THE Radio Constructor

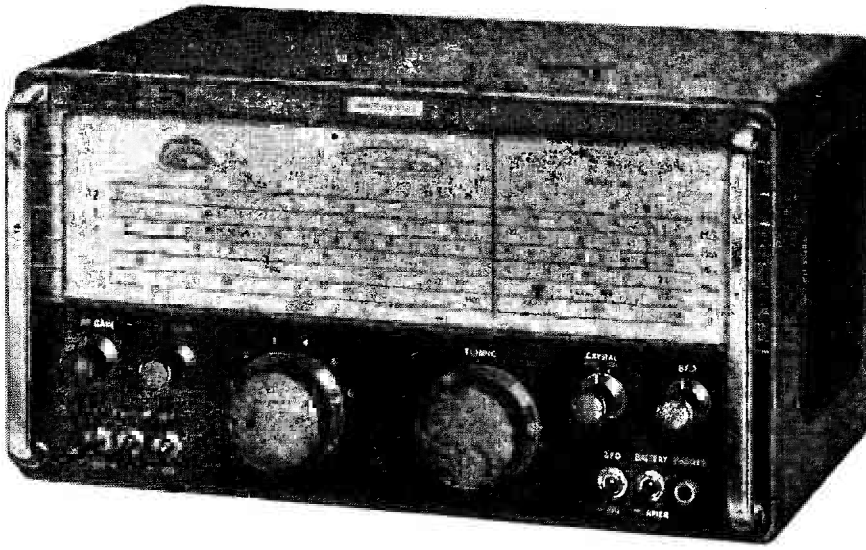
RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 17 NUMBER 1
A DATA PUBLICATION
PRICE TWO SHILLINGS

August 1963

HIGH QUALITY Modulator Design

TRANSISTORISED COMMUNICATIONS RECEIVER



—*the* EDDYSTONE '960'

500 kc/s------------to------------30 Mc/s

Nineteen semi-conductor devices
Six ranges cover 500 kc/s to 30 Mc/s
Good frequency resolution
High sensitivity
Two selectivity positions—one with crystal filter
Excellent frequency stability
Audio output up to one watt
Precision slow motion drive
Internal heavy duty battery
Provision for using external power supply
Robust construction
High reliability
Modern styling and finish

Illustrated brochure giving full specification and other information available on request from the manufacturers:

STRATTON & CO. LTD

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ANOTHER TAPE RECORDER BARGAIN

Mfrs.' 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, EZ280 and Silicon Diode.

2 tone Cabinet and 8" x 5" Speaker. Size 14" x 10½" x 7¼"	**£3.10.0**	+ 5/- carr.
Wired Amplifier complete with 4 valves, Front Panel, Knobs	**£5.12.6**	+ 3/6 carr.
B.S.R. Monardeck Type T.D.2	**£7. 7.0**	+ 4/6 carr.
Accessories—Mike, Tape, Screened Lead, Plugs, etc.	**£1. 1.0**	+ 2/- carr.
COMPLETE KIT comprising items above	**15 gns.**	+ 10/- carr.

Leaflet, Circuit and Instruction 2/- post free

New Boxed VALVES All Guaranteed

1T4	6/-	ECC83	8/-	PCC84	9/6
1R5	7/6	ECL82	10/6	PCF80	9/6
1S5	7/6	ECL80	10/6	PCL83	12/6
3S4	7/6	EF80	8/-	PCL84	12/6
3V4	7/6	EF86	12/6	PL81	12/6
DAF96	9/-	EL84	8/6	PL82	9/6
DF96	9/-	EY51	9/6	PL83	10/6
DK96	9/-	EY86	10/-	PY32	12/6
DL96	9/-	EZ81	7/6	PY81	9/6
ECC81	8/-	GZ32	12/6	PY82	7/6
ECC82	8/-	EM84	9/6	U25	12/6

Electrolytics All Types New Stk.

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		
16+16/450V	5/6	100+300/275V	12/6
32+32/450V	6/6		
1000/25V	3/9	2000+4000/6V	3/6

Ersin Multicore Solder 60/40 3d. per yard. ½lb. 2/6, etc.

NEW BRITISH RECORDING TAPE

Famous Mfr. Bulk Purchase—Genuine recommended Tape Bargain. Uncond. Guar. Fitted Leader & Stop Foils (except 3").

	Standard (PVC base)		Long Play (PVC base)		D'ble Play (Myiar base)	
3"	150ft. ...	3/9	225ft. ...	4/9	300ft. ...	6/6
5"	600ft. ...	11/6	900ft. ...	15/-	1,200ft. ...	25/-
5¾"	850ft. ...	14/6	1,200ft. ...	17/6	1,800ft. ...	32/6
7"	1,300ft. ...	17/6	1,800ft. ...	22/6	2,400ft. ...	42/3

Post and Packing—3" Reels 6d. Each additional Reel 3d. 4" to 7" Reels 1/-. Each additional Reel 6d.

EMPTY TAPE REELS (Plastic): 3" 1/3; 5" 2/-, 5¾" 2/-, 7" 2/3.
PLASTIC REEL CONTAINERS (Casettes): 5" 1/9, 5¾" 2/-, 7" 2/3

Jack Plugs. Standard 2½" Igranic Type, 2/6. Screened Ditto, 3/3. Miniature 1½", 2/3. Screened Ditto, 2/6.

Jack Sockets. Open Igranic Moulded Type, 3/3. Closed Ditto, 3/9. Miniature Closed Type, 1/9. Sub-min (deaf aid) ditto, 1/3.

Phono Plugs 1/-. Phono Sockets (open), 1/-. Ditto Closed, 1/6. Twin Phono Sockets (open), 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.

MULLARD "3—3" HI-FI AMPLIFIER

3 VALVES 3 WATT

3 ohm and 15 ohm Output

A really first-class Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line-up: EF86, EL84, EZ81. Extra H.T. and L.T. available for Tuner Unit addition. This is the ideal companion Amplifier for FM tuner units.

TECHNICAL SPECIFICATION—Freq. Response: ± 1dB. 10 kc/s. Max. Bass Boost 14dB at 80 c/s sensitivity: 100MV for 3W output. Output Power (at 400 c/s); 3W at 1% total harmonic distortion. Hum and Noise Level: At least 70dB below 3W.

COMPLETE KIT (incl. valves, all components, wiring diagram and special quality sectional Output Trans.) **ONLY £6.19.6** carr. 4/6.

Complete wired and tested, 8 gns. Wired power O/P socket and additional smoothing for Tuner Unit, 10/6 extra.

Bronze Escutcheon Panel, Printed Vol., Treble, Bass, On-Off, supplied with each Kit.

Recommended Speakers—R. & A. 12" with tweeter 52/6, WBHF10-12 £4.7.6, Goodmans Axiette £5.5.0, Axiom 10 £6.5.0. Carr. extra

Volume Controls—5K-2 Megohms, 3" Spindles Morganite Midget Type. 1⅛" diam. Guar. 1 year. LOG or LIN ratios less Sw. 3/-. DP. Sw. 4/6. Twin Stereo less Sw. 6/6. D.P. Sw. 8/-.

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.

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% ⅛ and ¼W 3d., ½W 5d. (Midget type modern rating) 1W 6d., 2W 9d. **Hi-Stab** 5% ⅛–½W 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/-.

JASON FM TUNER UNITS

Designer-approved kit of parts:
FMT1, 5 gns. 4 valves, **20/-**.
FMT2, £7. 5 valves, **37/6.**
JTV MERCURY 10 gns.
JTV2 £13.19.6. 4 valves, **32/6.**

NEW JASON FM HANDBOOK, 2/6. 48 hr. Alignment Service 7/6. P. & P. 2/6.

Speakers P.M.—3 ohms 2½" E.M.I. 17/6. Goodmans 3½" 18/6. 5" Rola 17/6. 6" Elac 18/6. 7" x 4" Goodmans 18/6. 8" Rola 20/-. 10" R. x A. 25/-. 9" x 6" Goodmans 25/-. E.M.I. Tweeter 29/6.

Speaker Fret—Expanded gilt anodised metal ⅛" x ¼" diamond mesh, 4/6 sq. ft., multiples of 6" cut. Max. width 4 ft. 4 ft. x 3 ft. 47/6. Carr. extra

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

BONDACOUST Speaker Cabinet Acoustic Wadding, 12" wide, any length cut 1–6 ft.

BARGAINS 4-SPEED PLAYER UNITS

Single Players	carr. 3/6
Garrard-SRP10	£5.5.0
B.S.R. Latest Model TU12	72/6
E.M.I. Junior "985"	67/6
Auto-Changers	carr. 5/-
Garrard AT6 Mono	9 gns.
Garrard "Auto-Slim"	£6.15.0
Collaro C60	£6.19.6
B.S.R. (UA14)	£6.10.0

ENAMELLED COPPER WIRE—¼lb reels, 14g–20g, 2/6; 22g–28g, 3/-; 36g–38g, 4/3; 39g–40g, 4/6, etc.

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

TRANSISTOR COMPONENTS

Midget I.F.'s—465 kc/s ⅝" diam.	5/6
Osc. Coil—⅝" 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. ⅞" 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.

TRANSISTOR BARGAINS

Brand New—BVA 1st Grade

OC44	8/6	OC70	5/6
OC45	8/-	OC71	6/-
OC81	7/6	GEX34	2/9
2/OC81	15/6	OA70	2/9
GET114	6/6	OA81	2/9
OC72	7/6		

TRIMMERS, Ceramic (Compression Type)—30pF, 70pF, 9d.; 100pF, 150pF, 1/3; 250pF, 1/6; 600pF, 1/9.

PHILIPS, Bee Hive Type (conc. air spaced)—2–8pF, 1/-; 3–30pF, 1/-.

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

METAL RECTIFIERS- STC Types—RM1, 4/9; RM2, 5/6; RM3, 7/6; RM4, 16/-; RM5, 21/-; RM4B, 17/6.

BARGAIN CORNER

Brand New. Mfrs. surplus 1st grade
1 OC44 & 2 OC45, 15/6.
1 OC181D & OC81, 15/6.
All above and OA81, 32/6 post free.
½ Meg. VOL Controls D.P. Sw. ¼" flatted spindle. Famous Mfrs. 4 for 10/- post free.

RECORD PLAYER CABINETS

Contemporary style, rexine covered cabinet in mottled red and white polka dot. Size 18½" x 13½" x ht. 8½", fitted with all accessories including baffle board and anodised metal fret. Space available for all modern amplifiers and auto-changers, etc. Uncut record player mounting board 14" x 13" supplied.

Cabinet Price £3.3.0 Carr. and Ins. 5/-

2-VALVE 2 WATT AMPLIFIER

Twin stage ECL82 with vol. and neg. feedback tone control. A.C. 200/250V with knobs, etc., ready wired to fit above cabinet. **£2.17.6.** P. & P. 1/6. 6" Speaker and trans, 22/-. P.P. 2/-

COMPLETE R/PLAYER KIT. As ill. inc. BSR UA14 Unit Reduced Price £12.10.0. Carr. 7/6.

Ditto RECORD PLAYER KIT with BSR UA20 Unit. New Reduced Price £11.10.6. Carr. 7/6.

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

TS Est. 1946

RADIO COMPONENT SPECIALISTS

70 Brigstock Rd., Thornton Heath, Surrey
THO 2188 *Hours; 9 a.m., —6 p.m., 1 p.m. Wed. Terms C.W.O. or C.O.D. Post and Packing up to ½ lb 9d., 1 lb., 1/3 3lb., 2/3 5 lb., 2/9 8 lb. 3/6.*

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Heathkit DAYSTROM

Enjoy Yourself and Save Money

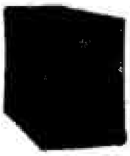
SINGLE SIDEBAND ADAPTOR. Model SB-10U. May be used with most A.M. transmitters. Less than 3W R.F. input power required for 10W output. Operation on 80, 40, 20, 15 and 10m bands on U.S.B., L.S.B. or D.S.B. **£39.5.0**

AMATEUR TRANSMITTER. Model DX-40U. Covers all amateur bands from 80 to 10 metres; crystal controlled. Power input 75W C.W., 60W peak controlled carrier phone. Output 40W to aerial. Provision for V.F.O. Filters minimise TV interference. **£33.19.0**

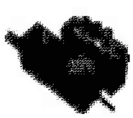
GRID-DIP METER. Model GD-1U. Functions as oscillator or absorption wave meter. With plug-in coils for continuous frequency coverage from 1.8 Mc/s to 250 Mc/s. **£10.19.6**

Q MULTIPLIER KIT. Model QPM-1. May be used with receivers having 450–470 kc/s I.F.; provides either additional selectivity or signal rejection; self powered. **£7.12.6**

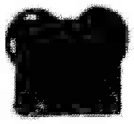
2½" SERVICE 'SCOPE. Model OS-1. Light, compact portable for service engineers. Dim. 5" x 8" x 14½" long. Wt. 10½lb. **£19.19.0**

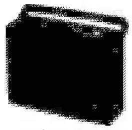

SB-10U


DX-40U


GD-1U


S-33


COLLARO


UXR-2

LATEST MODEL! "OXFORD" LUXURY TRANSISTOR PORTABLE Model UXR-2. Specially designed for use as a domestic, car or personal portable receiver. Many features, including solid leather case. Send for full details! **£14.18.0**

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. **£15.17.6**

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. Sensitivity 200mV. **£13.7.6**

COLLARO "STUDIO" TAPE DECK. The finest buy in its price range. Operating speeds: 1⅞", 3¾" and 7½" p.s. Two tracks "wow" and "flutter" not greater than 0.15% at 7½" p.s. Long Term Speed stability better than 0.5%. **£17.10.0**

Prices include free delivery in U.K.

☆ We guarantee that without previous experience

5" OSCILLOSCOPE. Model O-12U. Has wide-band amplifiers, essential for TV servicing, FM alignment, etc. Vertical frequency response 3 c/s to over 5 Mc/s, without extra switching T/B covers 10 c/s to 500 kc/s in 5 ranges. **£38.10.0**

ELECTRONIC SWITCH. Model S-3U (Oscilloscope Trace Doubler.) Enables a single beam oscilloscope to give simultaneous traces of two separate and independent signals. Switching rates approx. 150, 500, 1,500, 5,000 and 15,000 c/s. Sig. freq. response 0–100 kc/s. ±1dB. Separate gain controls and sync. output. Sig. input range 0.1–1.8V r.m.s. **£11.15.6**

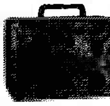
RESISTANCE CAPACITANCE BRIDGE. Model C-3U. Measures capacity 10pF to 1,000μF, resistance 100Ω to 5MΩ and power factor. 5–450V test voltages. With safety switch. **£9.5.0**

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. **£21.9.6**

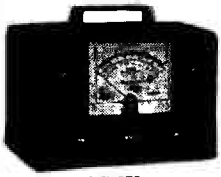
TRANSISTOR INTERCOM. Models XI-1U & XIR-1U. The master unit uses a 4-transistor amplifier, constructed on a printed circuit board, and an internal 9V battery. Remote stations use a similar battery for call only. Up to five remote units can be ordered for each master.
XIR-1U (remote) **£4.7.6**
XI-1U (master) **£10.19.6**

SUGDEN MOTOR UNIT "CONNOISSEUR CRAFTSMAN". Heavy duty motor operating at 33⅓ and 45 r.p.m. Very heavy 12" turntable. Virtually no rumble. **£16.6.6**

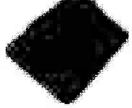

O-12U

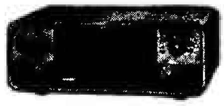

S-3U


C-3U


AG-9U


"GLOUCESTER"


GL-58


AM/FM TUNER

HI-FI AM/FM TUNER, Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£20.13.0). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total **£25.6.6**

HI-FI EQUIPMENT CABINETS. Our four cabinets meet a wide variety of tastes and requirements: the "CHEPSTOW" designed for those who have little floor space, the contemporary "MALVERN" for the Tape and Gram. enthusiast, and the "GLOUCESTER" Mk. I and II for those with traditional tastes. Supplied "in the white". Prices from **£11.12.6** to **£18.10.0**
An additional range of assembled and finished cabinets is now available from us, details on request.

GOLDRING LENCO TRANSCRIPTION RECORD PLAYER. Model GL-58 with G-60 pick-up arm and Ronette 105 cartridge. **£18.19.2**

GARRARD AUTO/RECORD PLAYER, Model AT-6. With Ronette 105 cartridge. **£13.12.1** With Decca Deram pick-up **£14.6.1**

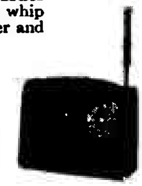
HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Presentation similar to S-33. **£10.19.6**

4 W-B TRANSISTOR PORTABLE RECEIVER. Model RSW-1. In a handsome leather case it has retractable whip aerial and socket for car radio use. Covers Med., Trawler and two S wave bands. **£19.17.6**

HI-FI SINGLE CHANNEL AMPLIFIER. Model MA-12. 12W output, wide freq. range, low distortion. **£11.9.6**

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. **£5.2.6**


MA-12


RSW-1

250 AMERICAN HEATHKIT MODELS
MANY PREVIOUSLY UNOBTAINABLE
All for direct delivery from U.S. Plant to your U.K. address. **Illustrated Catalogue** and full details of Mail Order scheme can be obtained from us for the nominal charge of 1/- post paid.

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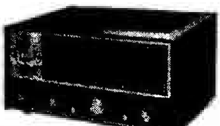
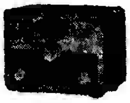

RA-1


VF-1U


GC-1U

NEW MODEL! AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160–10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amplifier Stage. Full specification sheet available on request. **£39.6.6**

THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric transfilters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised general purpose receiver for Amateur and Short wave listeners. Printed circuit boards, telescopic whip antenna, tuning meter and large slide-rule dial, 10 transistors. **£39.17.6**

AMATEUR TRANSMITTER. Model DX-100U. The world's most popular, compact and completely self-contained Amateur Transmitter. Covers all amateur bands: 160–10 m. 150W d.c. input. Careful design has achieved the stability and high performance for which the DX-100U is noted and no less than 35 disc ceramic capacitors reduce TVI to a minimum. **£74.19.0**

VARIABLE FREQUENCY OSCILLATOR. Model VF-1U. Calibrated 160–10 m. Fundamentals on 160 and 40 m. Ideal for our DX-40U and similar transmitters. **£11.17.6**

Deferred terms available over £10


V-7A


MM-1U


RF-1U

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. **£13.18.6**

MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V A.C. and D.C.; 150μA to 15A D.C.; 0.2Ω to 20MΩ. 4½" 50μA meter. **£12.10.0**

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics and up to 100mV output on all bands. **£12.15.6**

AUDIO WATTMETER. Model AW-1U. Up to 25W continuous, 50W intermittent. **£15.15.0**

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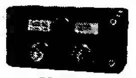
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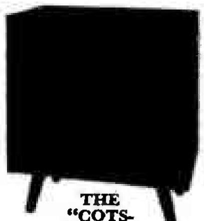
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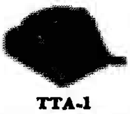
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CONTRIBUTIONS on constructional matters are invited, especially when they describe the construction of particular items of equipment. Articles should be written on one side of tbe sheet only and should preferably be typewritten, diagrams being on separate sheets. Whether hand-written or typewritten, lines should be double spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will redraw in most cases, but all relevant information should be included. Photographs should be clear and accompanied by negatives. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for reply or return, and should bear the sender's name and address. Payment is made for all material published.

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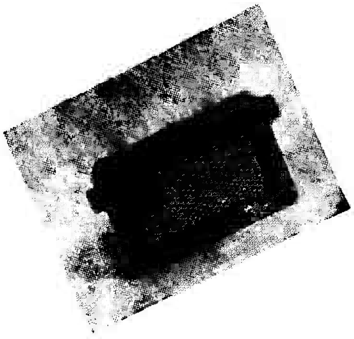


Superhet Transistor Radio Receiver

By P. GREEN

THE TRANSISTOR RADIO HAS BROUGHT BACK TO the constructor the old days of building his own receiver. Today, the constructor's objective is to build his own transistor set. Many circuits have been published, with articles describing their construction, but these are mostly miniature sets in which the sizes of the speaker and ferrite rod aerial are limited. There are, also, straight and reflex circuits, with which good results can be obtained from local stations.

This state of affairs does not satisfy many constructors, for whom the superhet is the only answer to their requirements. The assembly of a superhet transistor radio is well worth while, and very little extra effort and expense is involved. Also, the constructor will be much happier with the results.

The dèsign of the transistor superhet described here is a departure from miniature layouts, although the overall dimensions of the receiver (excluding knobs) are still only 7¾ x 4¾ x 2¼in. The cabinet is constructed from a polythene case which is available in various pleasing colours. A 6 x 4in loudspeaker is employed, and the finer quality of sound available from this relatively large unit is something to be proud of.

The Circuit

The circuit of the receiver appears in Fig. 1 and,

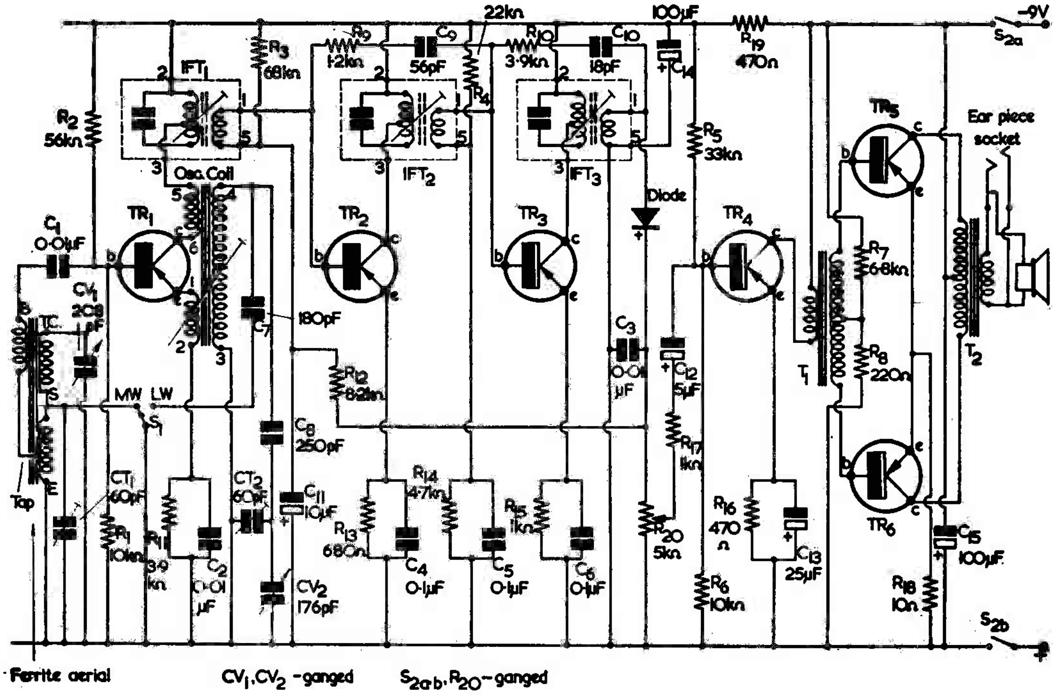
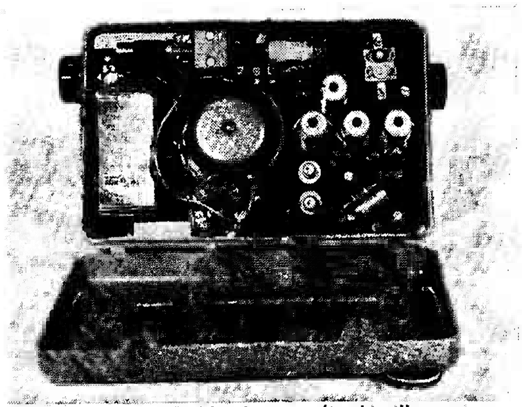


Fig. 1. The circuit of the receiver

as may be seen, it employs a standard superhet design. The ferrite rod aerial couples into the mixer/oscillator transistor TR_1, in the collector circuit of which is connected the first i.f. transformer IFT_1. The secondary of IFT_1 feeds transistor TR_2 which, in turn, drives TR_3 by way of IFT_2. The secondary of IFT_3 couples into the detector circuit provided by diode D_1, R_{20} and C_3, an a.g.c. voltage being fed back to the base of TR_2 by way of R_{12}. The detected a.f. tapped off R_{20} is fed, via R_{17} and C_{12}, to the driver transistor TR_4 which then couples, by way of transformer T_1, to the output transistors TR_5 and TR_6.

