case} = 75\text{°C}.$$

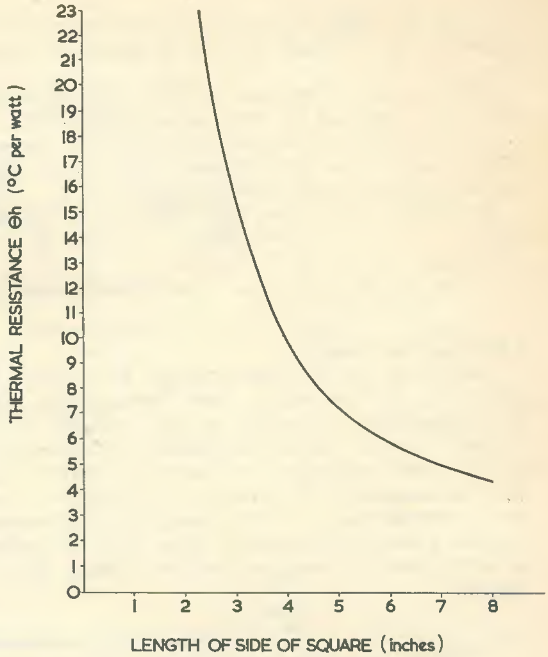

Fig. 2. *Heat sink sizes for various thermal resistances of a fin. (Courtesy Electric Valve and Semiconductor Manufacturers Association)*

From the case to the heat sink the temperature drops by:

$$T_{case} - T_h = P_{tot} \times \theta_i$$
$$T_h = T_{case} - P_{tot} \times \theta_i$$
$$T_h = 75 - 10 \times 0.5$$
$$T_h = 70\text{°C}.$$

Similarly:

$$T_{ambient} = 70 - 10 \times 2.2$$
$$T_{ambient} = 48\text{°C}.$$

Example 3

If $T_{j\,max} = 90$°C, $\theta_i = 0.5$°C/W, $P_{tot} = 5$W, $\theta_m = 1.5$°C/W, $T_{ambient} = 25$°C, what is the minimum size of heat sink required? If it were painted matt black, what size would it need to be?

Now:

$$\theta_h = \frac{T_{j\,max} - T_{ambient}}{P_{tot}} - \theta_m - \theta_i$$
$$= \frac{90 - 25}{5} - 1.5 - 0.5$$
$$\theta_h = 11\text{°C/W}.$$

[1] This curve is taken from the booklet *The Use of Semiconductor Devices*, published by the Electronic Valve and Semiconductor Manufacturers' Association. Acknowledgements are due to the Association for permission to reproduce the curve here.—EDITOR.

[2] The value for θ_h chosen for this example (2.2°C/W) is a little lower than the range covered by the curve of Fig. 2, which indicates heat sink dimensions that may under normal conditions be *safely* applied. The figure of 2.2°C/W is quoted by Mullard, in their literature on the OC28 series, as the θ_h for an air-cooled heat sink of 7 x 7 x $\frac{1}{16}$in made of blackened aluminium.—EDITOR.

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From the curve of Fig. 2 we may then see that this gives us a length of side of square of about 4in.

We thus have a heat sink of minimum area about 16 sq. in. This can be made up as (say) 4 x 4in. or 5.3 x 3in. We cannot use a fin 2 x 8in. because this would violate one of the conditions we must work to if we use the curve.

If we use a fin painted matt black on both sides, then:

fin area=16 x 0.7=11.2 sq. in.

A matt black fin 3 x 4in. would thus be suitable.

Checking the Design

The design for the heat sink can be checked by measuring the mounting base temperature with the equipment operating at the required total dissipation and maximum ambient temperature. From these readings the junction temperature can be calculated (provided θ_m is known from the data sheets). If the junction temperature is greater than the permitted value, then the design is unsatisfactory, and the heat sink must be improved.

Example 4

If $P_{tot}=5W$, $T_{case}=60°C$

$\theta_m=3°C/W$,

are we within the specified $T_{j\ max}$ of 90°C?