It will be noted that the Components List specifies both Ediswan and Mullard transistors. Ediswan transistors were used in the prototype, but the Mullard alternatives may be employed equally well in receivers using the present circuit.



The components inside the case (in this illustration, the long wave ferrite frame coil is shown, incorrectly, with its tag ring on the inside)

Components List

Resistors

(All fixed resistors ¼ watt 10%)

R_1	10kΩ
R_2	56kΩ
R_3	68kΩ
R_4	22kΩ
R_5	33kΩ
R_6	10kΩ
R_7	6.8kΩ
R_8	220Ω
R_9	1.2kΩ
R_{10}	3.9kΩ
R_{11}	3.9kΩ
R_{12}	8.2kΩ
R_{13}	680Ω
R_{14}	4.7kΩ
R_{15}	1kΩ
R_{16}	470Ω
R_{17}	1kΩ
R_{18}	10Ω
R_{19}	470Ω
R_{20}	5kΩ miniature volume control (log track) with switch

Transistors

TR_1	XA102 or OC44
$TR_{2,3}$	XA101 or OC45
TR_4	XB103 or OC71
$TR_{5,6}$	XC101 or OC72 (Matched pair)

Diode

D_1 OA81

Switches

S_1 Wavechange s.p.s.t. (see text)

$S_{2(a),(b)}$ On/off d.p.s.t. (Part of R_{20})

Speaker

6 x 4in, 3Ω impedance (see text)

Capacitors

C_1	0.01μF
C_2	0.01μF
C_3	0.01μF
C_4	0.1μF
C_5	0.1μF
C_6	0.1μF
C_7	180pF 10%
C_8	250pF 10%
C_9	56pF 2%
C_{10}	18pF 2%
C_{11}	10μF, electrolytic, 6V wkg.
C_{12}	5μF, electrolytic, 6V wkg.
C_{13}	25μF, electrolytic, 6V wkg.
C_{14}	100μF, electrolytic, 12V wkg.
C_{15}	100μF, electrolytic, 12V wkg.
CT_1	60pF trimmer
CT_2	60pF trimmer
$CV_{1,2}$	176/208pF twin-gang (Jackson Bros type 00, without trimmers or slow motion drive)

Inductors

Ferrite Rod Aerial, Osmor type PW/FR1

Oscillator Coil (Red), Osmor type PW/01

$IFT_{1,2}$ Osmor type PW/2 (White)

IFT_3 Osmor type PW/3 (Blue)

T_1 Driver transformer type LT44, (Clyne Radio Ltd)

T_2 Output transformer type LT700, (Clyne Radio Ltd)

Miscellaneous

Expanded metal speaker grille, 6½ x 3½in
Earpiece and earpiece socket
External battery socket (optional)
Battery type PP6, Paxolin panel
2 Knobs, Polythene lunch box (Woolworths) 7¾ x 4¾ x 2¾in, screws, nuts, rivets, etc.

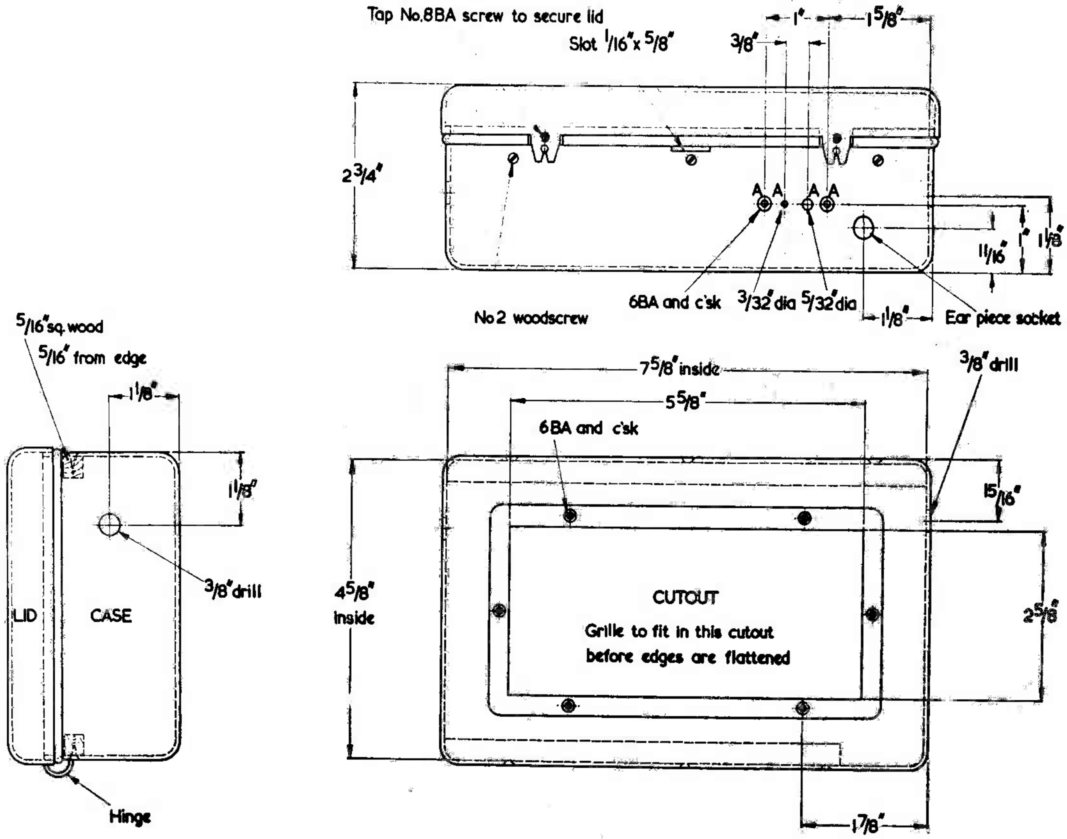


Fig. 2. Drilling and cutting the polythene case. The holes marked "A" should only be drilled if an external supply socket is to be fitted. This point is discussed in the text

Construction

Construction may commence with the cabinet. This consists of a converted polythene lunch box (available at Woolworth's stores) which is modified as shown in Fig. 2. The hole in the bottom for the grille can be cut out with a penknife, whilst the other holes must be carefully drilled. Countersinking should be carried out with the drill held in the hand. Note that two pieces of wood $\frac{5}{16}$in square are secured to the two long sides of the case. These will later hold the Paxolin panel on which the main components are mounted. The holes marked "A" in Fig. 2 are for an optional socket whose function is described at the end of this article. They should not be drilled at this stage unless it has been decided to employ such a socket. See under "External Connections".

The baffle board (Fig. 3) and speaker grille may now be fitted behind the speaker cut-out. The edges of the grille are flattened so as to fit between the baffle board and the sides of the case, as shown in Fig. 4.

Fig. 5 illustrates the manner in which the speaker, baffle board and Paxolin panel are mounted inside the case. It is essential that the speaker employed has a round magnet having a diameter less than $2\frac{1}{8}$in. The speaker must be mounted such that it does not interfere with the semicircular cut-out in

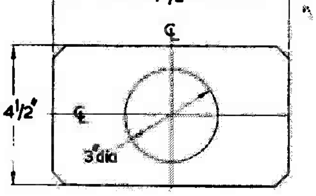


Fig. 3. The baffle board. This is made of $\frac{1}{8}$in hardboard

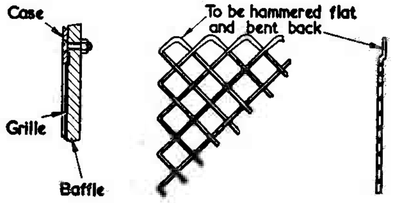


Fig. 4. How the grille is fitted

the Paxolin panel. As may be noted from Fig. 5, the speaker is not mounted centrally on the baffle board.

The Paxolin panel has next to be cut and drilled out, and the requisite dimensions are given in Fig. 6. It will be seen that no dimensions are given for the holes which take the two 60pF trimmers. The writer employed a double trimmer here, but single trimmers may be used instead, if desired.

Next to be made is the tuning capacitor support shown in Fig. 7. This has two 6BA nuts soldered to it in order to facilitate mounting, these corresponding with two holes on $\frac{1}{2}$in centres in the Paxolin panel.

The capacitor support is followed by the wave-change switch blade, which is cut out from $\frac{1}{32}$in brass. See Fig. 8, which also shows the switch assembly. The contacts shown in this diagram are taken from an old Yaxley switch wafer, $\frac{1}{16}$in roundhead copper rivets being employed to fasten these, and the blade, to the Paxolin panel. A washer should be placed on the end of the rivet near the panel before rivetting.

The transistor lead-out wires may next be threaded with coloured sleeving for identification, employing red for emitter, green for base, and white for collector. This sleeving will assist in identifying the leads when wiring up.

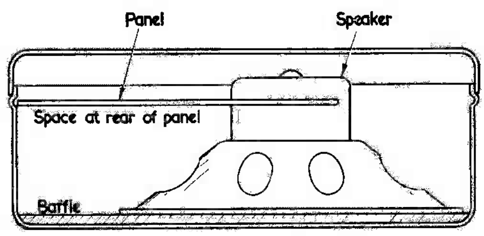


Fig. 5. Internal layout after assembly

Assembly

The assembly of the major components to the Paxolin panel may now commence. Their positions are shown in Fig. 9. It will be seen from this diagram that two double tags are eyeletted to the panel to provide connections for the speaker, and that a further two tags are fitted for the negative and positive supply lines to the board. It is necessary

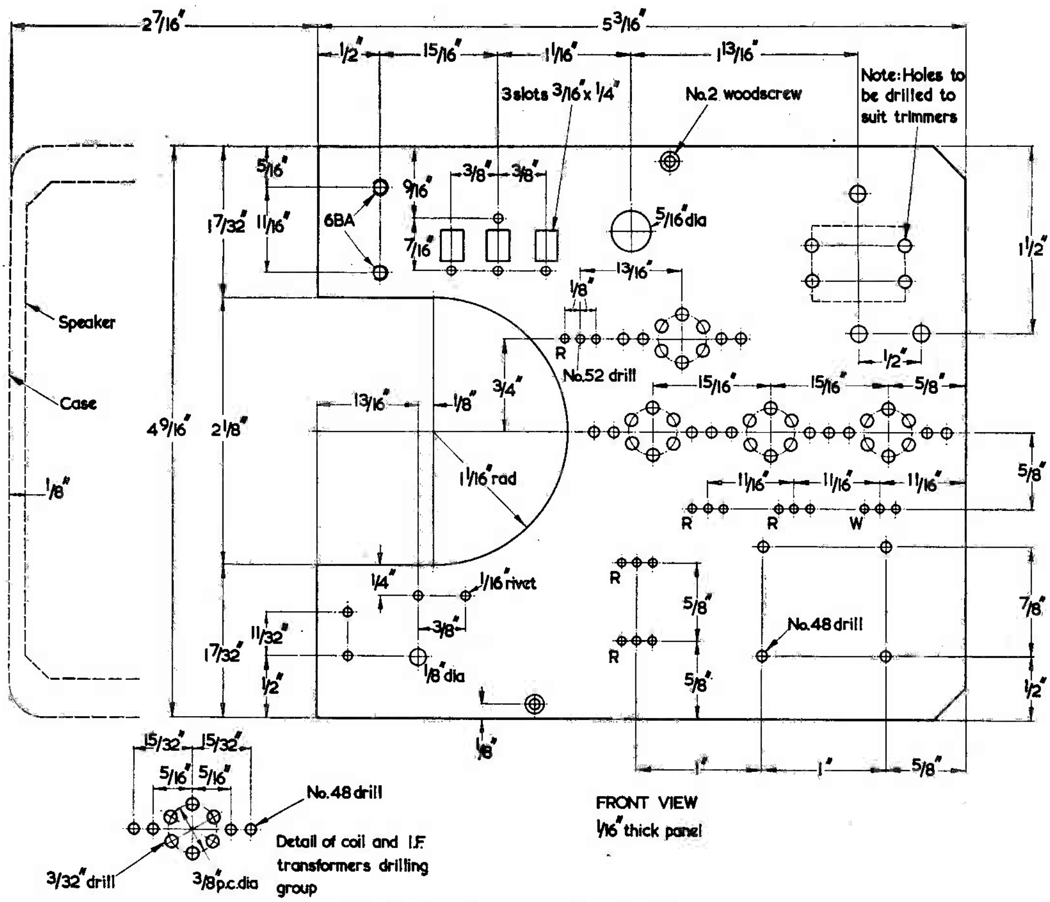


Fig. 6. The dimensions of the Paxolin panel

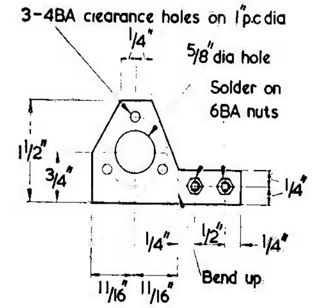


Fig. 7. The tuning capacitor support. The material is 0.032in mild steel

also to provide a mounting for the ferrite frame. As may be seen from Fig. 8 and the illustrations, this mounting was given in the prototype by a fibre clamp, secured by two 6BA screws. The ferrite frame aerial must, of course, clear the Paxolin panel and the wavechange switch contacts. The ferrite rod is not finally mounted at this stage.

The transistor lead-outs are next threaded through the holes provided for them. These holes are identified in Fig. 10 by the letters "W", "G" and "R", which indicate whether the associated sleeving should be white, green or red. The i.f. transformers and oscillator coil may next be fitted, this being done by passing the mounting lugs through the appropriate holes and then back through the adjacent holes as in Fig. 11. Fig. 11 illustrates also how the i.f. coil lugs may be soldered together. The orientation of the oscillator coil and i.f. transformers is shown in Fig. 10. T_1 and T_2 are fitted by passing their mounting lugs through the panel, fitting a washer on each and soldering over. Finally, mount the tuning capacitor to its bracket and bolt this to the panel.

Wiring Up

A start can now be made in wiring up. Fig 10. shows the wiring layout of the underside of the panel. The positive supply line may first be fitted, this connecting to all earthy points. (It may be necessary to temporarily remove the tuning capacitor bracket whilst connecting to the trimmers.) The negative line may next be soldered in, and this can stand off the panel by about ½in. Bare 22 s.w.g. tinned copper wire may be used here, and it will become self-supporting after it has been soldered to a few points. Thread on a short length of sleeving at the supply terminal tags, red for positive and black for negative; this will provide a good reminder to avoid mistakes. All the straight direct connections may next be made, employing thin p.v.c. covered wire. A number of capacitors, C_2, C_4, C_5 and C_6, have resistors in parallel with them. These resistors may be primarily soldered across the capacitors and the resulting assembly then soldered into circuit on the panel.

The remaining capacitors, resistors and other components can now be fitted as shown in Figs. 9 and 10, a heat shunt being applied to all transistor leads during soldering. Note that the neutralising components, R_9C_9, $R_{10}C_{10}$ are pre-assembled,

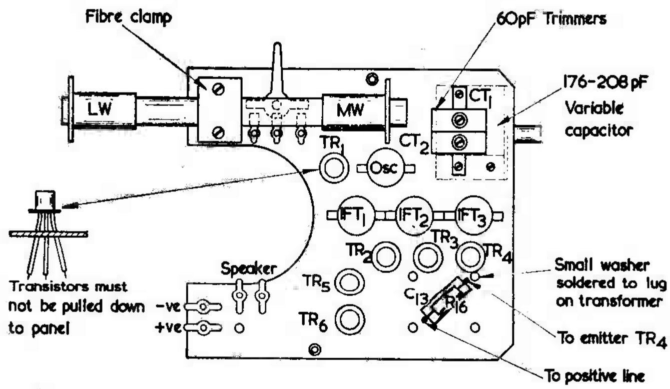


Fig. 9. The principal components above the chassis

and are mounted by connecting the assembly junctions to tag 1 of each i.f. transformer.

The ferrite rod aerial is next fitted to the panel and it is connected into circuit as shown in Fig. 12. Fig. 9 shows the positions taken up by the Medium and Long wave coils on the ferrite rod. The leads from the ferrite rod aerial to the panel components need to be flexible. These leads are approximately 6in long and they pass through the $\frac{5}{16}$in hole under the Medium wave coil before passing on to the appropriate circuit points.

After carefully checking all wiring on the panel, this may be fitted into the case, and mounted in place on the wooden sections previously fitted. It should be noted that external connections have to be made to the speaker, the earpiece socket, the volume control and the on/off switch. The earpiece socket is fitted in the position indicated in Fig. 2, and this, with the speaker, is wired up as shown in the circuit diagram of Fig. 1. The connections to the volume control may be made

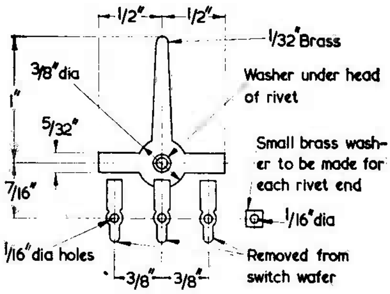


Fig. 8. Details of the wavechange switch

following Figs. 1 and 10. It should be remembered that the positive and negative supply lines from the panel are connected to the battery via the switch contacts on the volume control. The photograph illustrating the interior of the case shows the layout of the components here. The PP6 battery is fitted with its terminals away from the volume control, in order to prevent short circuits to the metal case or terminals of the latter.

Testing

When the receiver has been completed it may be tested and aligned. Since the i.f. transformers and oscillator coil are supplied pre-aligned, little adjustment, if any, will be required with these components. I.F. alignment may be carried out with the aid of a modulated signal generator feeding an output at 470 kc/s to the "Tap" tag of the ferrite rod aerial. Signal generator output should be kept as low as possible to avoid a.g.c. voltages masking the effects of core adjustment.

R.F. alignment is carried out in the conventional manner and, as no standard tuning scale is fitted, there should be no necessity to adjust the core of the oscillator coil. The position of the Medium wave coil on the ferrite rod should be adjusted for optimum

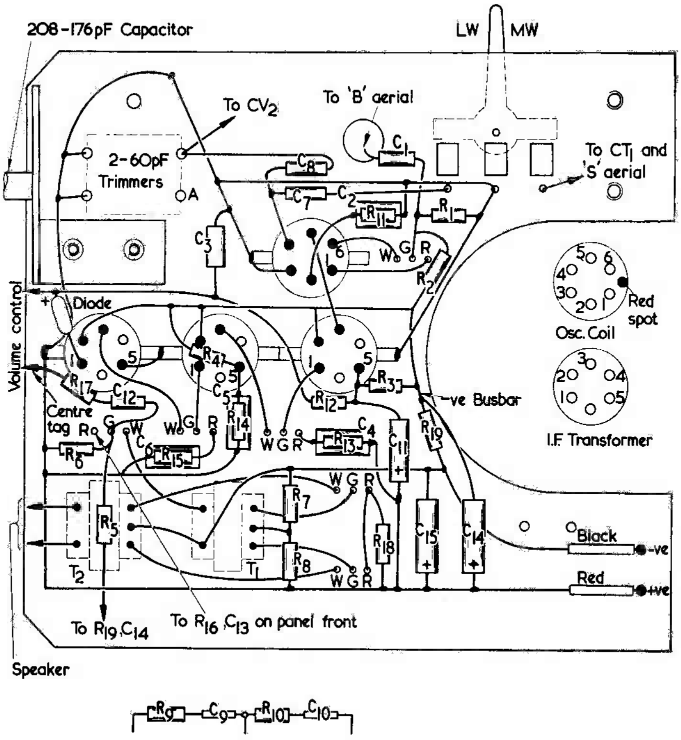


Fig. 10. The wiring on the underside of the panel

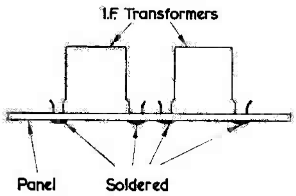


Fig. 11. The method of securing the i.f. transformers and oscillator coil

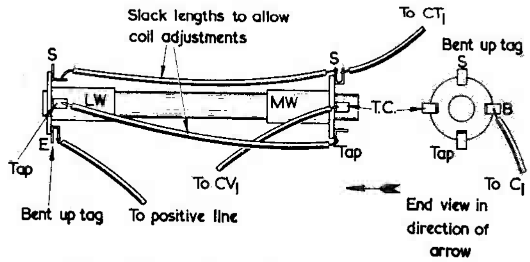


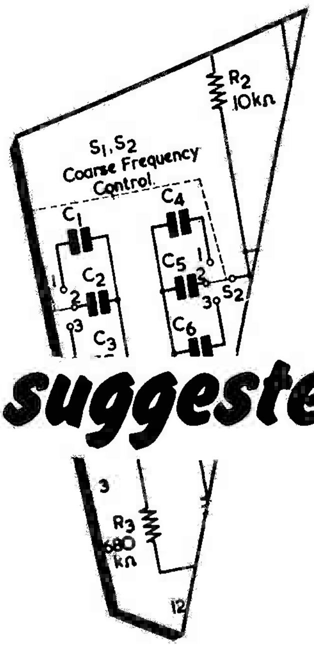
Fig. 12. Connections to the ferrite rod aerial

signal strength for a signal at the low frequency end of the Medium waveband, trimmer CT_2 then being adjusted for optimum results at the high frequency end. This procedure may need to be repeated several times for best overall results. On the Long waveband, set the tuning capacitor to receive the Light Programme on 1,500 metres (200 kc/s) and adjust CT_1 and the position of the Long wave coil on the ferrite rod for optimum results. If more accurate tracking is required, on this band, the position of the coil may be adjusted at the low frequency end of the band, and CT_1 adjusted at the high frequency end.

External Connections

As has already been stated, a socket is available for an earpiece. Such a socket may also be employed for connection to an external loudspeaker.

It is also possible, with the prototype, to connect an external battery, should this be desired. A 2-way socket is fitted to the holes marked "A" in Fig. 2, whereupon the external battery may be plugged in at this point, as shown in the accompanying illustration. The use of a large external battery may prove economical, if the receiver is to be employed for long periods. The dimensions for the "A" holes given in Fig. 2 apply to the particular plug and socket employed by the writer, and may be modified for alternative plugs and sockets. It is important, however, to employ non-reversible types in order to ensure that the external battery is not applied with incorrect polarity.



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The circuits presented in this series have been designed by G. A. French, specially for the enthusiast who needs only the circuit and essential data

No. 153 Low-Cost Variable Voltage Power Unit

An h.t. power unit which is capable of offering a wide range of readily adjustable voltage outputs is always a useful item of equipment in the experimenter's or service engineer's workshop. Usually, such devices tend to be based on stabilised power pack principles and are, in consequence, somewhat expensive. This month's Suggested Circuit is for a simple h.t. power unit which is capable of providing a range of output voltages from about 60 to 350 (according to load and the secondary voltage of the mains transformer employed) at currents up to 50mA or more. The unit requires few more components than are needed in a conventional half-wave rectifier circuit, and it may in consequence be built at little greater cost. No voltage stabilising techniques are employed and the regulation of the circuit is considerably poorer than would be given in a fully stabilised unit. In practice, the regulation is about twice as bad, at some output voltages, as that of a conventional half-wave power unit. It is felt that this is not, for many applications, a serious disadvantage, and that it is counterbalanced by the low cost of the unit and its simplicity.

The Circuit

The circuit of the power unit is shown in Fig. 1, and it will be noted that it employs a mains transformer having a single wave h.t. secondary winding which offers a voltage between 200 and 250. This voltage is applied to the anode and screen-grid of a PL81, the cathode being connected to the reservoir capacitor C_1. The rectified voltage across C_1 is smoothed by the choke (or smoothing resistor) and C_2, and is then applied via the current reading meter to the output terminals. A shunt voltmeter monitors the output voltage. The grid of the PL81 is connected to the slider of R_2, this latter component being the variable voltage control.

To explain the action of the circuit, it is helpful to commence with the half-cycle which causes the anode and screen-grid of the PL81 to go negative of chassis. Under this condition the control grid is also negative, and the valve passes no current.

On the following half-cycle the anode and screen-grid go positive. So also does the control grid, the positive voltage here varying according to the position of the slider of R_2. In consequence, cathode-follower action takes place, and the voltage on the cathode becomes dependent upon that on the control grid.

Since it only conducts during positive half-cycles, the PL81 functions also as a rectifier. In common with normal half-wave rectifiers it then causes charging pulses to be fed to the reservoir capacitor during each positive half-cycle. It is whilst the reservoir charging currents flow that the grid potential takes control, and the setting of R_2 then governs the actual voltage to which the reservoir capacitor charges. When the slider of R_2 is at the bottom end of its track, the rectified voltage across C_1 is at minimum. When the slider of R_2 is at the top of its track, the voltage across C_1 is maximum.

Choice of Valve

Although the circuit is extremely simple in basic principle, a number of difficulties arise with respect to the valve chosen.

The first requirement of the valve is that it should be capable of passing a high current; and the most suitable types generally available which meet this requirement are audio output valves or line output valves. At the same time the valve is subject to high peak inverse voltages. In general, line output valves are more capable of working with such voltages than are audio output valves and it is for this reason that a PL81 is suggested here.

For a 250 volt h.t. secondary the maximum possible p.i.v. on the anode and screen-grid of the valve (relative to cathode) is 700 volts. Maximum p.i.v. figures are not, of course, available for the PL81, and it is possible that the valve is over-run in the present circuit. When the slider of R_2 is at the top of its track, a p.i.v. of 700 volts on the control grid (relative to cathode) may also appear. The PL81 has a maximum negative grid voltage rating of 1kV, but this is under line output conditions in which the voltage has a maximum duration of 18µS only. In consequence, there may, again, be over-running of the valve.

In order to check these points, the author employed a PL81 in a prototype circuit with a transformer having a secondary voltage of 300. The PL81 performed quite satisfactorily, and there was no evidence of any trouble due to the high voltages applied to its electrodes. In consequence it would seem reasonably safe to employ a PL81 in similar circuits, particularly if the secondary voltage is not greater than 250; i.e. 50 volts less than that used by the author for checking the circuit. Due to the possibility of over-running the valve, however, the author cannot *guarantee* that other PL81's will behave in similar manner, and the circuit is experimental in this respect.

The PL81 is intended for series operation and has a heater voltage of 21.5 at a current of 300mA. This voltage is not available from standard transformers, and it may be necessary to add a suitable heater winding to an existing transformer, or to obtain the voltage by other means. There are a number of transformers available on the component and surplus markets which could be pressed into service (with, perhaps, series resistors) to provide a heater voltage for the PL81. An alternative idea would consist of employing an EL81 (with a heater voltage of 6.3 at 1.05A) instead of the PL81. However, the EL81 is not exactly equivalent to the PL81 although it is employed, generally, in similar line output circuits. The EL81 cannot, therefore, be *guaranteed* as being entirely reliable in the present circuit, and its use must be considered as being experimental also.

These factors may make some experimenters consider the inclusion of a fuse to protect the circuit in case of valve failure. Such a fuse could be inserted between the upper terminal of the mains transformer h.t. secondary and the anode and screen-grid of the valve. Since it will also be passing reservoir capacitor ripple current, the fuse will need a value somewhat higher than the smoothed current drawn from the output terminals of the unit.

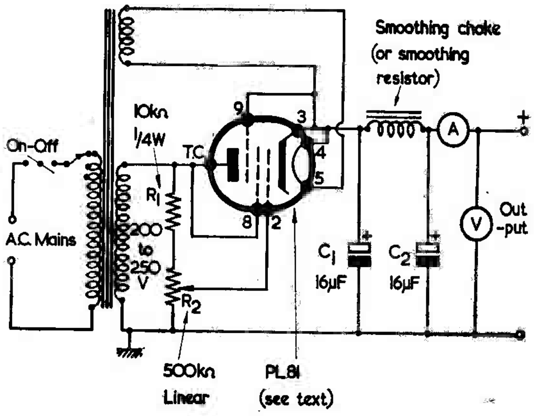


Fig. 1. The circuit of the variable voltage power unit

A resistor, R_1, is inserted between the upper end of R_2 and the upper terminal of the secondary. The purpose of this resistor is to prevent the control grid from reaching the same potential as the anode and screen-grid when high output voltages are required. If the control grid were to have the same potential as the anode and screen-grid a relatively heavy positive grid current may flow and this would be an undesirable feature.

It is necessary to connect one side of the heater to the cathode of the valve to ensure that the maximum heater-cathode potential is not exceeded. With the PL81 this is 200 volts, whilst the corresponding figure for the EL81 is 100 volts. The transformer heater winding insulation must be capable of withstanding the rectified voltages which appear between the valve cathode and chassis.

The PL81 has a maximum cathode current of 180mA, but, due to the low regulation of the unit, it would be impracticable to draw a current as heavy as this from the present circuit. A maximum current around 50mA would seem to be a reasonable figure, and this can be provided by a number of inexpensive mains transformers with single wave h.t. secondaries. The range of output voltages available will then, of course, depend upon that given by the secondary.

Other Components

The remaining components in the circuit require little comment.

Either a smoothing choke or a smoothing resistor may be employed, according to the experimenter's wishes. A 1.2kΩ component rated at 3 watts should be satisfactory for a smoothing resistor. The use of a resistor will, of course, degrade the regulation of the circuit but not, for most requirements, by an excessive amount.

A current reading meter in series with the positive output terminal is a desirable adjunct, and it is very helpful for determining circuit conditions in equipment fed by the unit. Such equipment could, for instance, be initially connected to the unit with R_2 slider set to the bottom end of its track. R_2 slider could then be slowly advanced, the current drawn by the equipment being monitored by the meter as the h.t. voltage increases. The current reading meter could have a full-scale deflection of 50 or 100mA.

A voltmeter across the output terminals is also shown, but many experimenters will probably dispense with this and rely upon a testmeter connected across the output terminals whenever the power unit is employed. If a voltmeter is fitted to the unit, it is assumed that it will have a sensitivity of around 1,000Ω per volt, which is quite adequate for the present purpose. Such a voltmeter will then also function as a bleeder resistor, and will discharge C_1 and C_2 when the power unit is switched off or when R_2 slider is changed to a lower setting. If the voltmeter is not incorporated it would be advisable to fit a bleeder resistor in its place. For the present application, a value around 220kΩ at 1W would be adequate. It should be mentioned that some form of bleed is essential as, otherwise, the output voltage may remain at a high figure even after R_2 has been adjusted for a low output voltage

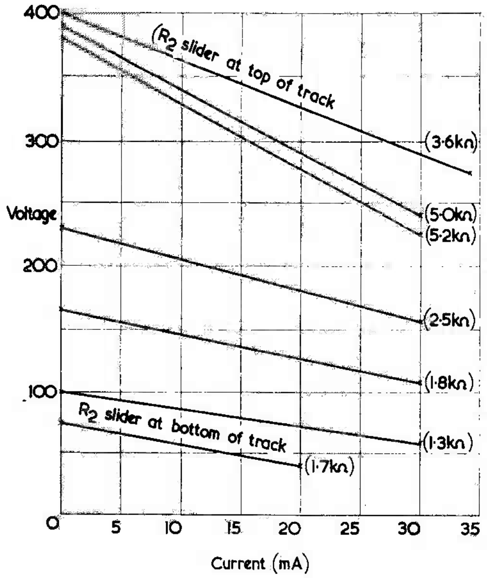


Fig. 2. Voltages obtained under no-load and loaded conditions with the prototype

A 220kΩ bleeder gives a time constant of about 8 seconds in conjunction with C_1 and C_2, and this figure should be adequate with a simple circuit of the type under discussion.

No working voltage is specified for C_1 and C_2, as these depend on the h.t. secondary voltage of the mains transformer employed. The working voltage should be 350 for secondary voltages between 210 and 250. For secondary voltages below 210 the working voltage may be 300.

The potentiometer, R_2, is a conventional carbon track component.

Results With The Prototype

As was mentioned above, the circuit was checked with a prototype, the secondary voltage of the transformer employed being 300. To provide severe operating conditions for the PL81, R_1 was omitted, the upper end of R_2 being connected directly to the upper terminal of the transformer secondary. The secondary resistance of the transformer employed was fairly high, at 450Ω, whilst the primary resistance was 100Ω. Voltages across C_1 were measured for varying loads and for various settings of R_2.

The results are given in Fig. 2. It will be noted that, off load, the voltages across C_1 varied between 75 and 400 according to the setting of R_2. Also shown are the voltages resulting from various loads, the currents drawn being mostly at 30mA. Each straight line joins the voltages given under no-load and loaded conditions for a particular setting of R_2 and its slope shows the regulation resistance under these conditions, this resistance being indicated at the right hand side. Thus, one line demonstrates that a voltage of 100 off load drops to 60 when a current of 30mA is drawn. Under these conditions, therefore, 30mA corresponds to a voltage drop of 40, and results in a regulation resistance of 1.3kΩ. The same effect would be given by a 1.3kΩ resistor in series with a 100 volt supply having perfect regulation. The resistance inserted by the transformer, say 600Ω, contributes to the regulation resistance, and this figure could be subtracted from the regulation resistances shown in Fig. 2, if a more accurate picture of circuit performance were required.

It will be seen that regulation resistance is fairly low for voltages below 240 or so, and that it then gets progressively higher as voltage increases. This corresponds, to some extent, to the performance given by a conventional half-wave rectifier circuit. The regulation resistance increases—but not to an unusable value—at the higher voltages, and it then reduces slightly when R_2 slider is at the top end of its track. It is possible that this final improvement is the result of the onset of grid current (which is prevented, in Fig. 1, by the inclusion of R_1).

Throughout the tests with the prototype, the PL81 functioned correctly and gave rise to no trouble.

Building contract placed for new BBC and VHF sound relay station for Shetland

The B.B.C. announces that a contract has been placed with Messrs. Pearson & Tawse Ltd., of Angusfield, Aberdeen, for the construction of the buildings for the new Shetland television and v.h.f. sound relay station which is to be built at Ward of Bressay, some three miles south-east of Lerwick, and for its associated receiving station at Fitful Head. The Shetland station will receive its programme for re-transmission from the B.B.C.'s Orkney station. The Orkney transmission will be picked up at Fitful Head from where the television programmes will be fed by radio link and the three sound programmes by Post office line to the Shetland relay station.

The Shetland station is one of a number of additional stations which the B.B.C. is building to extend and improve the coverage of its television and v.h.f. sound services. The date for the start of the service is dependent upon the completion of the buildings, on which work has now started, but it is hoped to have the new station in operation within about twelve months.

By

G. A. STEVENS

Low-Cost High Fidelity Amplifier

The difficulties involved in constructing a high fidelity amplifier at low cost are well known to audio enthusiasts. This article describes an ingenious approach to the problem and its author offers some thought-provoking views on the subject of the output transformer.

RECENTLY, THE WRITER HAD TO DESIGN A SERIES of 10 watt amplifiers to professional standards and driven at the normal level for such equipment, i.e. OdBm (or 1mW across a 600Ω resistor). This is, in terms of voltage, 775mV. It was important to make each amplifier as cheaply as possible whilst still retaining the highest standards of performance, and considerable care was devoted to designing a circuit with these ends in view. The final design was capable of being built for £6 to £7 only.

The most expensive items in any normal power amplifier are the inductors; these comprising the mains and output transformers and the smoothing choke. Since no compromise could be made in the choice of mains transformer, all economies had to be carried out on the smoothing choke and output transformer. Now, whilst in normal domestic audio amplifiers R-C smoothing has virtually ousted the use of chokes, this is not considered adequate in professional equipment in view of the stringent signal/noise ratio required. However, after several trials it was found that by double-decoupling the supply to the output stage, professional requirements could be met without the use of a choke, the only additional cost being that incurred by using a triple instead of a double capacitor. Since the triple capacitor was available at low cost, there was a considerable saving in cost and space.

The Output Transformer

The output transformer presented a more difficult problem. A transformer designed to sell cheaply means that the manufacturer has had to make economies, particularly in the amount of iron used for the core. This in turn limits the power output, especially at low frequencies, due to magnetic saturation of the core material. However, if a given transformer can deliver 10 watts at 1 kc/s it will be satisfactory if, at the lower frequency limit (about 30 c/s), it can deliver not less than 25% of its rated output, which in this case is 2.5 watts. If the sounds that make up normal speech or music are analysed into their respective frequencies, it can be shown that, for a 10 watt composite signal, the low frequency components form usually less than 1 watt. Obviously the ratio varies with different types of programme material but even an organ, say, gives very little output at low frequencies where core saturation is liable to become evident. Also, since the full 10 watts of the amplifier would not normally be used except to handle transients, which by their nature contain little low frequency components, an additional amount of power becomes available.

Another difficulty arises due to the presence of negative feedback, which includes the transformer. Due to too low a primary inductance at low frequencies, and to too high a leakage inductance and capacitance at high frequencies, a cheap transformer gives rise to phase shifts in an amplifier which can cause peaks in the response, and eventually, if too much feedback is applied, oscillation or squegging. However, by designing an amplifier so that its phase shifts compensate for those in the transformer, and by deliberately controlling the frequency response, quite large amounts of feedback can be applied. In the present design, 19dB of feedback is applied over the main loop and, although the output transformer cost less than a £1, no core saturation took place from 30 c/s upwards for powers of 5 watts or less, giving thereby a very adequate power response at low frequencies. At high frequencies the loop gain of the amplifier is reduced by C_3 to avoid instability. Also, a transformer was chosen with an untapped secondary giving a 15Ω output only (since most high grade speakers are of this impedance) and the simplification of the secondary winding reduces the leakage inductance.

An important consideration in keeping the cost down was in the choice of valves. Whilst double valves (viz. ECL82, ECL86) would initially be cheaper, when one section aged or developed a fault the whole unit would have to be replaced.

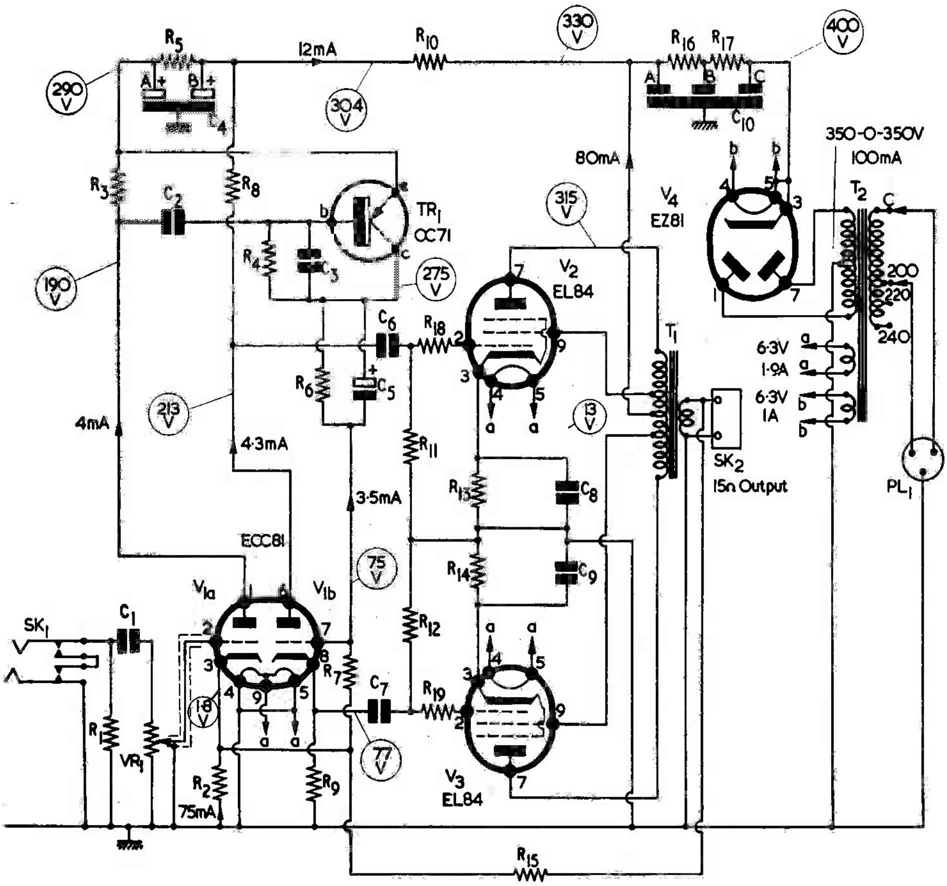


Fig. 1. The circuit of the amplifier, showing voltages and currents at various points. Voltage readings were taken with a Model 8 Avometer (20,000Ω per volt) but, since most points in the circuit are at low impedance, a less sensitive meter could be used

Components List

Resistors

R_1	600Ω	¼ watt	10% carbon
R_2	270Ω	¼ watt	5% carbon
R_3	22kΩ	½ watt	10% carbon
R_4	470kΩ	¼ watt	10% carbon
R_5	1.8kΩ	¼ watt	10% carbon
R_6	56kΩ	1 watt	10% Carbon
R_7	22kΩ	½ watt	10% carbon
R_8	18kΩ	½ watt	1% H.S.
R_9	18kΩ	½ watt	1% H.S.
R_{10}	2.2kΩ	½ watt	10% carbon
R_{11}	330kΩ	¼ watt	10% carbon
R_{12}	330kΩ	¼ watt	10% carbon
R_{13}	330Ω	½ watt	5% carbon
R_{14}	330Ω	½ watt	5% carbon
R_{15}	3.9kΩ	¼ watt	5% carbon
R_{16}	330Ω	5 watts	10% wirewound
R_{17}	470Ω	5 watts	10% wirewound
R_{18}	1kΩ	⅛ watt	10% carbon
R_{19}	1kΩ	⅛ watt	10% carbon
VR_1	1MΩ	pot. log track	

Capacitors

C_1	0.5μF, 150V wkg. paper
C_2	1μF, 150V wkg. paper
C_3	2,000pF, 5% silver mica
$C_{4(a),(b)}$	16+24μF, 350V wkg. electrolytic
C_5	1μF, 250V wkg. electrolytic
C_6	1μF, 250V wkg. paper
C_7	1μF, 250V wkg. paper
C_8	250μF, 25V wkg. electrolytic
C_9	250μF, 25V wkg. electrolytic
*$C_{10(a)}$	80μF, 450V wkg. electrolytic
$C_{10(b)}$	40μF, 450V wkg. electrolytic
$C_{10(c)}$	20μF, 450V wkg. electrolytic

Transformers

T_1*	Output transformer 7000Ω anode-to-anode. Taps at 20%
T_2	Mains transformer. Secondaries: 350-0-350V at 100mA, 6.3V at 1.9A, 6.3V at 1A. (Ellison type MT127 would be suitable)

Valves
V_1 ECC81
V_2 EL84
V_3 EL84
V_4 EZ81

Tagboards
2 off, vertical mounting, each with two rows of 16 tags

Transistor
TR_1 OC71

Sockets
SK_1 Jack socket
SK_2 Small speaker output socket

* C_{10} and T_1 are available from Intrinsic Developments, 80 Kings Road, Berkhamsted, Herts.

Since the output valves have to be replaced more frequently due to their high dissipation, the final choice consisted of a pair of EL84's. Here again, separate cathode bias resistors were used so that the cathode currents are automatically balanced without having to choose matched valves, this also avoiding the need to change both valves should one fail.

The Circuit

As may be seen from Fig. 1, a transistor is employed in the early stages of the amplifier. By using a transistor, a stage gain in excess of 500 may be obtained without trouble with induced hum from the heaters. Due to its low input impedance the transistor has to be driven by one half of an ECC81 ($V_{1(a)}$). $V_{1(a)}$ offers nothing towards the amplification of the circuit. Indeed there is a reduction in the a.f. voltage from the grid to the anode but this is unimportant since the function of this stage is purely to provide a *current* drive to the transistor. The voltage attenuation serves to reduce the overall noise and hum caused by V_1, as well as microphony.[1] The output impedance of $V_{1(a)}$, together with its linearity, is improved by leaving the cathode bias resistor R_2 unbypassed, this also providing a convenient point for the application of the main feedback loop. The signal is then fed via C_2 into the base of the transistor TR_1. Since TR_1, in order to be able to drive the phase splitter fully, has to have 15 volts between emitter and collector, it is advisable to use only first grade transistors here, and not any of the surplus variety which have very large characteristic spreads and may easily break down. The bias for the transistor is provided by R_4 which compensates for the normal spread of characteristics, and which provides negative feedback. The signal is now d.c. coupled to the grid of $V_{1(b)}$. The

[1] The overall gain from the grid of V_1(a) to the grid of V_1(b) is about X100-200 (including an approximate loss of X3 in V_1(a) due to the function of this valve as a current generator).—EDITOR.