Then:

$$T_{j\ max}-T_{case}=P_{tot} \times \theta_m$$

$$T_{j\ max}=P_{tot} \times \theta_m + T_{case}$$

$$=3 \times 5+60$$

$$T_j=75°C.$$

The design is, therefore, well within the rating.

Conclusion

Although this article has shown how to determine the size of heat sink required for a particular application the method should be treated only as an accurate guide. It should be remembered, also, that Fig. 2 only applies under specified conditions. In practice it may be necessary to fold the heat sink, or use more than one fin. If conditions depart from those recommended, the results provided by Fig. 2 must be modified to suit the application. In any case it is always advisable to check the results and, wherever possible, keep the junction temperature as far below the maximum permitted temperature as possible.

RADIO TOPICS . . .

by Recorder

One of the minor difficulties which beset audio enthusiasts is the problem of coupling the sound channel of a mains-operated television receiver to a high fidelity amplifier or to a tape recorder. The reason for the difficulty is that, whereas the high fidelity amplifier or tape recorder chassis are fully isolated from the mains supply, that of the television receiver is not. Practically all the exposed metalwork on high fidelity equipment is at chassis potential and, because of the mains isolation, offers no shock hazard at all. On the other hand, television chassis are connected to one side of the mains supply and must not, under domestic conditions, be touched at all.

Isolation by Capacitors

How, then, can the sound channel of a television receiver be safely coupled to the input of a high fidelity amplifier? It might at first sight be thought that the coupling could be made by means of isolating capacitors as shown in my accompanying diagram, Fig. 1 (*a*). In this, the television receiver is connected to the mains supply such that its chassis is at neutral potential. An a.f. signal is taken, for the purpose of illustration, from the sound detector load, and it is assumed that the high fidelity amplifier chassis is at earth potential. But there is a hidden snag in this arrangement. The neutral line of the mains supply is rarely at true earth potential, and it normally carries a volt or so with respect to earth. For instance, in my own house at the moment (I've just got out the testmeter to check it!) the a.c. potential between the neutral line and earth is 0.7 volts.

This small alternating voltage appears across C_2 in Fig. 1 (*a*), whereupon this component can be replaced by a generator offering the same voltage, as in Fig. 1 (*b*). The result is that the voltage applied to the high fidelity amplifier input is the sum of the signal voltage plus the alternating voltage between the neutral side of the mains and earth, and reproduction from the hi-fi loudspeaker will be marred by a continuous, and probably very loud, hum. If, due to incorrect connection to the mains, the television chassis assumes live mains potential, the generator of Fig. 1 (*b*) will be churning out some 240 volts a.c., and there will then be a prodigious hum, to say the least, from the hi-fi amplifier!

Even if the hi-fi amplifier chassis is not connected directly to earth, the hum problem will still exist. This is because the hi-fi chassis will be coupled capacitively to the mains via stray capacitances in its mains transformer and any anti-mains-modulation capacitors which may be fitted, and will then take up an a.c. potential relative to earth which will almost inevitably be different from that on the TV chassis. Increasing the value of C_2 doesn't provide an answer under these conditions, either. For safety reasons, the sum of C_1 and C_2 should not be allowed to exceed 0.02μF.

Isolation by Transformers

Isolation between the two chassis by way of capacitors offers, therefore, no help at all towards solving the present problem. The only other simple means of isolation is by way of transformers and here, fortunately, there are two very simple solutions to the problem. One of these solutions, the cheaper, has the disadvantage that the circuitry involved is not *quite* hi-fi. The other allows full hi-fi techniques to be followed but at much greater expense.

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Fig. 2 (*a*) shows how an isolating transformer may be coupled to the existing output transformer in the receiver, the secondary of the added transformer coupling to the high fidelity equipment. The isolating transformer is a special type which is specifically designed to offer full isolation, at mains voltages, between its primary and secondary. Two transformers in this category are manufactured by Radiospares Ltd., and I must hasten to add that they can *only* be obtained through radio retailers. Radiospares do not supply components direct to members of the public.

The two Radiospares transformers are known as the "Universal" Speaker Isolating Transformer and the "Midget" Speaker Isolating Transformer. As a guide to prospective purchasers these transformers are available from Home Radio (Mitcham) Ltd. under Cat. No. T070 for the "Universal" and Cat. No. T071 for the "Midget". Alternatively, you can obtain them from your own local component supplier.

The main function of these transformers is to isolate extension loudspeakers or headphones when employed with live chassis radio and television receivers. They may also be used to provide isolated feeds for tape recorders and the like. The "Universal" has the further advantage of being able to match loudspeakers to various impedances. Both transformers are flash-tested at 2,000 volts a.c., and the insulation between primary and secondary is completely adequate for mains isolation. The "Universal" measures 2.12in wide by 1.87in high by 1.62in deep, and has fixing centres at 2.5in. Both the primary and secondary are tapped at 3, 7 and 15Ω to provide any particular speaker matching which may be required. The transformer has a "snap-on" cover to guard the terminals when mounted in accessible positions, and its power rating is 5 watts maximum. The "Midget" is a smaller and more inexpensive component which is intended to give a 1:1 ratio for 3Ω speakers (although good results are claimed up to 15Ω). It is 1.75in wide by 1.5in high by 1.18in deep, the fixing centres being at 2.12in.

Either of these transformers could be employed in the Fig. 2 (*a*) circuit. A better idea, in which either transformer could also be used, is shown in Fig. 2 (*b*). In this diagram, an internal switch fitted to the television receiver changes the secondary of the speaker transformer from the internal speaker to

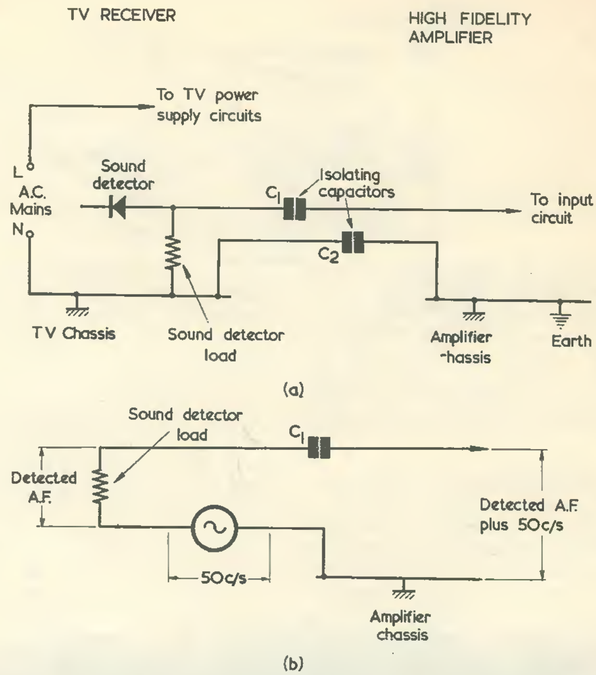

Fig. 1 (a). An unsatisfactory method of attempting to couple the sound channel of a mains-operated television receiver to a high fidelity amplifier. To assist the explanation, unscreened cable is shown between the two chassis (b). A small a.c. voltage appears between the two chassis in (a), and becomes added to the detected a.f. voltage fed to the amplifier

the isolating transformer, the secondary of the latter being loaded with a fixed resistor. Assuming a 1:1 ratio in the isolating transformer, the fixed resistor has the same value as the loudspeaker impedance.

The switch wiring of Fig. 2 (*b*) should be inside the television cabinet so that none of the connection points can be inadvertently touched, and it will probably be found that the switch, itself, may be readily mounted on the back cover of the TV set. A rotary type with insulated knob is preferable. High a.f. voltages can be developed across the primary of a valve speaker transformer if its secondary is unloaded, whereupon the switch should, ideally, be of the make-before-break type. However, the ordinary type of switch should suffice in practice if the output transformer is not carrying high level signals at the moment of switching over.