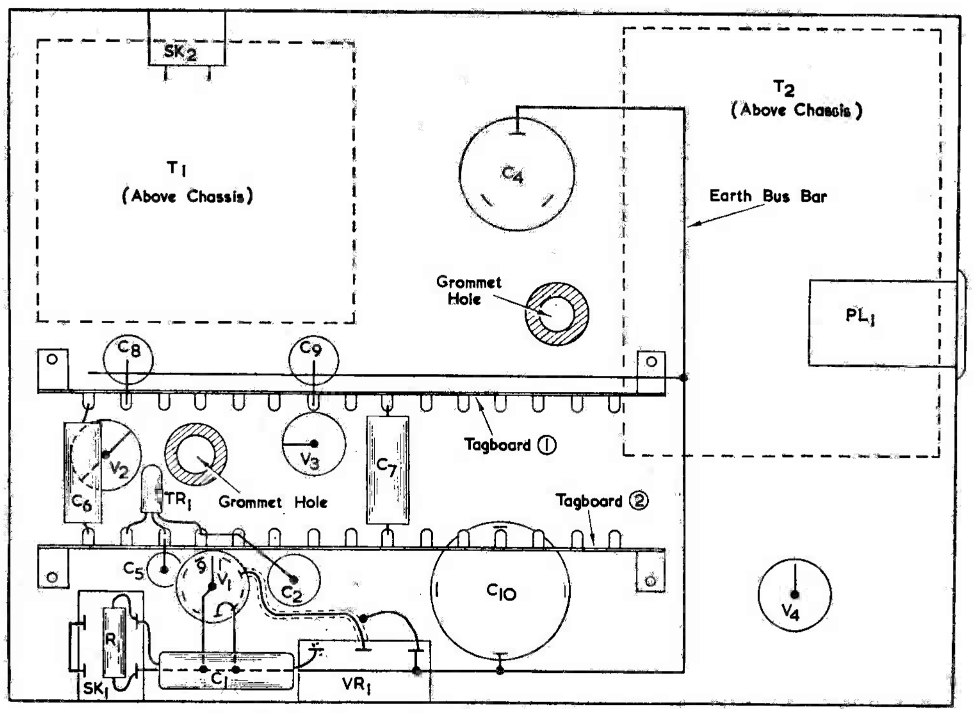


Fig. 2. The layout of the main components below the chassis

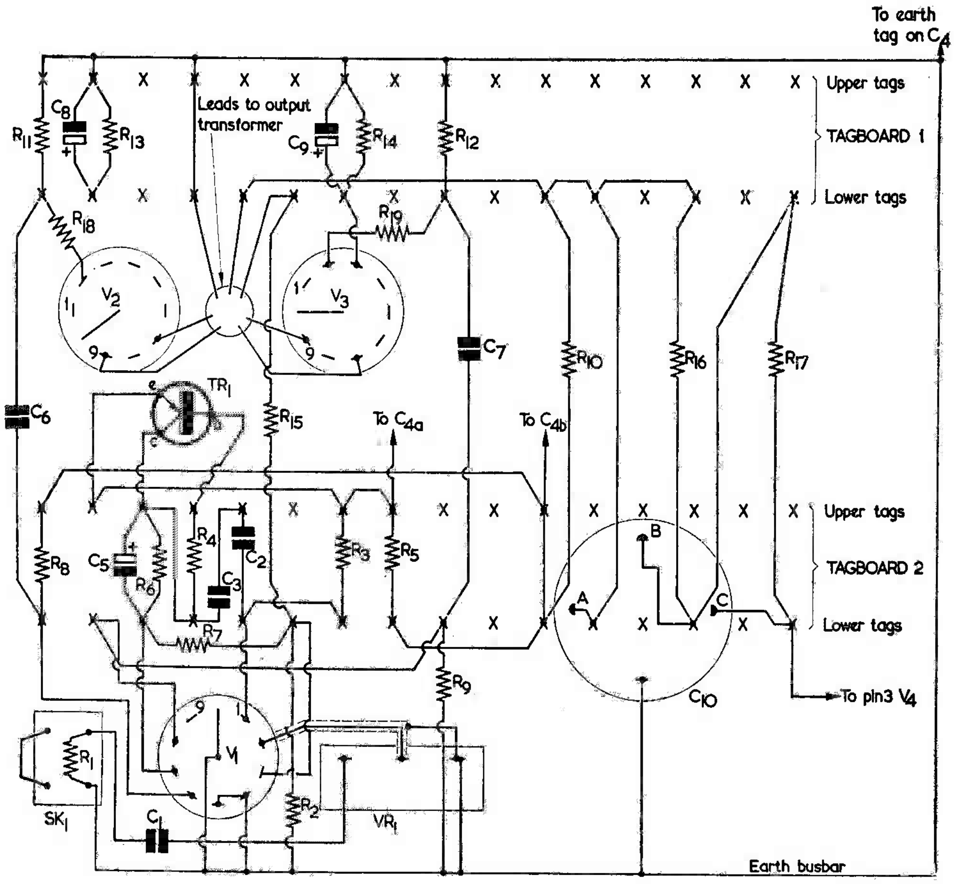


Fig. 3. The wiring and components around V_1, V_2 and V_3. In this diagram the tagboards are shown opened out flat, individual tags being indicated by crosses

divider chain R_6R_7 is coupled to the upper end of R_2 in order to help provide correct bias for $V1_{(a)}$ whilst keeping the value of R_2 down in order that it shall not produce too much reduction of gain.

Although the original amplifier was designed to work from a 775mV signal across 600Ω, the sensitivity may be improved by the substitution of an OC75 for the OC71 in the TR_1 position. R_1 can, also, under these circumstances, be completely removed since it only serves to match the low impedance output source from the pre-amplifier with which this unit was intended to be used.

$V_{1(b)}$ functions as a conventional split load phase-splittter. Its outputs, from anode and cathode, are fed to the control grids of the two output valves V_2, V_3, via their respective coupling capacitors.

The output stage is of the distributed load type with the screen-grids tapped at 20% along the windings. The cathodes of the valves are each separately biased and decoupled to help balance the currents through the output transformer. The values of the decoupling capacitors C_8 and C_9 have been made large by usual standards, in order to improve the phase response at low frequencies. Modern capacitors are now made as physically small as units having a tenth of the capacitance several years ago, and those specified do not take up excessive space. One side of the 15Ω output to the speaker is earthed, the other being connected via R_{15} to the cathode of $V_{1(a)}$ to provide the main feedback loop.

The power supply is conventional, using R-C smoothing throughout. As previously explained, the use of double decoupling ($R_{16}R_{17}C_{10}$) ensures that hum level is reduced to a very low level, and it should be mentioned that, by employing a 350V transformer, the smoothing resistors can be made sufficiently large in value to allow for a 70V d.c. drop across them. Since the amplifier only consumes about 92mA there is sufficient reserve to feed about 5-10mA from $C_{10(a)}$ to a pre-amplifier if needed.

Construction

The amplifier was built on an aluminium chassis measuring 7 x 10in, as shown in the layout diagram, Fig. 2. No trouble should be found in construction provided this layout is followed. Sufficient space has been left around both transformers to allow for variations in their size without cramping any other component. Whilst it was not needed in the original, a base plate on the chassis might be useful if the amplifier is mounted above any other unit that may radiate hum into the wiring. So far as the reduction of hum is concerned, there are one or two important wiring points that should be adhered to. The first of these concerns the earthing in the amplifier. All earths are taken to a J-shaped busbar made of 16 s.w.g. tinned copper, one end of which connects to the earth tag on SK_1 (the input jack socket), the other end terminating at the earth tag of C_4 as illustrated in Fig. 2. Both C_4 and C_{10} should be isolated from the chassis either by putting tape between their cans and their mounting clips or, as in the writer's amplifier, by the use of prong mounting capacitors mounted on insulated plates. The upper row of tags on tagboard 1 are also connected to the main busbar by another length of 16 s.w.g. wire, see Fig. 2. The chassis connection to the busbar is made via a tag placed under one of the fixing screws for V_1 valveholder.

The heaters of V_1, V_2 and V_3 are connected by a tightly twisted pair of wires, and the only connection to chassis is at pins 4 and 5 of V_1 to the busbar. It was found that centre-tapping the heaters made no appreciable difference in the hum level compared with that given by the present method, and so this simpler scheme was adopted.

The only other point in the construction that is not immediately apparent from the layout diagrams is that one of the fixing holes for tagboard 1 is under the mains transformer, and so it should be countersunk and the tagstrip mounted before the transformer is fitted. The wiring layout for the main components on the tagstrips is given in Fig. 3.

Performance

When the wiring is completed and checked, the amplifier may be turned on and the voltage checked against those marked in the circuit diagram. Small

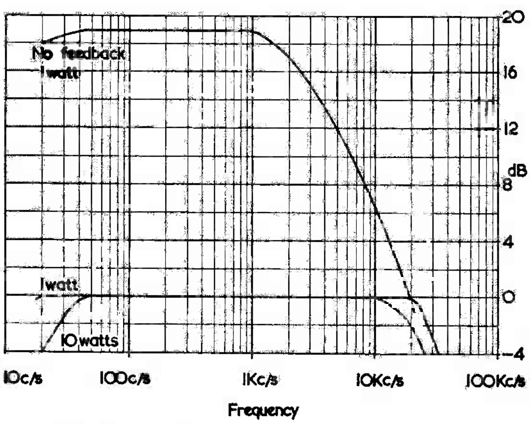


Fig. 4. The frequency response of the amplifier

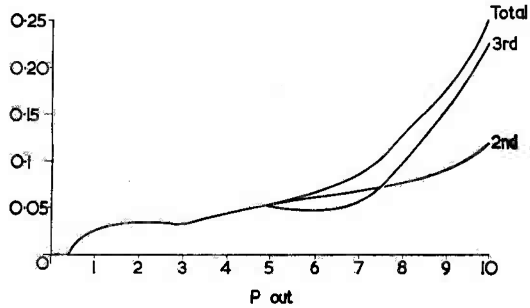


Fig. 5. Distortion at 1 kc/s

differencies are to be expected but large variations should be investigated, as they indicate either faulty components or wiring errors. Particular care must be taken with the circuitry associated with the transistor. If, on switching on, the amplifier breaks into oscillation, it should be switched off at once, and the connections to the secondary of T_1 should be reversed.

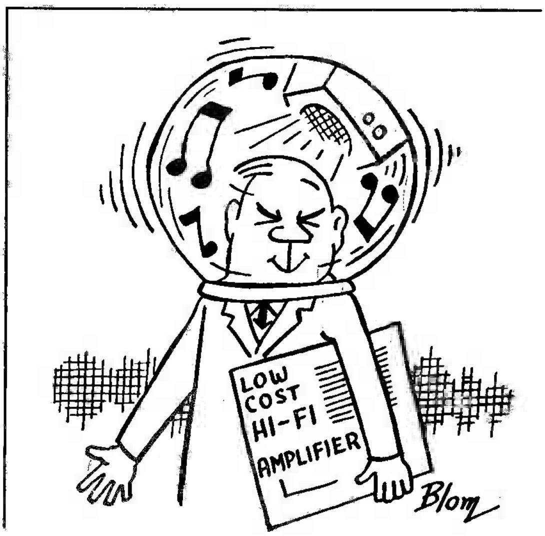
TABLE

Amplifier Performance

Power Rating*	10 watts
Frequency Response*	Below 10 c/s to 30 kc/s ±3dB
Distortion*	0.1% at 7.5 watts output
Input Level	0dBm (1mW across 600Ω) =775mW
Signal/Noise Ratio	−90dB (0dB=10 watts)
Feedback (in main loop)	19dB

* Measured with continuous sine wave drive. With normal speech or music the maximum output, and output level for a given distortion, will be increased by a factor of 10 to 20%.

The distortion and frequency response figures of the original amplifier are shown in Figs. 4 and 5.



The power response was taken at 10 watts, but although the feedback maintained the output voltage down to 25 c/s, core saturation caused distortion of the wave shape and so, as previously stated, the power level should be restricted to about 4 to 5 watts at these frequencies.

Even with the ear placed close to the speaker enclosure the hum and noise level was completely inaudible. Since the earlier versions of the ECC81/12AT7 used to be rather prone to microphony, the amplifier was checked for this by tapping the valve gently, whereupon the microphonic noise was almost inaudible. In normal use no microphony was apparent at all.

All the relevant performance figures are set out in the Table. Unfortunately, due to lack of a suitable generator, it was not possible to plot the response below 20 c/s, but at this figure the phase and amplitude response was so good that the response must extend down to a much lower frequency before falling off. Since the application of a continuous sine wave shifts the d.c. working points of the valves, the power ratings given in the power output and distortion figures will be improved by a considerable factor with normal speech and music.

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.

Bosch Car Radio.—P. A. Booker, 6 The Ridings, Hare Hill, Addlestone, Surrey, would like the circuit and data of this 12V American model X636-12. Valve line-up 77, 77, 78, 75, 42, 84.

* * *

Indicator Unit Type 97.—P. N. Roberts, 31 George Frederick Road, Sutton Coldfield, Warks, requires the circuit or manual.

* * *

Raymond TV Model F11B.—H. Wildash, 4 Bibury Avenue, Woodhouse Park, Wythenshawe, Manchester, 22, wishes to acquire the service sheet or manual, also the present address of the manufacturer.

* * *

Minivox C Tape Recorder.—R. Hutchinson, 102 Durley Avenue, Pinner, Middx, requires the circuit diagram. Also would like to receive information on the construction of a mains unit to eliminate the batteries.

* * *

R.G.D. Mk.103 Tape Recorder.—R. J. Ridge, 13 Sycamore Drive, Finchfield, Wolverhampton, Staffs, would like to borrow or purchase the operating instructions and/or circuit diagram for this recorder.

* * *

Philips Radiogram BX600A.—A. Jaques, 185 Bispham Road, Blackpool, Lancs., requires the service sheet for this Dutch built chassis.

* * *

Indexes.—R. K. Lloyd, Box 1164, Lusaka, North Rhodesia, Central Africa, would like to obtain indexes for *The Radio Constructor* 1961 and 1962; *Practical Wireless* from 1950 onwards and *Wireless World* 1950 to 1955 inclusive.

TR5043 Unit.—C. Hall, St. Peter's College, Saltley, Birmingham, 8, would like to buy or borrow the circuit diagram and any other information in respect of this unit which comprises the BC625A transmitter and the BC624A receiver.

* * *

BC348.—E. A. Bilton, 26 Beulah Hill, London. S.E.19, requires the circuit or manual, borrow or purchase.

* * *

Receiver type R100-URR.—M. P. Donaghy, P.O. Box 790, Salisbury, Southern Rhodesia, urgently requires the circuit or manual, together with any modification details.

* * *

Twin Tube Unit 110QB/13.—A. G. Gaunt, 6 The Bungalows, Leeming Bar, Northallerton, Yorks., is in need of any information with respect to this unit—especially interested in conversion of this, or an old B.B.C. only TV receiver, to an oscilloscope —all letters answered.

* * *

R1224A Receiver.—F. Bending, "Seychelles", 108 St. Katherines Road, Exeter, Devon, would like to purchase the service manual of this battery operated receiver.

* * *

Band I (40 Mc/s).—J. Newgas, Madison Lodge, Compton Avenue, London, N.6. Will any reader who has developed any circuits for a cheap transistor receiver or a crystal radiation detector please contact the above reader.

Inexpensive Medium and Short Wave Receiver *by Ian Macdonald*

Our contributor describes a three valve receiver covering the Medium and Short wavebands which will be of particular interest to the experimenter. A special feature of the receiver is a novel reaction circuit which allows very simple coils to be employed

THIS RECEIVER IS INTENDED BOTH FOR BEGINNERS and for experimenters. Although the design employs only one tuned circuit, it performs well on both the bands covered. In the prototype, coils for the Medium and Short waveband are used, but it is possible to wind coils to cover other ranges as well, should this be desired.

The Circuit

The circuit appears in Fig. 1. In this diagram, V_1 functions as a leaky-grid detector, the associated grid capacitor and grid leak being C_3 and R_3. The cathode of V_1 taps, via S_2, into either L_1 or L_2, whereupon the circuit takes up the form of an electron-coupled oscillator. This configuration allows the provision of reaction whilst employing coils which consist of a tapped tuned winding only. Reaction control is effected by potentiometer R_1, which varies the voltage on the screen grid.

The aerial connection is made at the cathode. It will be noted that, as with reaction windings, no aerial coupling windings are needed at all.

Capacitors C_5 and C_6 bypass r.f. voltages appearing at the anode of V_1.[1] This anode is coupled, via screened cable, to C_7 and, thence, to the grid of V_2. The anode and screen grid of V_2 are strapped together, with the result that this valve functions as a triode a.f. amplifier, the signal on its anode being passed, by way of C_{10}, to the volume control R_8. A further r.f. bypass component is provided by C_9. The slider of R_8 connects to the grid of output valve V_3, which feeds the speaker in conventional manner.

The receiver circuit does not include a power

[1] It is possible that a single 200pF capacitor, connected at the anode in the C_5 position, would function as well as the two 100pF components shown.—EDITOR

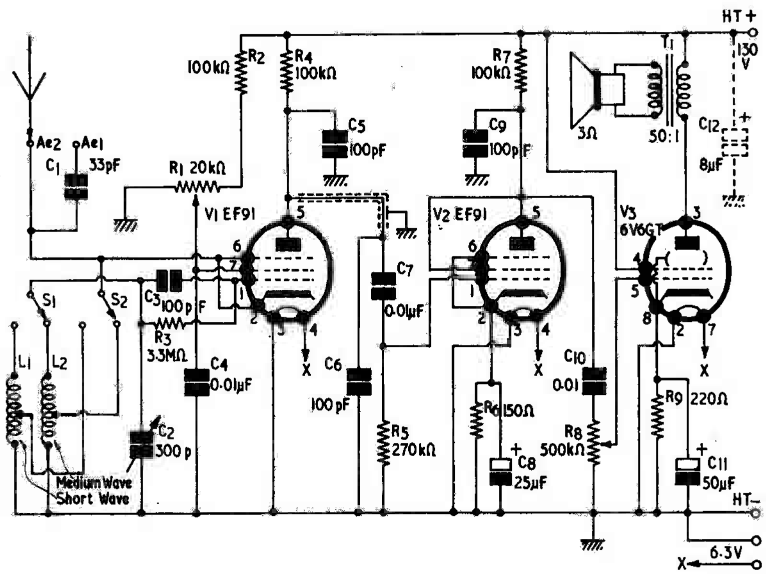


Fig. 1. The circuit of the receiver. In the practical layout, resistor R_4 connects to the anode of V_1 at the remote end on the screened cable

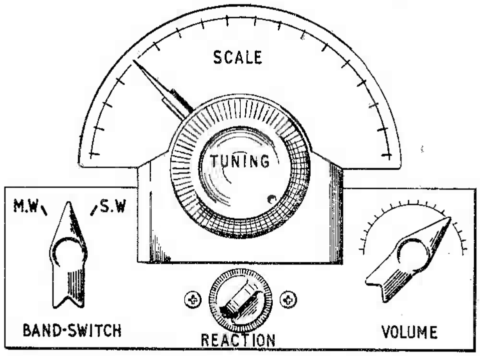


Fig. 2. The layout of the controls

Above-chassis view of the receiver

supply, as it is felt that many constructors will either have a suitable supply already available, or have access to a receiver or similar item of equipment which can provide the voltages needed.

The power requirements of the receiver are 6.3V at 1.05A for the heaters, and approximately 130V h.t. at 35mA. The h.t. supply should have a smoothing capacitor connected across its output terminals. If such a capacitor is not fitted, an additional 8μF capacitor should be connected between the h.t. positive line and chassis in the receiver itself, as shown, in dotted line, by C_{12} in Fig. 1. Such a capacitor may be desirable, in any case, if the leads to the power supply are long.

Construction

The large components are mounted as shown in Figs. 3 and 4. Some of the resistors and capacitors are mounted on a 12-way tagboard positioned on the underside of the chassis, whilst the remainder are mouuted between the valves and the coils.

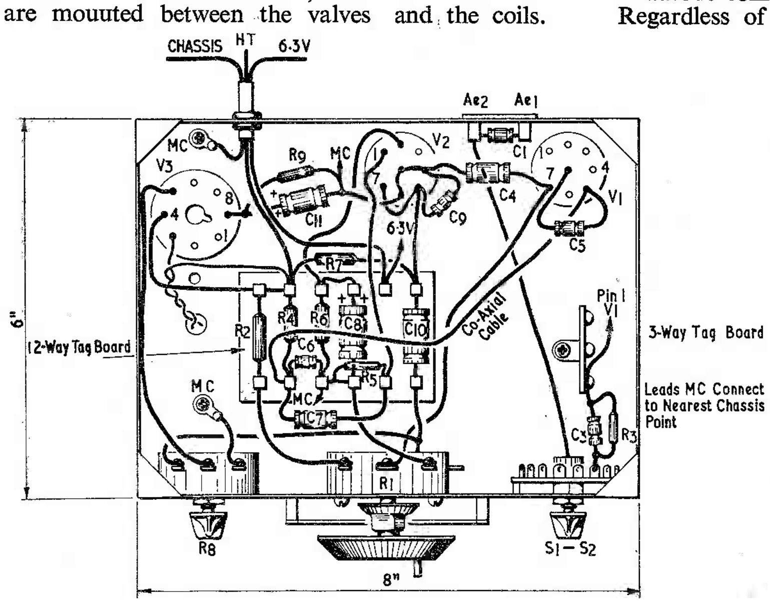


Fig. 3. The principal components below the chassis

The layout shown in Fig. 3 should be followed as closely as possible, and wiring should be kept short. Coaxial cable is used between the anode of V_1 and C_7 to prevent undesirable feedback. A slow-motion drive for C_2 is necessary as tuning is sharp. Any drive may be utilised, and that employed in the prototype was removed from an R1132A receiver, obtainable on the surplus market. This gives a ratio of 36:1 and has proved very successful. The loudspeaker is not shown as it is mounted externally. A cabinet may, of course, be built to house both the receiver and speaker if desired.

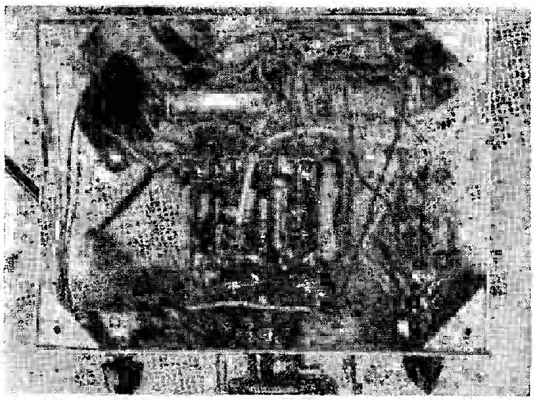
Coil Design

Coil design is of a very simple nature, since each coil consists of one winding only, with a tap for the cathode connection.

Regardless of the frequency coverage, all coils employed with this circuit should have the tap approximately one quarter of the total number of turns from the earthy end of the winding.

The Short wave coil is wound with 20 s.w.g. enamelled copper wire, and consists of 15 turns. The first 8 turns are wound on the former, and the next 7 turns are interwound with these. The tap then appears on the 12th turn. The finish of the winding is the earthy end of the coil. The former is of ¾in diameter, the winding being spaced over a length of ¾in on the former. (See Fig. 5 (*a*)).

The coil for Medium waves employs 32 s.w.g. d.c.c. copper or litz wire. It consists of 100 turns, wound in 10 layers of 10 turns each. The complete coil



Showing layout of components below the chassis

covers a length of 1in on a 1in diameter Paxolin former. The coil was impregnated in wax after completion, as shown in Fig. 5 (*b*).

Aerial coupling windings were tried but found unnecessary. The set performs satisfactorily with coils of the type just described up to 35 Mc/s. On frequencies higher than 35 Mc/s the receiver becomes unstable and difficult to tune properly. It will, however, operate very well on low frequencies down to about 500 kc/s.

Aerials

Two socket positions are provided. Ae1 is the Short wave aerial connection and Ae2 is the Medium wave aerial connection. However, the Ae2 socket may be used for all bands if prevailing reception conditions are good.