The circuits of Fig. 2 represent the instance I mentioned earlier where the circuitry is not *quite* hi-fi. This is because the detected sound signal has to pass through the a.f. stages of the receiver, which are almost certain to include a single-ended output pentode, and two transformers. Fig. 2 (*a*) is a little worse than Fig. 2 (*b*) because the output valve load is a loudspeaker whose impedance will vary quite considerably with frequency. Nevertheless, if the volume control in the television receiver is kept at a low level (mainly to keep down distortion introduced in the receiver a.f. stages) reproduction over the hi-fi system should be quite acceptable and should be noticeably better than occurs with the TV receiver speaker on its own. If the output from the secondary of the isolating transformer is coupled to a tape recorder, the results obtained will, of course, be streets ahead of what is given by such artifices as placing the tape recorder microphone in front of the TV loudspeaker.

The voltage available across the secondary of the output transformer should be more than adequate for normal purposes. If, for instance, the TV volume control is set to produce an output of 50mW, this corresponds to nearly 0.4 volts across an impedance of 3Ω. The secondary of the isolation transformer could, therefore, be plugged direct into the "radio tuner" socket of any normal high fidelity amplifier. No trouble should be given by

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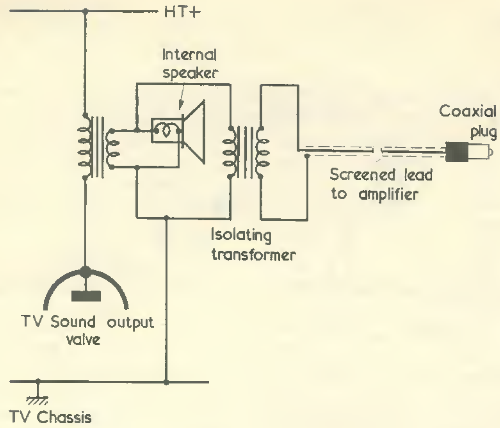
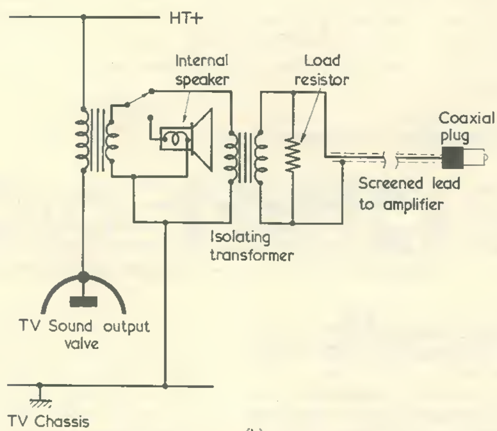


(a)



(b)

Fig. 2 (a). Incorporating an isolating transformer between the TV receiver and the amplifier
(b). An alternative way of using the isolating transformer. The load resistor should have a wattage rating equal to the output power of the output valve

feeding the "radio tuner" input of the amplifier from the very low source impedance offered by the isolation transformer.

These last comments assume that the TV volume level will be turned well down when coupling up to the hi-fi equipment. This should satisfy most instances likely to be encountered in practice, but it may occasionally be found that, with some TV sets, the level of background noise (hiss, "frame tick", etc.) relative to sound level increases at low volume control settings. If this occurs, a compromise setting of the TV volume control is needed which causes these background noises to be over-ridden by signal level, without the latter being too high to introduce excessive (by hi-fi standards) distortion.

Isolating the TV Set

The use of an isolating output transformer offers a safe, inexpensive, and very simple method of coupling a mains-operated TV set to high fidelity equipment. But it may not satisfy the seeker after perfection, who will want to take his output direct from the sound detector circuit in the television receiver. There is, however, one completely practicable answer for the perfectionist, and it consists of isolating the entire TV set!

A suitable component for carrying out this function is the Radiospares 200 Watt Mains Isolating Transformer, and I must once again state that this component can only be ordered through a retailer and *not* direct from Radiospares Ltd. This transformer is primarily intended to isolate a.c./d.c. equipment being serviced on the test bench, and its power rating of 200 watts is quite adequate for any conventional television receiver. The transformer has a 1:1 ratio and can handle the full rated load at any voltage in the range of 200 to 250. Its width is 4in, its height is 4.75in, its depth is 4.5in, and its fixing centres (four holes) are 3.5 by 3.31in. The weight is a good solid 12lb. As is to be expected, this transformer is considerably more expensive than the two output isolating transformers of Fig. 2, and readers contemplating its use should ascertain its cost before ordering. It offers, nevertheless, an extremely tidy solution to the problem of obtaining really high fidelity coupling from the sound channel of a mains operated TV set. The transformer is connected up between the mains supply and the TV receiver in the manner shown in Fig. 3.

One final point needs to be resolved. When the circuit of Fig. 3 is used, the constructor may find difficulty, even with the service manual of the TV receiver before him, in finding a suitable take-off point for the hi-fi amplifier input. This is because the television sound detector is normally followed by a sound interference limiter, whereupon the circuitry tends to become rather complicated. Further complexity is introduced if the TV receiver is a dual-standard model, in

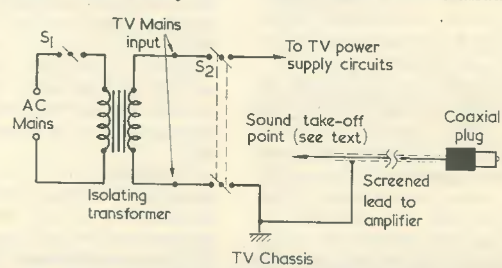


Fig. 3. Isolating the TV set. S_2 is the on-off switch installed in the television receiver, whilst S_1 is an external switch. The outer conductor of the screened cable now connects direct to the TV chassis

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which the 405–625 switching arrangements cause an output to be taken either from the 38.15 Mc/s a.m. detector on 405 lines, or the 6 Mc/s f.m. detector on 625 lines. Yet another pitfall for the unwary is that the input resistance of the amplifier should not cause the a.c./d.c. a.m. diode load ratio to be seriously upset. (For the record, the d.c. diode load is the resistor immediately following the a.m. detector, and the a.c. diode load is this resistor in parallel with any other resistors coupled to it by way of capacitors. The ratio should not be too far removed from unity if distortion on certain types of modulation is not to occur.)

Fortunately, these problems may all be overcome with nearly every type of TV set by the simple process of taking the detected a.f. from the slider of the television receiver volume control, as in Fig. 4. This should ensure that the take-off point is after the sound interference limiter *and* the 405–625 switching circuits. Also, provided that the television volume control is not advanced more than about one-third of full travel when the high fidelity equipment is connected, the input resistance at the "radio tuner" input socket of a conventional amplifier should not unduly upset the a.c./d.c. diode load ratio. Although unlikely in conventional TV receiver circuits, it is possible that a direct voltage may appear on the track of the volume control due to a.g.c. circuits and the like. If such a voltage is present, a 0.01μF capacitor may be inserted at the point marked with a cross in Fig. 4.

A.C./D.C. Receivers

Up to now we have concerned ourselves mainly with the problem of taking an a.f. output for high fidelity equipment from a TV receiver. The techniques used will also, of course, apply equally well to taking a similar output from an a.c./d.c. sound receiver. In this case, it should be possible to use a smaller and more inexpensive mains isolating transformer if a similar circuit to that of Fig. 3 is to be employed, and the Radiospares range includes a 75 Watt Mains Isolating Transformer which is ideal for this purpose. This has a 1:1 ratio and can operate at full load for input voltages from 200 to 250. The dimensions are 3.12in wide, 4in high, 3.80in deep, with fixing centres (four holes) at 2.62 x 2.5in. The weight is 5¾lb.