A long wire of about 40 feet using single 5 amp mains flex will work satisfactorily on Medium waves, and on Short waves up to 10 Mc/s. For higher frequencies the aerial should be shorter for best results.

Operation

The loudspeaker is connected directly to the output transformer by means of a twisted flex. If phones are preferred, a socket to suit a normal jack plug can be fitted on the rear panel of the chassis behind V_3.

The tuning scale employed in the prototype is marked in degrees (i.e. 0 to 180) and a calibration chart can be made by logging the stronger stations and noting their frequencies. Alternatively, the dial can be calibrated directly.

The Medium wave coil described is tunable from 200 to 400 metres, due partly to the low capacitance in C_2. If it is required to tune over the whole of the Medium waveband it would be preferable to make S_1 and S_2 a 3-way switch and fit an extra Medium wave coil.

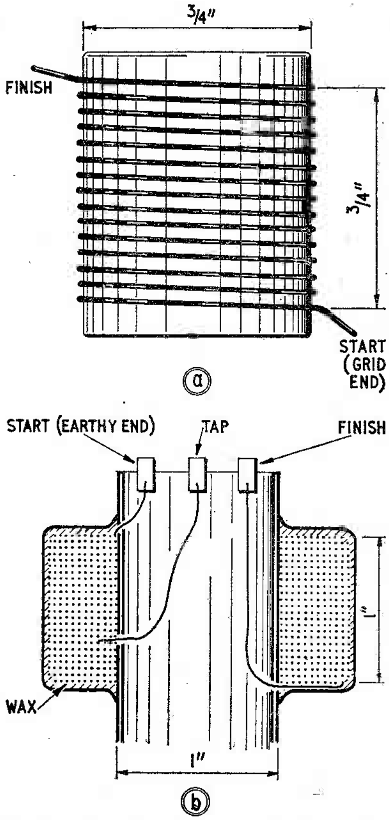


Fig. 5 (a). The short wave coil, L_1, for 18 to 35 metres. This comprises 15 turns of 20 s.w.g. enamelled copper wire, the last 7 turns being interwound between the first 8 turns. The cathode tap (not shown here) appears at the 12th turn from the start

(b). The medium wave coil, L_2, which covers 200 to 400 metres. It consists of 100 turns of 32 s.w.g. d.c.c., or litz, wire wound in ten layers of 10 turns each. The tap is made 25 turns from the start

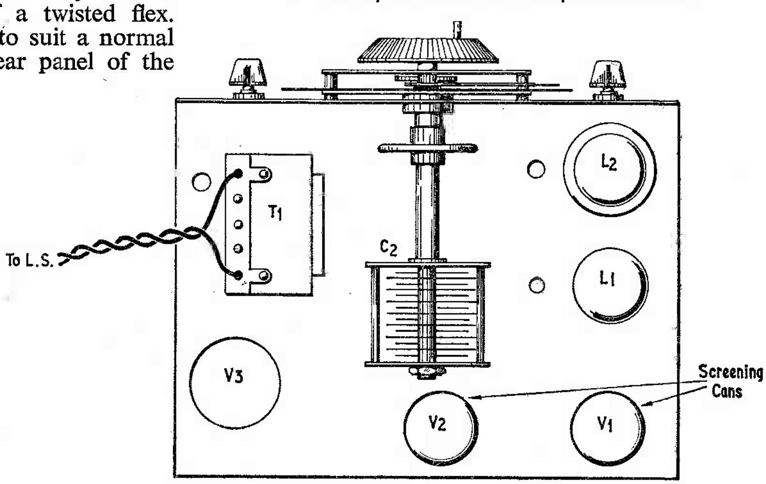


Fig. 4. The above-chassis layout

One coil could then tune from 200 to 400 and the other from 350 to 700 metres.[2]

Many constructors may wish to dispense with the Medium wave coil and fit an extra Short wave coil instead. The coil described here tunes from 18 to 35 metres approximately. Experimenting with different coils for the Short waves can be very interesting. So long as the comments concerning coil winding given here are borne in mind, no difficulties should be experienced.

The wavechange switch can have as many ways (up to 6-way) as required, this enabling different coils to be switched in.

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[2] The relatively low coverage on Medium waves may be partly due to a high self-capacitance in the coil, and this could be reduced by dispensing with the wax impregnation. Increased coverage would be given, also, by employing a larger capacitor in the C_2 position.—EDITOR.

Components List

Resistors

(All fixed resistors ¼ watt unless otherwise stated)

- R_1 20kΩ wirewound pot
- R_2 100kΩ
- R_3 3.3MΩ
- R_4 100kΩ
- R_5 270kΩ
- R_6 150Ω
- R_7 100kΩ
- R_8 500kΩ pot, log track
- R_9 220Ω, ½ watt

Capacitors

- C_1 33pF, silver mica
- C_2 300pF variable
- C_3 100pF, silver mica
- C_4 0.01μF, paper
- C_5 100pF, silver mica
- C_6 100pF, silver mica
- C_7 0.01μF, paper
- C_8 25μF, 12 V wkg., electrolytic
- C_9 100pF, silver mica
- C_{10} 0.01μF, paper
- C_{11} 50μF, 12V wkg., electrolytic
- C_{12} 8μF, 250V wkg., electrolytic (if required—see text)

Inductors

- L_1 Short wave coil—see text
- L_2 Medium wave coil—see text
- T_1 Speaker transformer, ratio 50:1

Valves

- V_1 EF91
- V_2 EF91
- V_3 6V6GT

Switches

- S_1, S_2 2-pole 2-way single wafer wavechange switch

Miscellaneous

- 2 B7G valveholders with skirts and screening cans
- 1 International octal valveholder
- 1 Slow motion gear, dial and knob, with spindle coupling
- 3 Pointer knobs (2 only if R_1 is type shown in illustration)
- 1 Aerial socket panel
- 1 12-way tagboard (See Fig. 3)
- 1 3-way tagstrip (See Fig. 3)
- 1 Chassis 8 x 6in, aluminium

EMI TV CAMERAS PROVIDE SHOW PREVIEW

Visitors to the British Industries Fair in Zurich will be able to see a preview of some of the principal exhibits before they enter the exhibition.

Nine EMI closed-circuit television cameras, positioned at suitable points in the three main exhibition halls, will transmit pictures of the various stands and displays to receivers erected in the main entrance hall of the Hallenstadion.

The latest EMI Type 8 all-transistor cameras will be used. These cameras are completely self-contained and will be linked directly by co-axial cable to a bank of nine standard domestic TV receivers in the entrance hall.

In general the cameras will show panoramic views of the exhibition but some will be fitted with special lenses which will allow close-up shots of display details.

Among the special events which will be televised on closed-circuit by the cameras will be the official opening ceremony on 2nd September.

BRADFORD TECHNICAL COLLEGE

Department of Engineering

Courses will be held for City and Guilds Radio Amateurs' Examination (Lecturer: D. M. Pratt, G3KEP) and G.P.O. Amateur Radio Morse Test (Instructor: A. W. Walmsley, G3ADQ) during the 1963–64 session on Wednesday evenings from 7 to 9 p.m.

The Morse class may only be attended if a pass has been obtained in the Radio Amateurs' Examination.

The fee for each course is £1 10s. (over 18). There is no fee for students under the age of 18.

Registration takes place from 6.30–8.30 p.m. on Monday and Tuesday, 9th and 10th September, at Bradford Technical College, Great Horton Road, Bradford 7.

Further details of the courses may be obtained from G3KEP.

News and Comment

I.A.R.U.

Some 80 delegates, representing 18 European countries, attended the recent International Amateur Radio Union Region 1 conference in Malmo, Sweden. These conferences are held every third year in a different country and at them matters affecting amateur radio are discussed and recommendations made to the respective national societies.

Such topics as the relationship between amateur bands and the new Geneva Radio Regulations; the European Band Plan with special reference to top band; rules for Dx and v.h.f. contests; co-operation of amateur scientific observers with professional workers during the International Quiet Sun Year; Radio Amateur Emergency Networks (a paper on this subject was given by our Managing Editor, Dr. Arthur C. Gee, G2UK); Amateur Radio News Bulletins, etc.

At the opening session, one of the subjects which aroused particular interest was the "intruder watch" operated on behalf of the Radio Society of Great Britain by Major Haylock, G3ADZ. Major Haylock and a group of short wave listeners monitor the amateur bands and check on all unauthorised radio transmissions which appear in them. The frequencies of these are measured and they are identified if possible, details being sent via the R.S.G.B. to the G.P.O., who endeavour to check such illegal activity if they possibly can do so. It was hoped by delegates at the conference that somewhat similar schemes could be brought into action by other national amateur radio societies.

The "intruder watch" is another of those R.S.G.B. services which rarely attracts the attention of the average radio amateur enthusiast, but which has in its quiet way done much to remove jammer and offending commercial stations, broadcast station harmonics, etc. from the amateur bands.

Electronic Ear

Two Californian brothers—a neuro-surgeon and the head of an electronics firm—have devised an electronic ear that has given hearing to a woman born completely deaf. John and James Doyle now hope to perfect techniques which will give hearing to many more people who cannot be helped by standard hearing aids.

In a series of experiments, Dr. John Doyle, of the University of Southern California School of Medicine in Los Angeles, implanted his brother's electronic device in the skull of nine patients, all of whom were able to discern sounds afterwards. The artificial ear weighs only two ounces and causes no discomfort when recessed into the skull.

An outside microphone picks up sounds, and the device stimulates an auditory nerve deep within the cochlea, an internal passage of the human ear. This in turn, transmits the sound to the brain.

James Doyle says his device works with totally deaf persons whose auditory nerves were thought to be completely inactive. He is now working on a thinner version of the artificial ear, which it should be possible to implant under the skin without recessing it into the skull.

Road Safety Record

From an idea by F. C. Judd, A.Inst.E., a popular contributor to this magazine and author of our recently published *Radio Control for Models*, the first gramophone record on road safety has been created. The stars of the record are Jack Warner, known to 15,000,000 viewers as P.C. Dixon of Dock Green, and Coco the Clown, O.B.E., otherwise Nicholai Poliakov, circus idol of children everywhere.

The two stars have given their services free and donate the entire royalties of the record sales to charities.

The script for Jack Warner's recording was written by F. C. Judd, who also produced the master sound tracks, complete with authentic effects.

Few people know that Jack Warner is an experienced racing driver and knows only too well the hazards that face everyone who takes a vehicle on the roads of Great Britain today. He began his working life as a motor mechanic and after studying motor engineering, became a car testing driver in France, which accounts for his familiarity with the French language.

Coco, O.B.E., of Bertram Mills Circus, International clown and author is known to millions of children everywhere. Of equal merit is his work for Road Safety, which began as the result of a serious accident to a child. It is this story that Coco tells on the record; "The Story of Charlie" which carries a vital message to all children. The recording was made by F. C. Judd when Coco told the story to some 300 young children at a school in South London. This is a story that must be told to *every* child and only the soft appealing voice of Coco can impart the vital message it contains.

Coco has won many awards for his road safety campaign. He is a star driver and a Knight of the Road, but his most coveted is the Order of the British Empire bestowed upon him recently for one of the most outstanding efforts on the part of one man to keep death off the roads.

Further information may be obtained from: F. C. Judd, 174 Maybank Road, South Woodford, London, E.18. Telephone: BUCkhurst 9315.

Simultaneous Translating System

The Westminster Theatre, London, will, it is believed, be the first theatre in the United Kingdom to install a simultaneous live translating system which will enable parties of 25 or more foreign visitors to follow the action of the play in their own language

Some months ago, when a party of German visitors visited the theatre to see "Through the Garden Wall", the management hired the translating equipment as an experiment. Each visitor was given a small transistorised receiving set, equipped with earphones, and a German translation of the play was relayed from the projection room. The experiment was so successful that the management decided to install the equipment permanently. The plan is to engage one actor and actress for each of the translations. With the present receivers it will be possible to have four translations of the performance being given at one time. The receivers have a numbered dial and foreign visitors will be informed which number to turn to receive the translation in their own language.

The equipment which has been installed by Phillips is the same in principle as that which is used by the United Nations.

The twenty-fourth in a series of articles which, starting from first principles, describes the basic theory and practice of radio

part 24

understanding radio

By W. G. MORLEY

IN LAST MONTH'S CONTRIBUTION TO THIS SERIES we continued our discussion on iron-cored transformers by examining leakage inductance, transformer efficiency and impedance matching. We shall now carry on to several practical applications of iron-cored transformers.

Some Practical Applications

Iron-cored transformers are very frequently employed in radio work, and a common application is given in the power supply circuits for valve radio receivers. Valve radio receivers require two sources of supply, one being at a low voltage for the valve *heaters* and the other being at a high voltage for the *high tension* circuits. We shall examine heater and high tension circuits in detail when we come to discuss the valve, but it is sufficient for the present purpose to recognise the fact that such supplies are required.

A typical transformer suitable for meeting heater and high tension requirements is shown in Fig. 144 (*a*). The transformer primary connects to the mains supply via the receiver on-off switch, and the two secondaries feed the heater and h.t. circuits respectively. The heater secondary, or "heater winding", would offer, typically, 6.3 volts at some 0.5 to 1.5 amps; whilst the high tension secondary would normally offer some 200 to 300 volts at currents ranging from 30 to 75mA.

A receiver is normally built on a metal chassis and it is convenient to use the large area of metal this provides as a common point for the various circuits in the receiver. The transformer of Fig. 144 (*a*) could then be wired up in the manner shown in Fig. 144 (*b*), wherein one end of each of the secondary windings is connected to the receiver chassis.[1] This is a practice which will be found in a number of receivers.

A very important feature of the circuit of Fig. 144 (*b*) is that, whilst the transformer provides the heater and high tension voltages required by the receiver, there is no direct connection between the chassis and the a.c. mains supply. The chassis is completely isolated from the mains supply and there is no risk of shock if it is touched. In consequence, all the metal appendages which are fitted to the chassis, such as knob spindles, chassis mounting bolts, etc., are similarly isolated from the mains supply.

An alternative type of receiver power transformer is illustrated in Fig. 144 (*c*). In this case, the transformer has a heater secondary only, and the receiver obtains its high tension supply direct from the a.c. mains. Since the mains supply now replaces the high tension secondary, one side of the mains input is connected to the receiver chassis. When compared with Fig. 144 (*b*) the circuit of Fig. 144 (*c*) has the advantage of employing a cheaper transformer, and of thereby saving cost. On the other hand, it has the disadvantage that the chassis is now connected to the mains supply and that there is a very real danger of serious shock if the chassis, or any of its metal appendages, is accidentally touched. In consequence, the chassis of a receiver having a power supply circuit such as that of Fig. 144 (*c*) has to be completely enclosed in an insulating cabinet, and all external metalwork must be isolated from the chassis or suitably covered by insulating materials. In the case of knob spindles, such insulation would be provided

[1] It will be noted that Fig. 144 (*b*) introduces a new circuit symbol, this representing the receiver chassis.

by the knobs themselves.

The type of transformer employed in the circuit of Fig. 144 (*c*) is frequently described as a *heater transformer*, since its function is to provide a voltage for the valve heaters only. In general, all transformers which offer power for radio receivers are described loosely as "mains transformers", in order to differentiate them from any other transformers which may be employed in the receiver. When a receiver chassis is connected to one side of the mains supply, as in Fig. 144 (*c*), the receiver is described as having a "live" chassis.

There is another form of "live" chassis power supply which may be briefly mentioned here. In this, the high tension supply is obtained direct from the mains, as in Fig. 144 (*c*). The valve heaters are not, however, fed from a heater transformer. They are, instead, wired up in series and connected across the mains supply via a resistor of suitable value. This type of power supply does not employ a transformer and it is often described as a *transformerless power supply* in consequence. As with the circuit of Fig. 144 (*c*), the chassis is connected to one side of the mains supply and the same precautions against shock have to be observed.

A somewhat dramatic example of what may be achieved with the aid of transformers is offered by the familiar National Grid network which carries electrical power across the country. The potential of the supply appearing across conductors in the National Grid is very high, and a figure of 132,000 volts is quite representative. The Supergrid operates at 275,000 volts, whilst equivalent systems in Sweden and Russia operate at about 400,000 volts. The function of the Grid system is to ensure that power generated at one end of a Grid "transmission line" may be absorbed at the other end with as little loss as possible in the line itself. Such loss will be given by the power dissipated, as heat, in the inevitable resistance in the line by reason of the current which flows through it. It is also desirable, on economic grounds, to employ as thin a conductor for the line as is reasonably practicable. The solution to these two requirements consists of employing a transformer to step up the voltage at the generator end of the line to a very high figure, and of using a second transformer at the receiving end to step the voltage down again, as shown, in simplified form, in Fig. 145. At the generating and receiving ends, there is a low voltage at a high current but, over the line itself, there is a high voltage at low current. In consequence, losses due to the resistance of the line are kept at a low level, and it becomes possible to effectively transmit very large powers by way of conductors which are, themselves, capable of carrying relatively small currents only.

Although this method of operation lies outside the field of radio, the principle involved is of importance. When, in radio work, power has to be transmitted over a cable or a line, it is quite often desirable to keep losses due to the resistance of the cable at a low level by employing a transformer at one or both ends. The cable is then caused to carry a low current at a relatively high voltage.

Magnetic Shielding

Because of their leakage inductances, all iron-cored transformers cause a magnetic field to appear about them. In some cases this field may result in an undesired coupling with another iron-cored transformer or inductor, whereupon it becomes necessary to reduce this coupling to an acceptable minimum.

The simplest and most obvious method of reducing the effect of the unwanted coupling is to position the two iron-cored components at a distance from each other. Further alleviation may be obtained by orienting them in relation to each other, and it is usually found that a low coupling is provided when the core axes are at right angles to each other, as in Fig. 146. Another technique consists of winding the transformer which radiates the field in

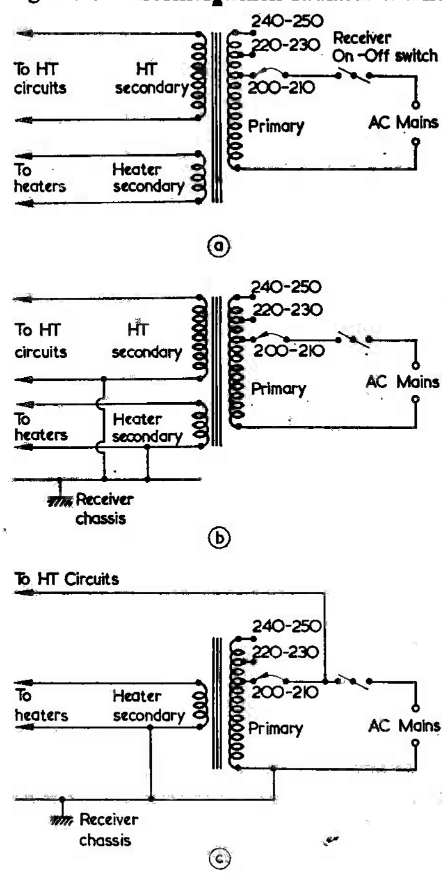


Fig. 144 (a). A typical mains transformer, as employed in a valve radio receiver. The taps in the primary allow for different mains supply voltages
(b). In a practical receiver, one side of the h.t. secondary and one side of the heater secondary may be connected to chassis
(c). An alternative arrangement consists of dispensing with the h.t. secondary of the transformer and of applying the mains input direct to the h.t. circuits

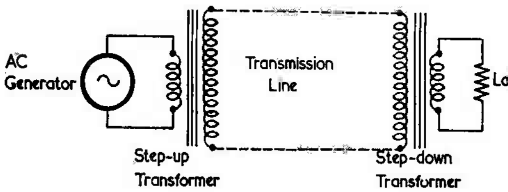


Fig. 145. Illustrating, in simplified form, the operating principle employed for transmitting electrical power over long distances

such a manner that its external field is low, and this may be achieved with a construction of the type illustrated in Fig. 147. Equal sections of the primary and secondary appear in both windings, with the result that each produces an equivalent and opposing field. The two fields tend to cancel each other out, particularly in the plane which passes between the windings at right angles to the laminations. However, transformers of this type are considerably more expensive to manufacture than conventional components and are not generally encountered in normal radio work.

The coupling between two iron-cored components may be reduced by introducing *magnetic shielding* between the two. In Fig. 148 (*a*) we see that the field from the iron-cored transformer on the left is capable of causing an unwanted coupling with a second iron-cored component on the right. In Fig. 148 (*b*) a shield made of high permeability material is interposed between the two components. The lines of force which reach the shield now flow through it instead of through the air, which has much lower permeability, and they do not extend beyond the shield. In consequence, the effect of the unwanted coupling is reduced.

In practice, the process of interposing a magnetic shield between two components, as in Fig. 148 (*b*), does not completely remove the coupling, because the field appears over a much wider area than can be occupied by a flat shield. For greater effectiveness it is desirable to have one of the components completely enclosed inside the shield, as in Fig. 148 (*c*).

It is more usual to shield the iron-cored component which is affected by the field than the component which generates it. The field about the affected component is bound to be weaker than that around the component which generates it, with the result that a given thickness of shield material has a greater shielding effect. In addition, it frequently happens that the affected component is smaller than the component which generates the field, a factor which makes it economically preferable to shield the former.

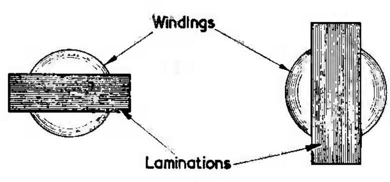


Fig. 146. The magnetic coupling between two iron-cored components may be reduced by mounting them with their axes at right angles, as shown here

Fairly adequate magnetic shielding may be provided by mild steel sheet, and it is a common practice to house iron-cored components which may be affected by external fields in mild steel containers. Much more effective shielding is provided by the high permeability materials such as Mumetal. Mumetal is very frequently used when highly efficient magnetic shielding is required.

The Choke

When, before we came to the subject of transformers, we dealt with inductance, we omitted any reference to the *choke*. This omission was intentional, and was due to the fact that chokes cannot be discussed in full without an understanding of iron cores.

A choke is, quite simply, an inductor, and its

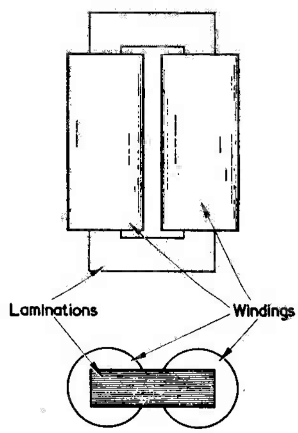


Fig. 147. A method of transformer construction which results in reduced external magnetic field. Equal sections of the primary and secondary appear in both windings

function is to offer an inductive reactance in any circuit in which it is fitted. Normally, a choke allows the passage of direct current, but it offers a relatively high impedance to radio frequencies or to audio frequencies. In some instances a choke is employed to offer a high impedance to radio frequencies and a low impedance to audio frequencies.

In the same manner as transformers, chokes may be either air-cored or iron-cored. Chokes intended for operation at radio frequencies are almost invariably air-cored, and components of this nature are, indeed, normally referred to as *radio frequency chokes*. They are presented on a circuit diagram by the standard symbol for inductance, and are usually identified by the letters "R.F.C." alongside, as in Fig. 149 (*a*).

Practical radio frequency chokes take up a number of forms, according to their inductance and function, and several typical examples are illustrated in Fig. 150. In Fig. 150 (*a*) the choke consists of several wave-wound pies connected in series to offer a low self-capacitance. This point is of some importance in radio frequency choke design because a high self-capacitance may offer a low capacitive reactance and thereby partly nullify the effect of the choke's high inductive reactance. The choke of Fig. 150 (*b*) employs a single wave-wound pie, whilst that of Fig. 150 (*c*) consists of a single layer of winding wire only. It is fairly usual to wind r.f. chokes on plastic formers in which the lead-out wires are imbedded. Quite frequently, single-pie or single-layer chokes are wound on conventional ceramic-coated composition rod resistors. In some cases, these resistors are intended to modify the functioning of the choke by offering resistance in parallel with it but the resistors are more frequently employed merely as convenient and inexpensive formers with lead-out wires. In the latter instance, the resistance value would be of the order of 1MΩ or more, in order to avoid applying too low a resistance across the inductive reactance of the choke.[2] An alternative technique, with single-layer chokes, consists of employing a rod of iron dust material as the former, the lead-out wires being imbedded directly into the ends of the rod. The iron dust material offers a high resistance between the lead-out wires, and it also enables the required choke inductance to be achieved with fewer turns.

Iron-cored chokes are almost invariably employed at frequencies lower than the radio frequencies, and are frequently referred to as *low frequency chokes* in consequence. They are represented by the standard symbol for iron-cored inductors with,

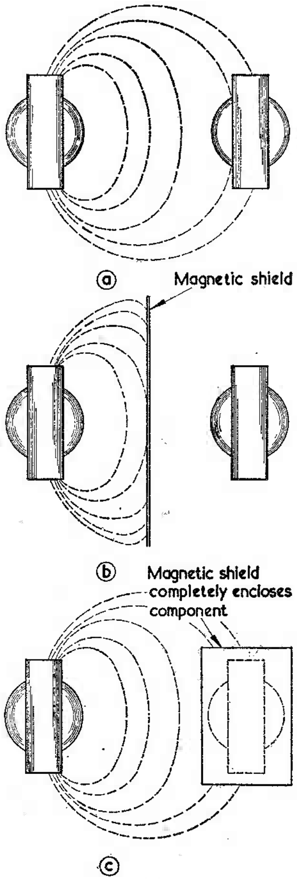


Fig. 148 (a). In this diagram the stray field from the iron-cored component on the left couples with that on the right
(b). If a magnetic shield is interposed between the two components, the stray field which approaches the shield flows through it instead of through the lower permeability air
(c). For efficient shielding, one of the components has to be completely enclosed by the shield. Small holes are provided in the shield to allow lead-out wires to pass through

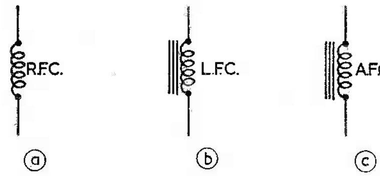


Fig. 149. Circuit symbols for (a) an air-cored r.f. choke, (b) an iron-cored low frequency choke and (c) an iron-cored audio frequency choke

[2] When resistors are used as formers for r.f. chokes, it is very desirable that low tolerance types (i.e. ±20%) be employed. Closer tolerance resistors may have been subjected during manufacture to a "copper spray", which operates as a short-circuited turn inductively coupled to the choke. See "Understanding Radio", Part 4 November 1961 issue.

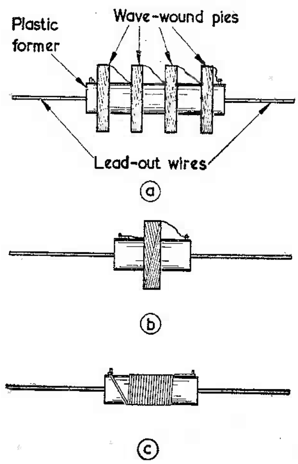


Fig. 150. Representative examples of r.f. chokes. A choke with four wave-wound pies is shown in (a), a single-pie choke in (b) and a single-layer choke in (c).

sometimes, the letters "L.F.C." alongside, as in Fig. 149 (*b*). Chokes intended to offer a reactance at audio frequencies are normally iron-cored also, although air-cored chokes for this function may quite often be encountered. Such chokes are usually described as *audio frequency chokes*, and the letters "A.F.C." are sometimes printed alongside their circuit symbols. See Fig. 149 (*c*).

Low frequency chokes, and iron-cored audio frequency chokes, are fitted with laminations in the same manner as an iron-cored transformer, and they have the same general construction. Iron-cored chokes are usually called upon to pass a direct current whilst offering a relatively high inductive reactance to a low frequency alternating current. The presence of the direct current has a considerable effect on the performance of the choke, because it applies a constant magnetising force to the core. If this magnetising force is too great the core may become saturated, and the choke will offer a low inductance. Because of this effect, the laminations in a low frequency choke intended to pass a direct current are always butt-jointed to reduce the flux density in the core. Despite this precaution, the inductance of a choke may still vary according to the direct current which flows through its winding, and it is usual to specify a low frequency choke in terms of its inductance for a particular direct current.

An interesting variation on low frequency choke design is offered by the *swinging choke*. Some power supply circuits require a choke which needs to have a high minimum inductance for low direct currents and a low minimum inductance for high direct currents. Instead of employing a choke which provides a high inductance at all levels of current, it then becomes more economic to use a swinging choke, which offers the high inductance at the low currents only. The core of the swinging choke tends towards saturation as the direct current which flows through it increases, and the inductance it offers falls in consequence, as is permissible in the application.

Next Month

In next month's issue we shall carry on to the subject of air-cored transformers.

AN *Electric* THERMOMETER

By K. Barry

THE OBJECT OF THIS DESIGN WAS TO PRODUCE A simple circuit which could be used to measure the cylinder head temperature of an automobile engine. The temperature sensitive element chosen to operate this device was a disc type thermistor specially mounted for surface measurement. This is used in conjunction with a moving coil meter and results in a thermometer with a useful range of 30°–100° C. (86°–212° F.).

Circuit Details

The circuit is shown in Fig. 1. A 12 volt supply is used, and this is dropped by R_1 to about 5.7 volts across Z_1, a zener diode. The diode ensures that a substantially constant voltage is fed to the meter circuit, thus making the meter reading independent of the battery voltage (over the range 10–20 volts). The potential across Z_1, is reduced by means of the potentiometer, R_2, R_3, and the voltage developed across R_3 is applied to the meter via the thermistor. The resistance of the thermistor falls as its temperature rises, thus allowing a larger current to flow.

Whilst the type of thermistor employed may be new to many constructors, they will probably be familiar with the thermistor used for limiting heater current surges in equipments using tubes with series connected heaters.

The meter recommended is a 500μA instrument, but a 0–1mA meter would probably do just as well.

Construction and Calibration

In the prototype unit, all the components other than the thermistor were mounted on a piece of synthetic resin bonded paper (commonly known as "Paxolin") and this was secured to the rear of the meter by means of its terminals. The thermistor was bolted to a piece of one sixteenth of an inch thick brass of size 2¾ x 1in, and with a three-eighths of an inch diameter hole at one end. This was clamped to the cylinder head by one of the head retaining nuts. (See illustration.) The thermistor unit should be mounted as far away from the fan as possible to prevent its being cooled by the fan blast,

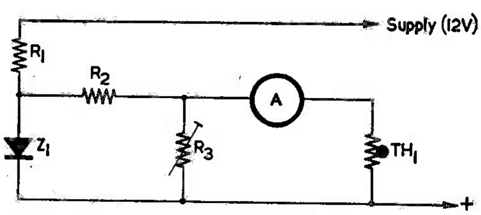


Fig. 1. The basic circuit of the thermometer

and it should be "lagged" (or thermally insulated) by winding several layers of paper around the unit and securing this in position with adhesive tape.

When the components have been wired, it is necessary to calibrate the device. A suitable method of doing this is to fill an aluminium pan with water, then stick the thermistor to the outside of the pan with adhesive tape.

The water should be brought to the boil and allowed to simmer gently for ten minutes. The thermistor should be connected to the rest of the circuit and the supply connected, whereupon it should be possible, by adjusting R_3, to obtain a full scale reading on the meter. When this has been carried out, a conventional mercury thermometer should be inserted into the water and the pan removed from the heating source. The meter reading should now be noted for given readings of the thermometer as the water slowly cools. The water should be stirred whilst the water is cooling, as water is a poor conductor of heat and considerable variations in temperature in different parts of the pan will otherwise occur.

When taking these readings it will probably be found easier to take measurements at about every 10° C. (or 18° F.) and plot a graph from which the precise meter indication for any temperature can be obtained. Having obtained these results the meter may be used as it stands, with a conversion table or curve to enable the exact temperature to be determined. Alternatively, the original calibrations may be removed and a fresh "temperature scale" inscribed in their place.

Results

The results obtained by the author are given below. A convenient way to use the meter without resorting to re-calibration is to mark a small "band" on the meter scale covering the normal operating temperature of the engine plus or minus 5° C. (or 9° F.). This band will show where the pointer should normally lie, and any abnormal tendency may readily be detected.

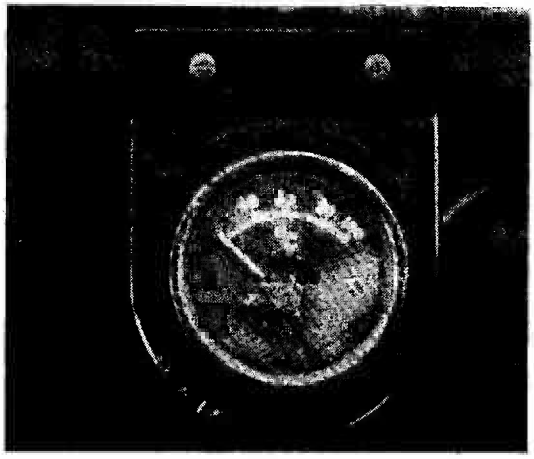
Typical Results

Temperature (° C.)	30	40	50	60	70	80	90	100
Meter Reading	21	29	39	51	63	77	89	100*

For the purpose for which this unit was designed, a high degree of accuracy is not really necessary, and examination of these results suggests another simple method of use without resorting to re-calibration of the meter. If R_3 is adjusted so as to increase the meter readings by five, then the following results should be obtained:

Temperature °C	30	40	50	60	70	80	90	100
Meter Reading	26	35	44	56	68	83	94	105
Error °C	−4	−5	−6	−4	−2	+3	+4	+5

The worst error, it will be seen, is 6° at 50° C., whilst at 70° C., which is a typical cylinder head temperature, the error is only 2° C.



The meter fitted in a car

The author chose, however, to re-calibrate the meter he used. This was done in the following manner.

Having first obtained a calibration curve, the meter case was removed, and the meter scale painted all over with matt black cellulose. When this was dry, the meter was connected in series with another 500μA meter, a variable resistor, and a dry battery. The current through the meter was adjusted by means of the rheostat, and was set so that the second 500μA meter gave a reading corresponding to that obtained on the original meter during temperature calibration at 40° C. A small dot was then marked with a soft pencil on the scale of the meter being calibrated. This process was repeated at currents corresponding to 60, 80 and 100° C. The scale of the meter was then released from the movement, and an arc linking the four pencil dots was drawn in white drawing ink. Short vertical lines were then marked over the pencil dots and the temperature readings marked. (A drawing of the scale is shown in Fig. 2.) When the ink was dry, the scale was replaced and the meter reassembled.

Installation and Use

The meter may either be mounted on the dash—

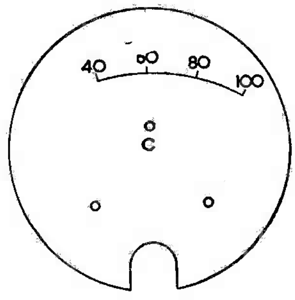
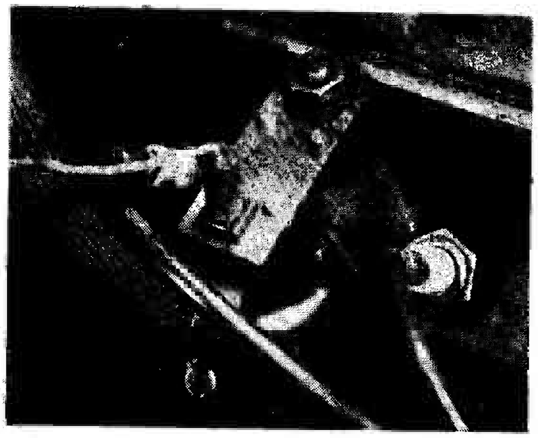


Fig. 2. The appearance of the re-calibrated meter scale

* These figures assume, of course, that a meter reading of 100 corresponds to full scale deflection.—EDITOR.



The thermistor mounting bracket secured to the cylinder head

if space permits—or on a small sub-panel which is then itself screwed to the dash (see Fig. 3 and illustration). The latter method is the easier and has the advantage of easy removal if it is desired to transfer the instrument to another vehicle.

When the meter and the thermistor unit have been installed, it only remains to connect them up. If the components other than the thermistor are mounted on the rear of the meter then all that is required is a lead to the "live" side of the battery, and one to a good chassis earth. A third lead to the thermistor unit is required. No earth or return lead from the thermistor is necessary, since one side of the thermistor is electrically connected to the metal mounting plate and the return circuit will be made via the engine.

A further use for this device is that of measuring the temperature of a hot water storage tank and giving a remote indication at some convenient point (e.g. with the meter mounted near the boiler).

Battery Polarity

The circuit given in Fig. 1 is only suitable for vehicles in which the positive pole of the battery is connected to chassis. For vehicles in which the negative pole of the battery is earthed Z_1 must be reversed. Also, the lead marked SUPPLY (—12V) becomes (+12V), whilst the earth line marked + becomes −. No damage will result through a brief accidental reversal of the supply, though a prolonged reversed connection may damage the zener diode through excessive heating.

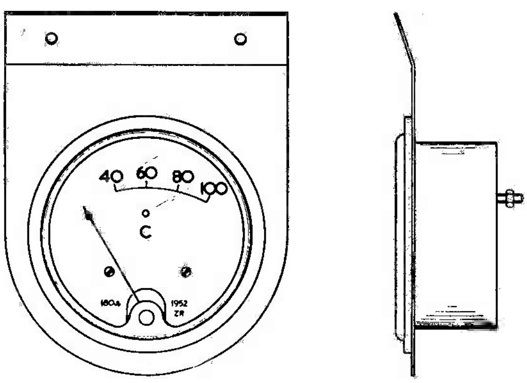


Fig. 3. The meter mounting bracket

Adding a Fourth Resistor

Since making the original prototype, the author has constructed a second thermometer. In this case, an attempt was made to obtain a linear scale, since this would make it unnecessary to remove the original meter scale markings. The attempt was partially successful, and results in a linear scale from 40 to 100° C. The meter readings against termperature are given below.

Temperature (° C.)	30	40	60	80	100
Meter Reading	32	39	60.5	81	100 (=full scale)

For this second thermometer, all that was done was to remove the original numbering (0–500) from the meter scale and insert the numbers 40, 60, 80, and 100 at the points corresponding to 200, 300, 400, and 500 respectively on the old scale. The scale up to the 40° C. mark was left un-numbered. The modification to the circuit necessary to obtain a linear scale simply consists of the addition of a 1.6kΩ resistor (R_4) connected in parallel with the thermistor. Since this value is not available in 10% resistors it may be necessary to use a series or parallel combination, say 1,500 + 100 or 820 + 820. It is possible that the exact value of shunting resistor required will depend on the particular thermistor used, whereupon the use of a 2.5kΩ rheostat as the shunting resistor may be more convenient. When the correct value for this rheostat and R_3 have been found, there is no reason why they should not be replaced by suitable fixed resistors. (As a matter of interest, in both thermometers made by the author R_3 was finally formed by a 33Ω resistor shunted by a 500Ω resistor.)

With regard to calibration, when the "linearising" resistor (R_4) is connected and set to 1.6kΩ approximately, a similar procedure to that outlined earlier is used. R_3 is adjusted for full scale at 100° C., whilst the "linearising" resistor, R_4, is adjusted at 40° C. for a correct meter reading. R_3 should then be re-set if necessary at 100° C. and a further check made at 40° C. to ensure the final correct setting for R_4.

Components List

R_1	330Ω 10% 1 watt
R_2	1.2kΩ 10% ¼ watt
R_3	50Ω wirewound potentiometer
Z_1	OAZ201 (Mullard)
TH_1	KB23 (Standard Telephones and Cables Ltd.)
M_1	0–500μA moving coil meter

EDITOR'S NOTES.—We are informed by Standard Telephones and Cables Limited that the KB23 thermistor may be obtained direct from their distributors at the retail price of 34s. 6d. each, inclusive of postage and packing. Distributors suggested are Messrs. Townsend-Coates Limited, 167 London Road, Leicester.

The data on the KB23 quotes a maximum operating temperature of 80° C. Standard Telephones and Cables Limited tell us that the protective resin around the block, which was the reason for this restriction, has now been modified, and that it is possible to use the KB23 thermistor at temperatures up to 120° C.

trade review . . .

Sound *Effects* RECORDS

We have received samples of the new Sound Effects records MFX-1 and MFX-2, these being the first and second respectively in a series of six such recordings to be issued to the general public.

Our well-known contributor F. C. Judd, A.Inst.E., Technical Editor of *Amateur Tape Recording* magazine, is the originator of all the master recordings for the series. We recently met Mr. Judd—quite by accident—at Liverpool Street Station, where he was busily engaged in obtaining a recording of a diesel locomotive commencing a long haul!

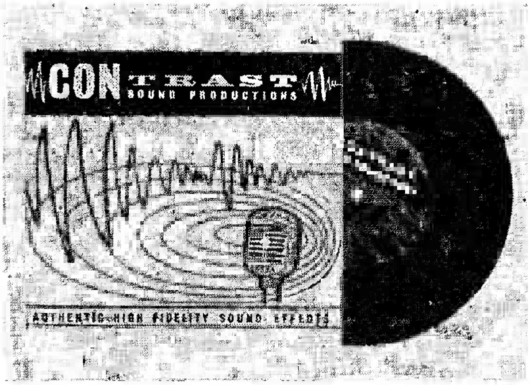
We found that the realism obtained on quite an ordinary record player was very impressive and undoubtedly these records will find a ready sale among those requiring to reproduce such effects.

MFX-1 contains 14 effects—Police Car, Police Launch, Lion Roar, Aircraft Landing, Building Falling, Road Drills, Ships Siren, Storm at Sea, Railway Trains (3, various), Car Door and Starter, Central Line Tube Train, and Cell Door.

MFX-2 features the following 12 effects—American Police Car Sirens (5, various), Applause, Car Crash, Glass Breaking, Footsteps (6, various), City-Waterloo Tube Train, Workmen hammering, and Orchestra Tuning-up.

All the sounds contained in these recordings are authentic although, in some instances, the mixing of several sounds has been carried out in order to create a "portrait in sound" such as the car crash on side 1 of MFX-2.

Lifelike reproductions of these effects can be achieved by using high fidelity reproducing equipment, particularly if the sounds are to be copied on to magnetic recordings or used for stage drama, or cine film sound-tracks, etc.



These two records are on sale through regular dealers at 7s. 6d. each, and the great advantage to amateur recordists, cine film enthusiasts and amateur dramatic societies, etc., is that they may be used, for amateur purposes only, free of copyright. Our illustration above shows part of the record (45 r.p.m.) and the two-colour glossy sleeve.

For readers who are interested, an advertisement for these recordings appears elsewhere in this issue.

Improved Silicon Rectifier Ratings

Westinghouse Brake and Signal Co. Limited have recently increased the current ratings of two high power silicon diodes types SxAN125 and SxBN200.

The SxAN125 range is now rated at 150 amperes in single-phase half-wave circuits, 300 amperes in single-phase bridge circuits and 420 amperes in three-phase circuits, at junction temperatures of 170°C.

Voltage ratings from 100 to 1,200 volts p.i.v. are readily available.

The rating of the SxBN200 range has been increased to 200 amperes in single-phase circuits and will provide 400 amperes and 575 amperes in single-phase bridge and three-phase circuits respectively. The diodes will operate at a continuous junction temperature of 170°C which, coupled with high thermal conductivity between junction and base, permits the use of small heat sinks.

IN YOUR WORKSHOP

This month, Smithy the Serviceman, accompanied as always by his able assistant Dick, leaves the Workshop to sample the delights of the English countryside in August. However, this does not prevent him from continuing the discussion on intermittent faults which he started last month

"THERE'S NOTHING," SHOUTED Smithy above the din of the traffic, "like going out into the country to get some fresh air!"

Dick jumped hastily into the ditch as a ten-ton lorry thundered past. Black diesel exhaust fumes shrouded the pair, rendering speech impossible for several moments. Dick eventually drew in breath to reply, but his words were lost in the sudden roar of a sports car, closely followed by a team of motor-cyclists with both throttles and silencers wide open. There was a short respite, to be violently shattered, as a motor-coach in full song rushed by. Someone in the coach threw an empty ice-cream tub at the Serviceman.

But Smithy was not to be defeated, and he walked defiantly on, followed by an increasingly reluctant Dick. The vehicles continued their plunging journey past the two. Three-wheelers, cars, lorries, articulated vehicles, buses, vans, coaches, motor-cycles, trailers and caravans, they all swept by, leaving Dick and Smithy tramping their solitary way along the isolated and perilous grass verge.

Suddenly, Dick ran along in front of Smithy, narrowly avoiding death in the process as a vast pantechnicon swayed crazily by at forty miles an hour. Dick disappeared. The perspiring Serviceman followed quickly, to find that his assistant had discovered a lane leading off the main road, and was already sitting on top of a gate some distance along it. Smithy followed, and the roar of the headlong traffic eased down to a distant hum.

Ever-Open Door

"Blimey," said Dick, as Smithy approached him. "I'm glad I've got away from *that* clatter!"

Smithy nodded and leaned against the gate.

"If I'd known," continued Dick bitterly, "that this is what happens when you suggest a quiet summer afternoon walk in the countryside, I'm jolly certain I would never have joined you."

"Nonsense," retorted Smithy. "The trouble with you is that you expect to have it easy all the time."

"There's another thing, too," continued Dick. "I don't like going for a walk with someone who is as exhibitionist as you are!"

"As *what*?"

"As exhibitionist," repeated Dick surveying the deeply affronted Serviceman with a cold and critical eye. "*Everybody* was looking at those awful old khaki shorts of yours!"

"I've never heard such rubbish in all my life," exploded Smithy. "Shorts are the obvious thing to wear when you go for a walk in the country. What is more, my shorts are perfectly respectable."

"I'll say they are," replied Dick. "Seeing that the bottoms are half way between your knees and your ankles."

"I see no reason," said Smithy, with dignity, "why I should discuss with you what I wear. Anyway, let's wander along this lane a bit."

"O.K." said Dick, "at least there's nobody down here to see us!"

Smithy snorted and purposefully started to walk down the lane. There were trees on either side and, as the pair advanced, they found that these were getting thicker and thicker. Eventually, they were walking through a veritable avenue of trees, the branches of which met over their heads and allowed a more gentle version of the August sunlight to diffuse through. The racket of the main road was now lost and forgotten, and the silence was disturbed only by the rustle of the leaves and the murmur of midges. It was very peaceful.

"We never," remarked Dick suddenly, "finished that discussion."