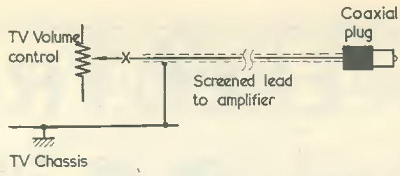


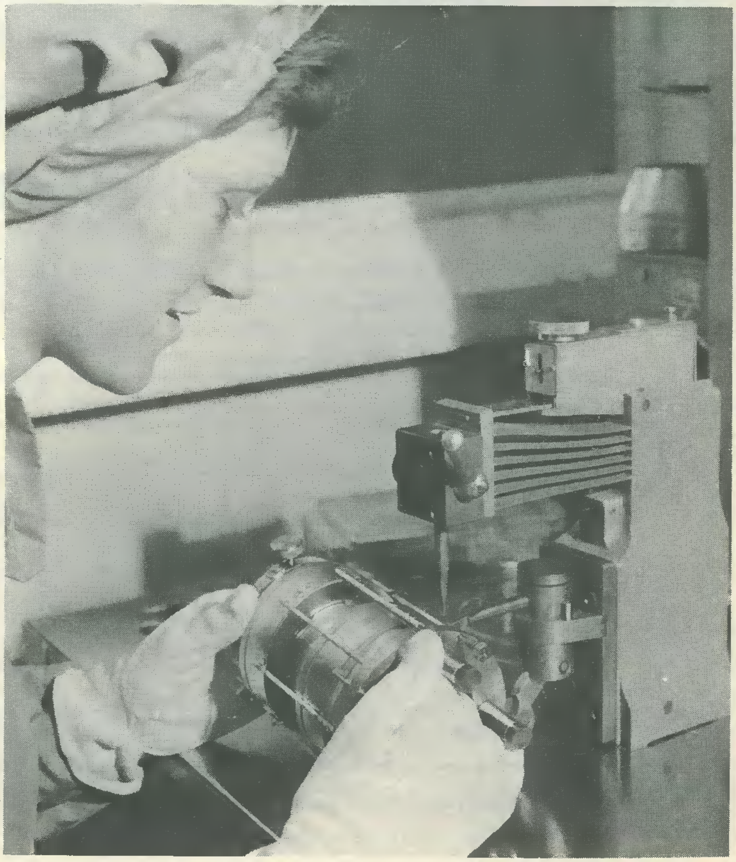
Fig. 4. A convenient sound take-off point will usually be given at the slider of the television receiver volume control

Camera Tube Assembly

I seem to have taken up nearly all my space this month discussing isolating transformers, but I would just like to slip in a few more words before finishing on the subject of the accompanying photograph.

This shows an operator spot-welding the electrodes of a 4½in image orthicon TV camera tube, one of the processes carried out at the Hayes plant of E.M.I. Electronics Ltd. The particular electrode assembly shown is quite a "handful", as you can see, and it constitutes, in fact, the image transfer system between the photo-cathode and the glass storage target of the E.M.I. tube. The upper welding contact protrudes vertically downwards from the block above the girl's right hand, the heavy welding current flowing through the six flexible copper straps connecting to this block from the main body of the spot-welding jig.

The electrode assembly shown is of particular importance so far as the quality of focus and accuracy of geometry of the resulting TV picture is concerned, and it is necessary to observe careful alignment of its constituent parts.



Spot-welding the electrodes of the image transfer system for a 4½in image orthicon television camera tube at the Hayes plant of E.M.I. Electronics Ltd.

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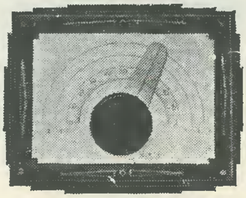

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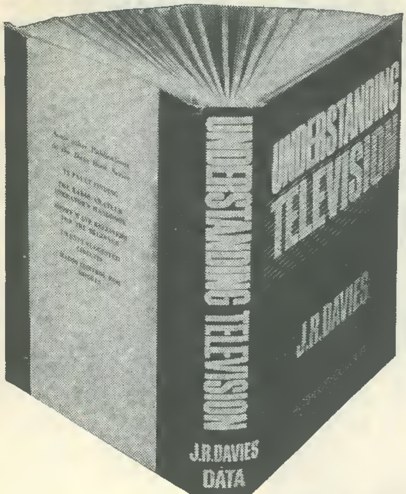

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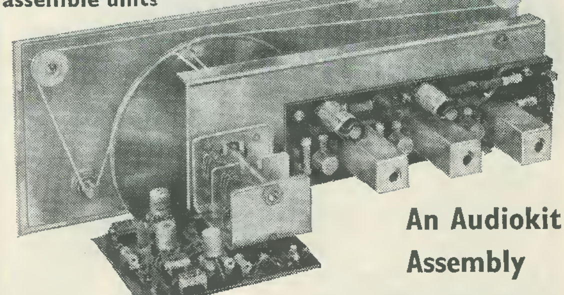