"I beg your pardon," said Smithy, jerked out of his reverie. "What discussion?"

"The one on intermittent faults, of course," replied Dick. "Don't you remember? We'd just got on to intermittent soldered connections on video chokes, after which you said we'd have a further natter the next time we had a few moments spare."

"Dash it all," grumbled Smithy. "Don't you ever close the hangar down? I've been looking forward to getting out of the Workshop for ages, and what happens? You start talking about work!"

"Well," persisted Dick, "we *do*

have a few moments spare now, don't we?"

"I suppose so," said Smithy resignedly. "And I suppose I won't get any peace until I give you the gen you want. How far had we got to, anyway?"

"We were talking about intermittent connections with wound components," replied Dick. "And you told me to particularly suspect soldered joints where the coil wire insulation is of the solder-through variety. You said that these joints were liable to give rise to intermittents because the wire insulation wasn't always satisfactorily dealt with at the factory."

"Oh yes," said Smithy "I recall it now. I should have added that there's another type of intermittent solder joint you get with wound components also. This is given by the connections you have with coils that are wound in sticks."

"In *sticks*?"

"That's right. In order to save production time, multi-layer coils, such as are used on l.f. chokes and iron-cored transformers, are normally wound in batches. You start off by putting, on the winding machine mandrel, a single long former which usually consists of specially treated paper material. (Fig. 1 (*a*)). You then start to wind the coils, of which there may be some four to sixteen or more side by side, according to the type of coil and the winding machine. (Fig. 1 (*b*)). As soon as one layer of wire has been wound on, the machine automatically inserts a sheet of interleaving paper, this being as wide as the former. When you've finished you have a complete set of coils—which you call a stick of coils—wound on the common former. The next thing to do is to cut these into separate coils; and you do this on the machine, with the aid of prepositioned knives. (Fig. 1 (*c*)). The final result is that you have a quantity of identical coils, after a total winding time which is only slightly more than that for one coil only."

Dick frowned.

"Well, that's certainly a money-saving idea," he said. "I'm a bit puzzled, though, as to how you make connections to the start and finish of each winding."

"That," pronounced Smithy, "is what I'm leading up to. One technique consists of simply hooking out the start and end turn of each winding after it has been removed from the winding machine mandrel. A turn or so of the actual winding wire is pulled out, and it provides its own lead-out wire. The alternative method is to apply a narrow strip of copper foil across the whole stick whilst it's on the winding machine mandrel, and of soldering the coil wire to this. (Fig. 1 (*d*)) When the stick is wound, the knives cut the strips off flush with the edges of the individual windings, and the lead-out wires are then soldered to the ends of the strips."

"But that means," protested Dick, "that you've got to force your soldering iron bit into the winding itself."

"That's right," agreed Smithy cheerfully. "Still, there's only interleaving paper at the winding edges and it's quite easy to make a quick joint without seriously charring the paper."

"I don't quite get the gist of all this," said Dick. "If you've got an intermittent joint at the point where the lead-out wire is connected to the strip, it should be perfectly easy to detect this *and* to repair it."

"True enough," replied Smithy. "Although you must remember that, by the time the winding reaches the service engineer, it will have been wax or varnish impregnated. And so a new solder joint will not be as easy as all that

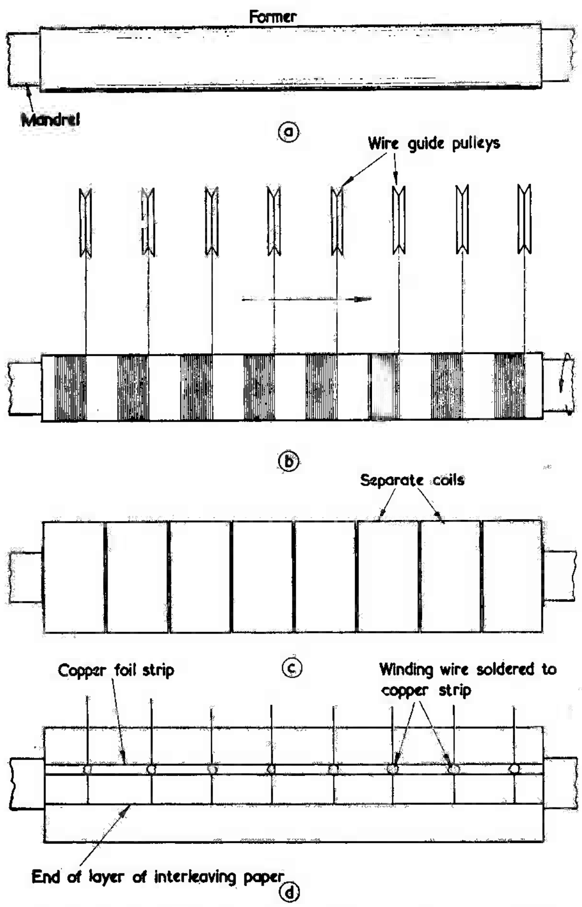


Fig. 1. Showing, in simplified form, how a stick of multi-layer coils is wound. In (a), the former is fitted to the winding machine mandrel. The coil is partly wound in (b), in which diagram the mandrel rotates on its axis whilst the wire guide pulleys move laterally so as to lay the wire evenly. In (c), the completed stick is parted, after being covered with an insulating paper tape, into its separate coils. The process of making connections with copper foil strip is shown in (d). The unwanted projecting wires from the joints are cut away after soldering. In a practical winding procedure, the former, interleaving paper and copper strip would be wider than is required for the coils themselves, the waste material at the ends being cut off after the stick is completed

to carry out. But you've missed my point. I'm not concerned with the joint between the lead-out wire and the copper strip. Instead, I'm concerned with the joint between the copper strip and the *winding wire*. If *this* goes intermittent you've had it. The joint between the winding wire and the strip is internal, and it can only be reached by stripping down the coil. Also, it's a fairly good candidate for the intermittent stakes, because it's one of the few joints which can't be subsequently inspected at the factory."

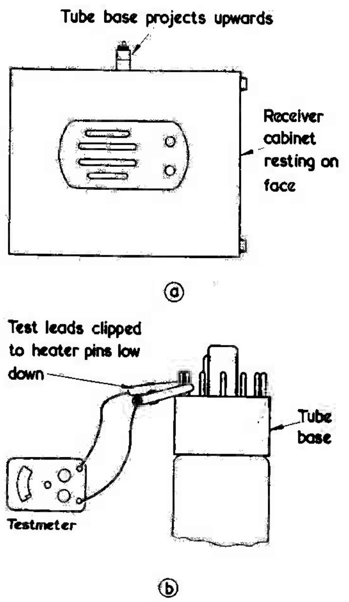


Fig. 2 (a). To make good an intermittent c.r.t. heater pin connection, the receiver is first placed on its face so that the tube base projects upwards (b). Two ohmmeter leads are then clipped to the heater pins low down. A soldering iron, together with a little solder and flux, is then applied to one of the pins, whereupon the ohmmeter will indicate whether the joint has been made good again

"Well, I'm blowed," said Dick. "I hadn't quite looked at it in that light. What sort of coils are manufactured with this copper strip idea?"

"As I said just now," remarked Smithy, "copper strip connections are common with l.f. chokes and iron-cored transformers. In the latter category you'll find such things as small mains transformers, speaker transformers and vertical output transformers. The technique is even employed for line output transformers, but you will very rarely find it giving you intermittents with those components."

"Why's that?"

"Because line output transformers handle high voltages. You may remember I referred to wetting voltages the last time we discussed this subject. If you have a poor connection inside a line output transformer you've got a really jumbo-sized wetting voltage to bridge the gap. When there's an actual break, this voltage will cause a spark to appear which will soon burn the conductors away. In other words, it is very rarely that line output transformers go intermittent due to poor connections. If a poor connection appears, the voltages in the transformer are such that it burns out completely, and you've got a component which is permanently u/s."

Other Intermittent Connections

"That's true enough," remarked Dick thoughtfully. "I don't think I can even recall an intermittent which has been caused by a line output transformer. Are there any other intermittents which may be given by poor solder connections?"

"Quite a few," replied Smithy. "One you bump into occasionally occurs at the bases of cathode ray tubes. If the tube has a Bakelite duodecal base you occasionally find that one of the heater lead-out wires from the glass has an intermittent solder connection inside its pin. There is, in fact, rather an interesting point here. From my own experience, I've found that this particular snag seems to occur far more frequently with receivers in which the c.r.t. heater is run from a mains transformer than in receivers where it is connected in a series heater string. I would guess that this phenomenon is due, once more, to wetting voltages."

"You don't," objected Dick, "*have* television sets with mains transformers these days."

"Yes you do," contradicted Smithy. "Although I will admit that they're very few and far between. Nevertheless, I can think of one recent model, at least, which employs such a transformer. And this brings me to a second interesting point. Which is that, when the c.r.t. screen goes blank because of the open circuit tube heater connection, there is a tendency to look inside the cabinet, see all the valves glowing away merrily, and assume that the tube heater is glowing as well. As, of course, it would be in a normal series-string set. You will even get a correct voltage reading across the heater tags on the tube base socket, but you can waste a lot of time looking for snags elsewhere if you don't also check visually that the heater is actually operating."

"That's something to remember," commented Dick. "How do you clear the snag?"

"It's usually simple enough," replied Smithy. "The first thing to do is to ensure that the Bakelite base is well and truly secured to the glass of the tube. These bases frequently work loose, and it's probably their subsequent movement relative to the glass which causes the trouble in the first place. If the base isn't secure, you should stick it down firmly with a good adhesive. When this has set, you then attempt to repair the open-circuit joint from outside. There's no need to remove the tube from the set to do this; all you have to do is put the cabinet on its face so that the tube base sticks upwards. (Fig. 2 (*a*)). The tube socket has to be removed from the base for the repair operation. You first of all fit two ohmmeter clips to the pins (Fig. 2 (*b*)) and then apply a little paste flux of the type which is suitable for electrical joints, such as Fluxite, to the end of one pin. You next apply the iron and a little solder to the tip of the pin. The solder and flux will run down the inside of the pin and, if you're lucky, the ohmmeter will indicate low resistance if they cause the previously bad joint to become good. At which point you remove the soldering iron, and all is well. If you're unlucky, the ohmmeter will still indicate an open-circuit, and this means that you've started operations on the wrong pin. So you repeat the process with the other pin."

"That's quite a business," said Dick, impressed. "Does it always work?"

"It has done with me," replied Smithy, "but I certainly wouldn't guarantee it as being 100% predictable. It's one of those jobs which should only be tackled by those who feel confident of doing it properly. The important thing to remember is that you only need a little additional solder, and that the iron should only be applied for a short time. It doesn't matter if you apply excess flux because, if this is of a reliable quality, it will remain inert after the job is completed. You must realise that the joint you've re-made will still be in the dicey category and that you want to avoid any possible mechanical movement or shock to the base or pin afterwards. You don't, for instance, want to leave a blob of solder at the tip of the pin after you remove the iron, because this will have to be cleaned off before you can get the tube socket back on again. A process which may well cause your repaired joint inside the pin to go open-circuit again."

"It doesn't sound a very *reliable* repair," commented Dick.

"It isn't," agreed Smithy, "but it's better than ditching the tube for an o/c heater!"

"Do you get any intermittent connections to the other pins?"

"Not so often," commented Smithy. "The heater pin connections seem to be the favourite. The current passed by the connections in the other pins is, of course, very small, and you could have quite a high resistance before you get into trouble."

Ceramic Capacitors

By now, the pair had left the tree-lined section of the lane, and were walking between low hedgerows. Idly, Dick pulled a stick from one of the hedges and slashed at the grass bank with it.

Rounding a corner, they were suddenly confronted by a cow.

"Now this *is* a bit of the countryside," said Dick enthusiastically. "It must be about ten years since I last saw a cow as close as this."

"I don't know about that," said Smithy, watching the animal somewhat fearfully. "Cows are meant to be in fields, you know, not walking about in the middle of lanes without proper supervision."

The cow lumbered up and examined Smithy with great interest. Her soft brown eyes gradually lowered until they came to rest on his shorts, whereupon her gaze became transfixed. With an air of complete fascination, she pushed her head forward and sniffed noisily. Smithy jumped back.

"Dash it all," he said nervously. "That brute's positively dangerous."

"It's those shorts of yours," replied Dick cheerfully. "She's never seen anything like them before!"

"Well, let's get on past her," said Smithy testily. "I came out for a walk, not to be messed about by hulking great animals like this."

They walked past the cow, Smithy taking great care to ensure that Dick was interposed between the beast and himself. As they wandered on, the cow turned her head round and gazed with utter absorption at Smithy's rear.

"Do you know," remarked Dick, "you've absolutely made that cow's day for her! She'll really have something to tell the other cows now when she gets back to them."

"Don't be silly," replied Smithy, his confidence returning as they moved further away. "Anyway, let's get back to those intermittent faults we've been talking about."

"Righty-ho," said Dick, equably. "Are there any other soldered connections inside components which may cause trouble?"

"I think I've covered most of the more usual ones," said Smithy. "Apart, that is, from disc ceramic capacitors. Although, to be truthful, the occasional troubles you get with these components has more to do with the silvering on the ceramic than with the actual soldering itself."

"Fair enough," said Dick. "Fire away!"

"As you know," said Smithy, "a disc ceramic capacitor consists basically of a round slab of ceramic with silvering on either side. The lead-out wires are then soldered to that silvering. (Fig. 3 (*a*)). The bond between the silvering and the ceramic is usually quite strong, and should be capable of withstanding a reasonable amount of pulling on the lead-out wires. Also, the capacitor is given an outside coat of hard insulating material which helps to increase its strength so far as tension on the wires is concerned."

"I'm with you," remarked Dick, "all the way."

"Right," said Smithy. "Now, these capacitors will normally give you excellent service, but you may occasionally find one which has been badly manhandled either in the receiver factory or during subsequent servicing. What happens then is that the silvering about the solder joint gets very slightly pulled away from the ceramic. (Fig. 3 (*b*)). Usually, the result is an obviously faulty capacitor but, if the silvering stays very close to the ceramic, you may still get sufficient capacitance for some circuit functions. Such as, for instance, decoupling applications where the circuit does not really require by any means as much capacitance as the capacitor normally offers. In these cases, the slightest mechanical shock can cause the capacitor to change from a good to a no-good condition, or vice versa."

"Wouldn't the fault be obvious?" queried Dick. "I mean, wouldn't you see an obvious break in the outside insulated covering?"

"Not always," said Smithy. "There might be just a faint crack around the area where the silvering has pulled away. Also, this could be covered by dirt and grime, or the capacitor could be tucked away in a corner where it's difficult to see. At all events, faulty ceramic capacitors of this nature can sometimes give you the dickens of a lot of trouble. The only good thing about them is that the fault normally becomes permanent if you bend the capacitor about a bit, or if you tap it."

"Are there any other snags with disc ceramics?"

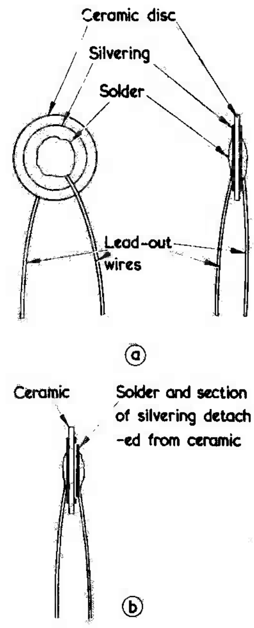


Fig. 3 (a). A typical disc ceramic capacitor without its final insulated covering
(b). Due to excessive tension on the lead-out wires, the solder joint and part of the silvering may become detached from one surface of the ceramic. Again, the final insulated covering is not shown

"There's an occasional one," said Smithy, "which you might encounter if you're unlucky enough. If the silvering process isn't carried out properly at the capacitor factory you may get "islands" of silvering on one or other of the ceramic surfaces. (Fig. 4 (*a*)). Such islands may be joined to the main body by a very narrow band of silvering (Fig. 4 (*b*)) and, if this connection becomes unreliable, you have a case of varying capacitance. This is a rare fault, admittedly, but it's one of the things that *can* happen."

"How do you locate it?"

"If," replied Smithy, "the nature of your intermittent fault is such that you suspect varying capacitance in the ceramic you would, in the normal course of events, swap it anyway. The fact that the intermittent clears with the new component then confirms that the previous one was faulty. Alternatively, you might be able to bring the faulty condition on by tapping the capacitor, or by warming it up slightly by holding a miniature soldering iron near it."

"That's not very conclusive, is it?" commented Dick.

"It isn't," agreed Smithy. "But then, the nature of intermittent faults is such that their repair is hardly every conclusive."

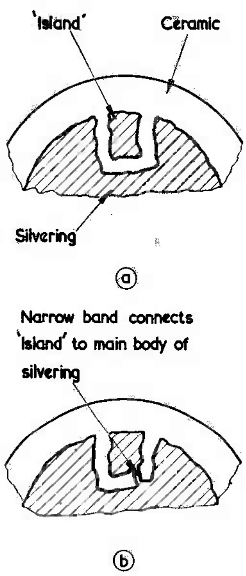


Fig. 4 (a). Detail showing how "islands" of silvering may appear on the surface of a ceramic capacitor
(b). A possible source of intermittent variations in capacitance is given when an "island" is connected to the main body of silvering by a very narrow band, as shown here

Intermittent Oscillator

There was silence for a moment, as they traversed another corner.

"Blast," said Smithy, "more cows!"

They were confronted, this time, by a veritable army of cows. Dick noticed a closed gate alongside them.

"I suggest we sit on this until they go by," he suggested hastily. "We'll never get through that lot."

Gratefully, Smithy clambered on the gate and the pair perched in silence, watching the cows as they ambled along in slow procession. There was, once again, evidence of a speculative interest in Smithy.

"Why do they keep looking at me like that?" said Smithy, irritably. "I find it quite unnerving!"

"If," chuckled Dick, "you were an old cow lying about in a field all day, you'd look around at anything new, if only to break the monotony!"

The cows continued on their course. There appeared to be an inexhaustible supply of them.

"What I can't understand," complained Smithy, "is how so many animals can be let loose like this. Surely, someone must have the responsibility for them. They must, after all, represent a fantastically high capital expenditure."

At long last, the end of the bovine cavalcade came into view. As the lost animal passed him Smithy was amazed to see that they were under the control of a diminutive youth about twelve years old.

"Hey, sonny-boy," called out Smithy, assuming the sugary accents of a fond uncle, "are you really looking after all those cows on your own?"

The boy, obviously annoyed at Smithy's patronising tones, looked at him in disgust. His eyes noticeably widened as he took in the full details of the Serviceman's nether attire.

"Cor," he remarked derisively, "if it ain't old Knickerbocker Glory his-self!"

Stung to the quick, Smithy lapsed into red-faced silence, a condition which he maintained for the next few minutes whilst the gate shook wildly to the suppressed chuckles of his assistant. The boy walked out of sight.

"You asked for that one," laughed Dick. "I've been telling you about them all day long, but you wouldn't listen to me. Fancy going out in a pair of gash old surplus shorts like that!"

"Gash old surplus?" said Smithy, outraged. "Let me tell you that I was *issued* with these!"

"*Issued* with them?" gasped Dick. "When?"

"During the war, of course," snapped Smithy. "Don't forget that, during the years when you were throwing your rattle out of your pram, I was defending my country!"

"Come off it, Smithy," said Dick scornfully. "Don't tell me that the Pioneer Corps were ever issued with khaki drill!"

"I am not going to discuss the matter further," said Smithy with dignity. "So far as I'm concerned, shorts for walking are *de rigeur*."

"So far as those shorts are concerned," commented Dick, "I'd say they were *de rigeur mortis*."

Smithy refused to answer, and he eased himself gently off the gate. He resumed his progress along the lane, with Dick walking by his side. Dick decided to return to the previous topic.

"I've got an intermittent fault on the bench right now," he remarked chattily. "I was going to ask you about it when we start work again."

"What are the symptoms?" asked Smithy, manifestly relieved at the change of conversation.

"Well," said Dick, "so far as I can see, there's something queer with the tuning capacitor. It's a Medium and Long wave valve set, and sometimes it works like a bomb and sometimes it's as dead as a doornail. It all seems to depend upon where the tuning capacitor is set."

"Tell me more."

"If," said Dick, "I switch it on and try and tune in a station at the low frequency end of the Medium wave band, there's not a sausage. If I then tune up to the high frequency end its works O.K. The funny thing is that, after I've tuned in a station at the high frequency end, it's all right at the low frequency end as well!"

"Is it the same on long waves?"

"I don't know," confessed Dick. "I've only had time to try it out on Medium waves up to now."

"It sounds to me like a worn-out oscillator valve," remarked Smithy. "If the oscillator valve is on the verge of packing in, it may still summon up enough strength to commence oscillating when you're at the high frequency end of the band, because this corresponds to a high L C ratio in the oscillator tuned circuit. Once the valve has started to oscillate it will continue to do so, even if you return to the more inefficient tuned circuit conditions at the low frequency end of the band. It's operating in the same way as a reaction circuit with bad backlash. Once you go into oscillation with such a circuit you have to reduce feedback quite a lot before you can come out of oscillation again."

"So the cure," remarked Dick, "is to fit a new oscillator valve?"

"That's right," said Smithy. "If that doesn't work the oracle, check the grid capacitor and the anode feedback capacitor if there is one. These may have gone low in value and caused a reduction in feedback. There are other obvious faults which could cause the trouble, too, such as shorted turns in the feedback winding, a high value anode resistor, and so on. But the valve itself is by far the most likely customer."

"I'll try that," said Dick, "as soon as we start work again."

Break For Tea

"Hallo," said Smithy, "it looks as though we're approaching a village."

A cluster of cottages came into sight, to be succeeded by a typical village street. An occasional lorry or car passed by but there was, otherwise, an air of complete serenity.

"There's a sign down there," remarked Dick, "which says 'Farmhouse Teas'."

"So there is," agreed Smithy. "Let's investigate."

And this they did. If we were to return to Dick and the amply attired Smithy some twenty minutes later, we would find them sitting out in a rose-bedecked garden whilst a middle-aged and motherly countrywoman set out in front of them two heaped plates of ham and eggs, to be attacked by the pair with much gusto and great helpings of H.P. Sauce. Which only goes to show that it is still possible to stumble on parts of rural England by the simple process of walking down a country lane.

Provided, of course, you choose the right lane.

book review . . .

TRANSISTOR TELEVISION RECEIVERS: A Survey of World Circuitry, British, American, German, Russian, Japanese. By T. D. Towers, M.B.E., M.A., B.Sc., A.M.I.E.E., Grad. Brit. I.R.E. Published 11th July, 1963, by Iliffe Books Ltd. 194 pages including 188 diagrams. Size 10in by 7½in. Price 55s. net (by post 56s. 6d.).

The change from valve to transistor television receivers has been slower than that in other electronic devices, but in many countries, such as America, Japan, Switzerland and France, it is rapidly gaining momentum and Great Britain is bound to follow the lead. The slow development was due to the high cost of transistors, now falling rapidly in price, and to the difficulty in transistorising certain sections of the circuitry now overcome with the development of more effective transistors, though extreme difficulty is still being experienced in obtaining enough power to drive the larger television tubes. The tendency has therefore been to concentrate on small and medium sized sets. Japan has specialised in the development of very small sets (5–6in screens) using microminiaturisation techniques, and now produces these on a commercial scale for domestic, industrial and executive use.