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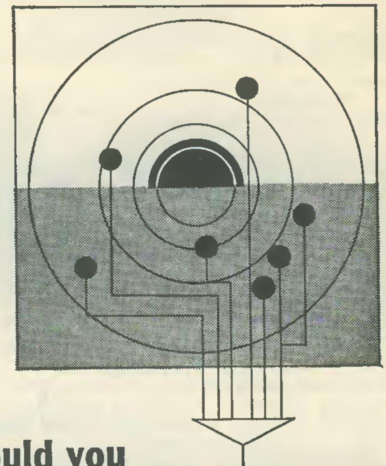

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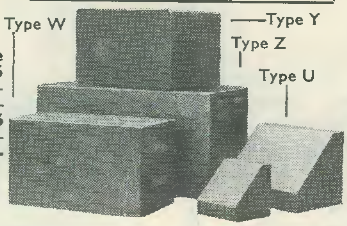

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TELEVISION SETS, RECEIVERS AND TRANSMITTERS

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.

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J/B

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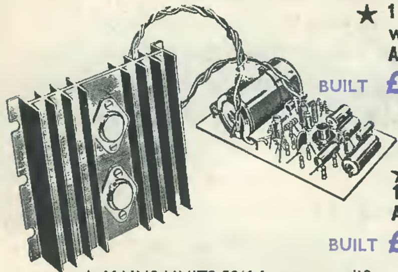
FIRST AND BEST PROVED & TESTED DESIGNS, QUALITY, COMPONENTS & UNITS

● TRANSISTOR HI-FI AMPLIFIERS

MONO or STEREO | 10 WATTS and 20 WATTS



★ 15 to 16 ohm 10 watt Power Amplifier
BUILT **£5-19-6** P.P. 2/6

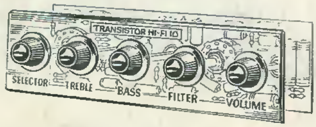
★ 3 to 4 ohm 10 watt Power Amplifier
BUILT **£5-10-0** P.P. 2/6

★ MAINS UNITS **59/6** for one amplifier. or **69/6** to power 2 amplifiers.

● PRE-AMPLIFIERS

★ Mono full function pre-amplifier with 8 input positions. Low noise, high quality and sensitivity. Gives 10 watts with one power amplifier or 20 watts with two amplifiers. Size: 9″ x 2½″ x 2″.

BUILT **£5-10-0** P.P. 2/–



★ FRONT PANEL PLATE **8/6**

● STEREO PRE-AMPLIFIER

Two Channel version of above. For use with two power amplifiers for 10+10 watts. Size: 9″ x 3¼″ x 1⅝″.

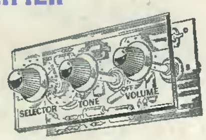
PRICE BUILT **£10-19-6** P.P. 3/6

★ Dark Brown with Gold Front Panel **12/6**.

● MULTI-INPUT PRE-AMPLIFIER

Simplified pre-amplifier for use with one or two power amplifiers, 8 inputs.

PRICE BUILT **65/-** P.P. 1/6



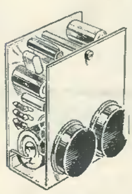
★ Front Panel Plate **6/6**.

All the above pre-amplifiers can be used with any valve or transistor power amplifier requiring 250mV for full output. They can be operated with two 9 volt batteries in series or from the power amplifiers. High gain, low distortion, excellent quality designs, combined with value for money.

CIRCUITS AND DETAILS ON REQUEST

Demonstrations of above equipment and VHF FM Tuner can be heard during normal shop hours. All units are fully guaranteed.

TWO PACKAGED TRANSISTOR QUALITY AMPLIFIERS



★ 6-Transistor printed circuit designs. Push-pull output for 3 to 5 ohm speakers. Can be battery operated. 6mV into 1 kΩ sensitivity. Response 40 c/s to 12 kc/s.

Can be used with above pre-amplifiers for mono or stereo in any amplification requiring a low distortion low cost amplifier. Overall sizes: 2½″ x 2″ x 1¼″.

★ 4 watt version operates from 12 to 18 volts. PRICE BUILT **79/6** P.P. 1/6

★ 1½ watt version from 9 to 12 volts. PRICE BUILT **65/-** P.P. 1/6

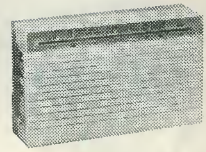
★ CIRCUITS AND DETAILS ON REQUEST ★

1½ watt and 4 watt

LATEST 5th EDITION 90-PAGE CATALOGUE
Fully detailed and illustrated. Price 2/6 post paid.

● FOR THE HOME CONSTRUCTOR

"REGENT-6" New!



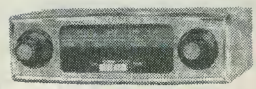
★**MEDIUM and LONG WAVE POCKET SUPERHET RADIO.** A new 6-transistor printed circuit designed with full coverage on both wavebands. Features "Cleartone" push-pull speaker output, geared tuning and complete set of 1st grade components. Moulded two-tone cabinet size 5″ x 3″ x 1¼″. Easy to follow building details. All parts sold separately.

★ Total cost of all parts **85/-** P. & P. 2/– (Battery 2/6 extra)

All Transistor Car Radio

★ **ONE HOUR TO BUILD WITH FACTORY ASSEMBLED CHASSIS AND PANELS**

6-transistor 3 diode Med. and Long Wave Superhet Design. Features double tuned IFT's, AVC. Permeability tuning with geared drive, push-pull car filling volume. Full tuning of both wavebands. A high sensitivity design on printed circuits to fit any type of vehicle. 12 volt positive earth only. All parts available separately. After sales service and guarantee.



THE "ROADSTER"
★ Total Cost to Build **£8-19-6** P.P. 3/6

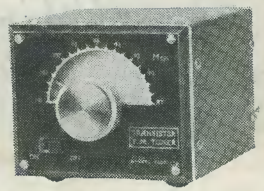
★7 x 4 inch. hi-flux speaker with baffle and car fixing kit **20/–** extra.
★ Circuit and details on request.

VHF TRANSISTOR HI-FI FM TUNER

★ **HIGH STABILITY — HIGH SENSITIVITY** ★

Features 5-Mullard transistors with 4 diodes, compact printed circuit, high gain, low distortion, superhet design. Full tuning from 87/105 Mc/s with geared tuning. AVC and AFC. 9 volt 9mA operation. 50dB S/N. Output up to 1 volt audio. Easy to build and align. Overall size in cabinet 3½″ x 2¼″ x 4″. All parts sold separately and guaranteed.

AFTER SALES SERVICE
★ CIRCUIT AND DETAILS ON REQUEST



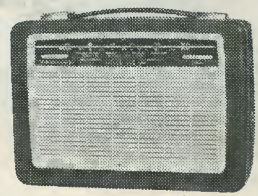
Total Cost with Front Panel **£6-19-6** P.P. 2/6
(Cabinet Assembly **20/–** extra)

"CONVAIR" PUSH BUTTON PORTABLE CAR RADIO

★ **UNBEATABLE FOR PERFORMANCE AND DESIGN** ★

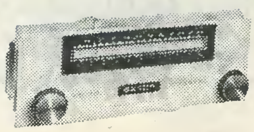
Printed circuit 6-Transistor 2-Diode superhet radio with full tuning on medium and long wavebands. Push-pull output up to 1 watt. Attractive portable cabinet, size 10″ x 7″ x 3½″ with horizontal slow motion tuning dial and push button wave change. Easy to build with superb performance. All parts sold separately. After Sales Service and Guarantee.

★ CIRCUIT AND DETAILS ON REQUEST



★ Total Cost of All Parts **£7-19-6** P.P. 3/6
(Batteries 6/– extra)
★ **The Finest Portable Available**

NEW! VHF FM TUNER



New 6-transistor superhet design.
Factory built and aligned units.
Covers 88 to 108 Mc/s. Horizontal tuning scale.
Total Cost £12-17-6 *Leaflet on Request*

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