The author has combed the world to obtain circuits from every country working on transistor receivers, and so has at his fingertips a unique store of information. In this book he has taken from the various countries the designs of each section of the receiver and has critically compared and contrasted them. A most valuable feature of his survey is the fact that all the circuits have been redrawn in a similar style, making for ease of comparison. In all there are nearly 190 circuit diagrams, for which the present large format has been chosen to show them to the best advantage.

T. D. Towers, the Chief Applications Engineer of Newmarket Transistors Ltd., first gives the reader a clear perspective of the subject. He then devotes a chapter to each of the following, tuners; vision i.f. amplifiers; video: amplifiers; audio i.f. amplifiers; synchronising circuits; field deflection circuits; line deflection circuits; picture tubes and associated circuits; power supplies. A further chapter discusses the transistor as an electronic device, how it operates and how it should be handled and tested. Finally, there is a useful chapter on the servicing of transistor television receivers.

This book—the first in its field, with its survey of designs from the United Kingdom, U.S.A., France, Germany, Russia and Japan—will be invaluable to all designers who wish to keep abreast of current developments and be prepared for the future.

CONTENTS: Preface—Acknowledgements—The Transistor in the Television Receiver—Transistor Tuners—Transistor Vision I.F. Amplifier—Video Amplifier—Sound Sections of Transistor Television Receiveas—Sync Separator Circuits—Field Time Base Circuits—Line Time Bases—The Picture Tube and Associated Circuits—Power Supplies in Transistor Television Receivers—Transistors for Television Receivers—Servicing Transistor Television Receivers—Index.

Catalogue Received . . .

Home Radio Ltd., 187 London Road, Mitcham, Surrey.

We have just received our copy of the latest catalogue (4th Edition, June 1963) and this 194-page publication, 7¼ x 9¾in, is available direct from them at 2s. 6d. per copy.

This lavishly illustrated component catalogue is, without a doubt, one of the finest radio retail shopping guides available in this country. The Index is comprehensive and any required item, no matter how small, is quickly traced—the type number, manufacturer and price all being listed.

The present edition has not only been enlarged but has also been subjected to some rearrangement, this achieving a better layout and an attractive presentation of the many hundreds of items listed and illustrated.

This latest catalogue should find a place on every constructor's bookshelf where it will serve both as an easy shopping guide and as a veritable mine of component information.

Cover Feature

High Quality Modulator Design

By D. NOBLE – G3MAW and D. M. PRATT – G3KEP

HAVING COMPLETED THE EXPERIMENTAL TRANSmitter for the 4 metre band described in the June 1963 issue[1], a suitable modulator was required in order to operate on telephony. It was decided that, as far as possible, the finished appearance of the modulator should match that of the transmitter. In order to achieve this, the modulator is built into a cabinet of similar dimensions to those of the transmitter, and both cabinets are similarly painted.

With a good crystal microphone the quality produced is of a high standard, comparing favourably with other amateur signals.

The output stage is capable of providing sufficient output to fully modulate any transmitter running up to 20 watts input.

[1] David Noble and David Pratt, "Transmitter Design for 4 Metres", *The Radio Constructor*, June 1963.

The unit has a built-in power supply providing 250 volts at 60mA for h.t. and the usual 6.3 volts for the heaters. However, it may be desired to use the unit while operating portable or mobile and, for this reason, provision is made for feeding in external h.t. and l.t. supplies.

Circuit

The first stage is an EF86 operating in a high gain amplifier circuit. This valve is a low noise pentode particularly suitable for the early stages of high gain audio equipment. It is designed to have extremely low hum and microphony characteristics.

Between the input socket and the valve an RC network is provided. This behaves as an r.f. filter, thus avoiding feedback caused by r.f. pick-up on the microphone cable being detected by the valve.

The output of V_1 is fed via the gain control to the

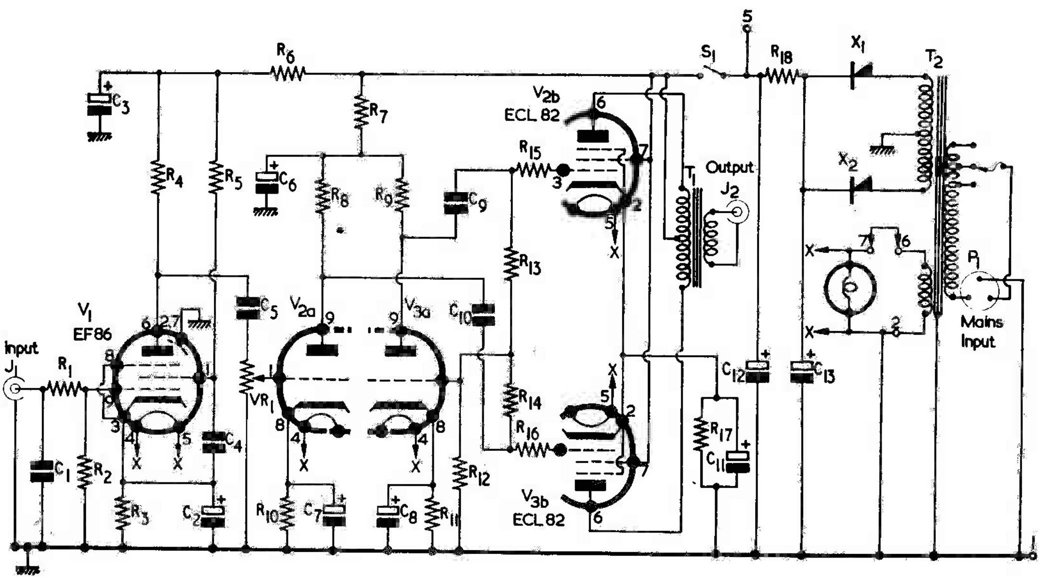


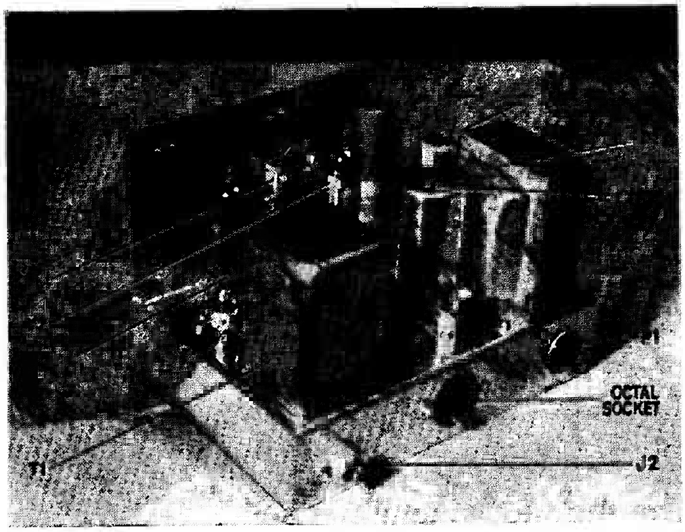
Fig. 1. The circuit of the modulator. The circuit points designated 1, 2, 5, 6 and 7 correspond to the appropriate pins of the octal valveholder mounted at the rear of the chassis. It will be noted that there is no switch in the mains input circuit

paraphase phase-splitter utilising the triode sections of two ECL82 valves. In order to obtain a balanced output from this stage it is important that several of the components be accurately matched. These are the two anode load resistors R_8, R_9; the two coupling capacitors C_9, C_{10}; and the two grid resistors R_{13}, R_{14}. Although the actual values themselves are not very critical, the pairs of components should be matched to within 2%. Of the matched pair R_{13} and R_{14} should, preferably, have the higher value.

Output Stage

The output stage consists of the pentode sections of the ECL82 valves operating in Class AB_1. Common cathode bias components (C_{11}, R_{17}) are used for the two valves. The resistor should be of the wirewound type rated to dissipate 2 watts. The screen grids of the valves are connected directly to the h.t. line.

The anode-to-anode load impedance of the output valves employed in this modulator is 10kΩ. The modulation transformer used is taken from the SCR522 transmitter, and this is obtainable from time to time on the surplus market. The SCR522 transformer has a turns ratio of 2:1, and it conveniently matches the anodes of the ECL82 pentodes to 2.5kΩ load such as that presented by an r.f. power amplifier stage operating at 250 volts and 100mA. The SCR522 modulation transformer satisfactorily matches the modulator to the 4 metre



Three-quarter rear view of the modulator

Components List

Resistors (All fixed resistors ½W 10% unless otherwise stated)

R_1	100kΩ
R_2	2.2MΩ
R_3	2.2kΩ
R_4	220kΩ, high stability
R_5	1MΩ, high stability
R_6	33kΩ
R_7	22kΩ
$R_{8, 9}$	100kΩ, matched (see text)
$R_{10, 11}$	1.2kΩ
R_{12}	1MΩ
$R_{13, 14}$	1MΩ, matched (see text)
$R_{15, 16}$	10kΩ
$R_{17, 18}$	390Ω, 2W, wirewound
VR_1	500kΩ pot, log track

Capacitors

C_1	39pF, tubular ceramic
C_2	50μF, 12V wkg., electrolytic
C_3	16μF, 350V wkg., electrolytic
C_4	0.47μF, 400V wkg., polyester
C_5	0.1μF, 350V wkg., polystryrene
C_6	8μF, 350V wkg., electrolytic
$C_{7, 8}$	50μF, 12V wkg., electrolytic
$C_{9, 10}$	0.1μF, 350V wkg., polystyrene, matched (see text)
C_{11}	50μF, 50V wkg., electrolytic
$C_{12, 13}$	50 + 50μF, 350V wkg., electrolytic

Valves

V_1	EF86
$V_{2, 3}$	ECL82

Rectifiers

$X_{1, 2}$	BY100

Transformers

T_1	SCR522 Modulation Transformer (see text)
T_2	Mains transformer. Secondaries: 250–0–250V 60mA, 6.3V 2A, R.S.C. (M/C) Ltd., 5 County Arcade, Leeds 1. (see text)

Switch

S_1	s.p.s.t. toggle switch. Bulgin type S600/PD

Plugs and Sockets

J_1	Coaxial socket. Belling-Lee type L604/S
J_2	Insulated coaxial socket. Belling-Lee type L603/B
P_1	Mains input plug. Bulgin type P429. (Matching socket is Bulgin type P430)
3	B9A valveholders
1	Octal valveholder
1	Pilot lamp fitting. Bulgin type D180

Miscellaneous

1	Pilot lamp, m.e.s. 6.3V 0.15A
1	Knob
1	5-way tagboard (i.e. 5 tag pairs). Bulgin type C120
2	15-way tagstrips
1	Chassis (as Figs. 2 and 3). This fits into Cabinet type W, available from H. L. Smith & Co.

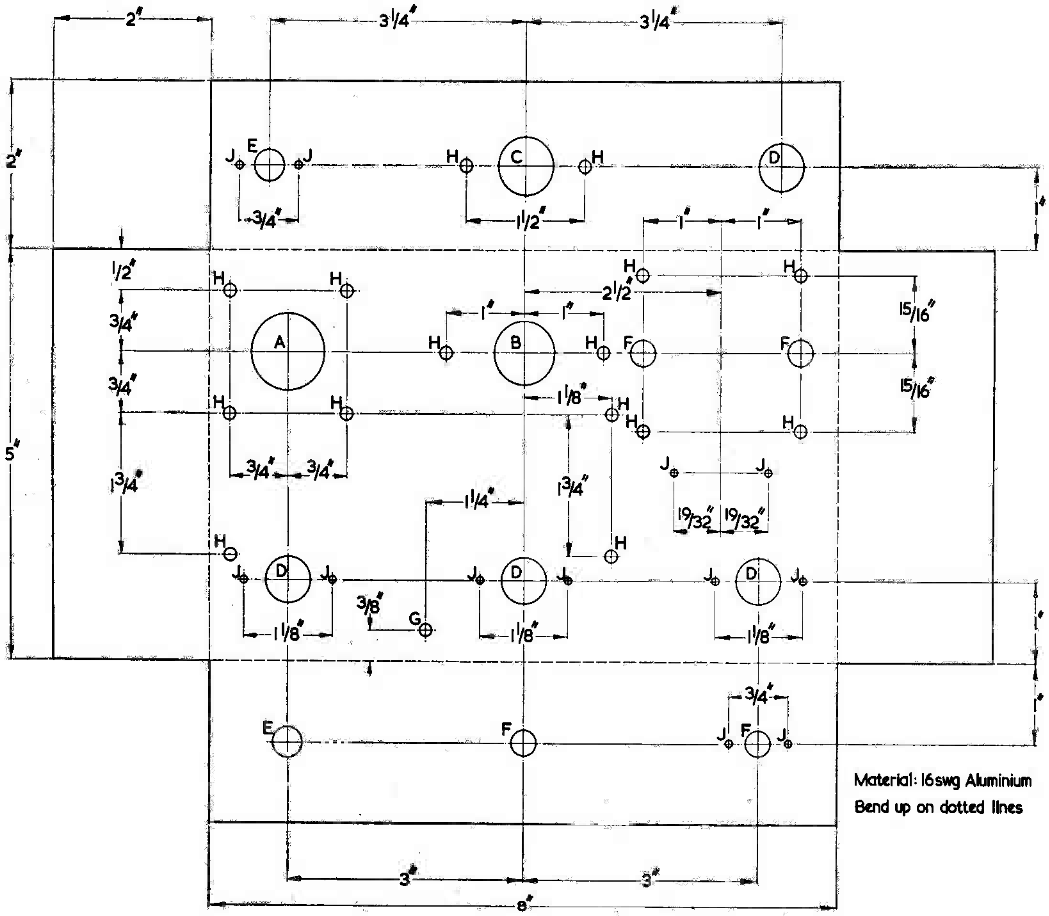


Fig. 2. Details of chassis dimensions

transmitter described in the June issue.

If it is desired to use this modulator design for a transmitter having a higher impedance, e.g. a top band transmitter with its P.A. operating at say 300 volts at 30mA, then an output impedance of 10kΩ will be required from the modulator. A transformer with a turns ratio of 1:1 would be required and the Collins modulation transformer, available on the surplus market, will be quite suitable. This, however, is rather bigger than the SCR522 transformer and some slight alterations may be required to the chassis layout. The Woden modulation transformer type UMO is also suitable. This is a multi-ratio transformer and will match the modulator to any impedance between 310 and 14,400Ω.

The power supply is quite conventional except for the use of silicon rectifiers rather than a valve. The main reason for using these is to save chassis space. The mains transformer is a miniature type available from Radio Supply Company (Manchester) Limited. The rectifier heater winding is, of course, not used.[2]

Construction

The modulator is built on a 16 s.w.g. aluminium chassis measuring 8 x 5 x 2in. The three valves are symetrically positioned at the front of the chassis while the transformers are fitted towards the rear corners. Between the transformers are the electrolytic capacitors C_{12}, C_{13}.

The front panel is made from 16 s.w.g. aluminium and measures 6 x 9in. It is attached to the chassis by the fixing screws or nuts for the input socket, the gain control and the h.t. switch. The front panel also carries a pilot lamp which indicates when the heater supply is connected.

Chassis and panel drilling details are given in Fig. 2 and Fig. 3 respectively, hole dimensions being

[2] The maximum recurrent p.i.v. for the BY100 silicon rectifier is 800, this corresponding to 283 volts r.m.s. from each half of T_2 secondary. Care should be taken to avoid excess voltage on T_2 secondary, as would be given, for instance, by tapping down too low on the primary. Both h.t. and heater secondaries referred to in the components list are almost fully loaded by the modulator valves and pilot lamp, and should only be lightly loaded by ancillary equipment (as mentioned under "Construction").—EDITOR.

TABLE
Holes on Chassis and Panel Drawings

Hole	*Dimension*
A	$1\frac{1}{2}$" dia.
B	$1\frac{1}{4}$" dia.
C	$1\frac{1}{8}$" dia.
D	$\frac{3}{4}$" dia.
E	$\frac{15}{32}$" dia.
F	$\frac{3}{8}$" dia.
G	$\frac{5}{16}$" dia.
H	$\frac{5}{32}$" dia.
J	$\frac{1}{8}$" dia.

listed in the Table. A Bulgin 5-way tagboard type C120 is used for the components associated with V_1, while for V_2 and V_3 two 15-way tagstrips are used.

An octal socket is provided at the rear of the chassis to enable the h.t. and l.t. voltages to be measured. It is recommended that the pin connections indicated on the circuit diagram be used. If desired, the socket is suitable for feeding ancillary equipment, e.g. an audio oscillator. An external power supply may also be fed into this socket while working portable or mobile. So that this can be achieved, it is necessary to disconnect the heater winding of the internal mains transformer, and this is done by using a jumper lead between pins 6 and 7 of the octal socket. On removal of this jumper the heater winding is disconnected. Thus, except while

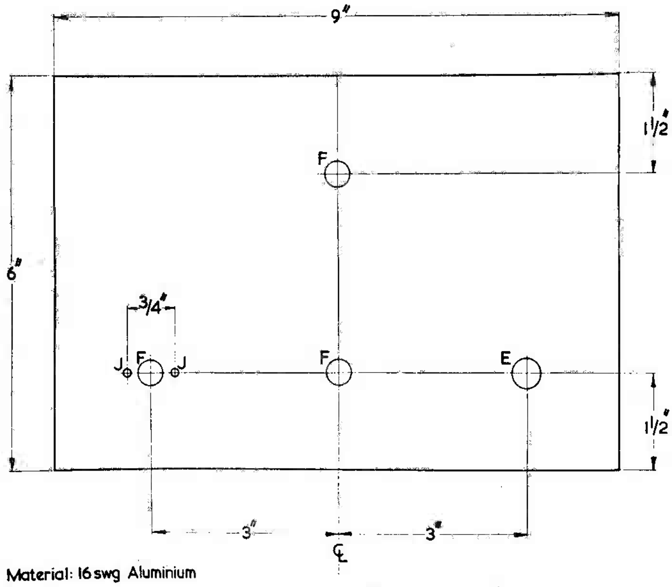
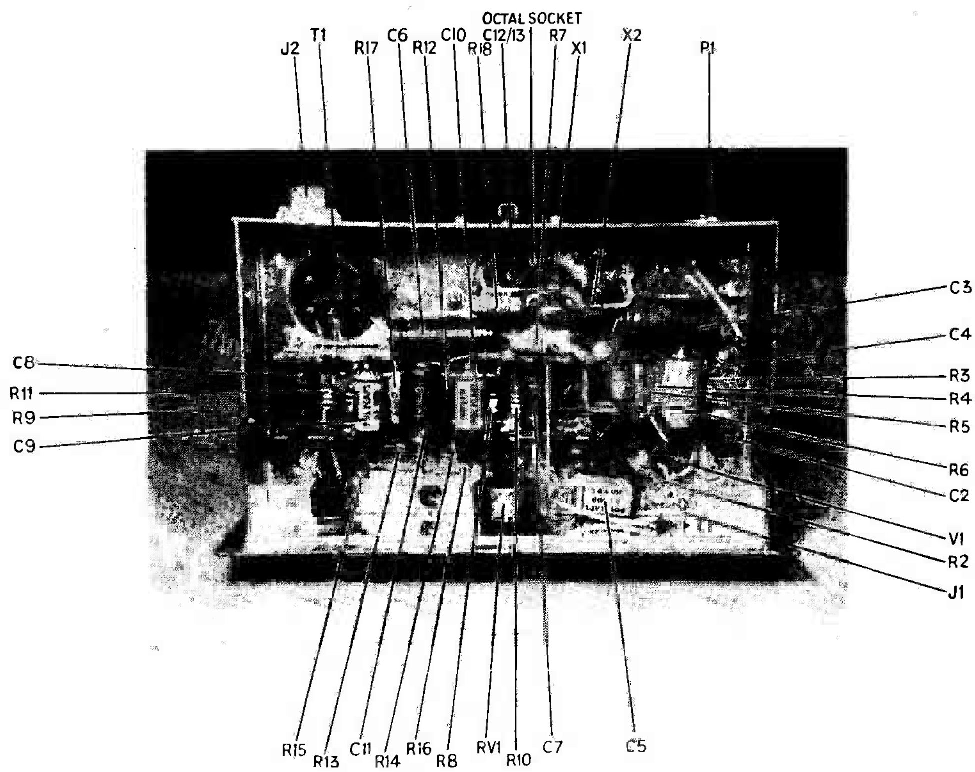


Fig. 3. The front panel



Underside view of the modulator showing the positions of the various components using the modulator from an external supply, pins 6 and 7 of the socket should be connected together. The rear of the chassis also carries the Bulgin three-pin mains connector, and a Belling-Lee insulated coaxial socket for the audio output.

No difficulty should be experienced in assembling the unit, particularly if the recommended components are used. The photographs show the positions of the major components.

Testing

After completing the modulator, a 2.5kΩ load should be connected across the secondary of the modulation transformer. This may consist of a 2.4kΩ and a 100Ω wirewound resistor connected in series. If an oscilloscope is available this may be connected across the 100Ω resistor, and the distortion of the amplifier measured with a sinusoidal input.

If no test gear is available, a pair of high impedance headphones may be used as a load, but care must be exercised in advancing the gain control in order not to damage the phones or eardrums!

Conclusion

This little modulator should provide a reliable audio source for any low power transmitter. It will be of particular interest to the newcomer to Amateur Radio who is contemplating building equipment to form the basis of his station.

An introduction to . . .

COLOUR TELEVISION

By J. R. DAVIES **PART 3**

In the second article in this series we saw how, in the transmitted colour television signal, the chrominance subcarrier and its sidebands can be interleaved between the sidebands of the luminance signal, thereby enabling the chrominance information to be transmitted within the same bandwidth as is occupied by the luminance signal. We learned also that, when the transmitting camera scans a white scene,

$$Y=0.59G+0.30R+0.11B$$

where Y represents the voltage amplitude of the luminance signal, G the voltage amplitude of the "green" tube signal, R the voltage amplitude of the "red" tube signal, and B the voltage amplitude of the "blue" tube signal. It is possible to transmit chrominance information by means of the R-Y and B-Y colour difference signals, the R, B and G signals being reclaimed at the receiver by combining these with the Y luminance signal. It was further noted that, when the transmitting camera scans a monochrome scene (i.e. black, greys and white) the colour difference signals drop to zero.

The N.T.S.C. Primary Colours

Fig. 6 shows the C.I.E. Chromaticity Diagram, this being marked up with the three primary colours employed in the N.T.S.C. colour system. It will be noted that these primary colours do not correspond *exactly* with the spectrum colours which appear on the outside curved line of the Diagram. For instance, the N.T.S.C. primary green does not correspond to the fully saturated spectrum green, although it is very close to this colour. The N.T.S.C. primary blue is similarly desaturated, and it is slightly removed in hue from the spectrum blue also. There is, again, a slight difference in hue between the N.T.S.C. primary red and the spectrum red, although it can be seen that the N.T.S.C. primary red is a fully saturated colour. These small discrepancies do not detract from the performance of the colour system to any very great extent, and the primary colours chosen for the N.T.S.C. system are such that they may be readily reproduced by practical cathode ray tube phosphors.

The colours given by additive mixing of the N.T.S.C. primary blue and the N.T.S.C. primary green lie along a straight line drawn, on the Diagram, between these two points. The same applies to the colours which may be produced by additive mixing of the N.T.S.C. primary green and the N.T.S.C. primary red, and by additive mixing of the N.T.S.C. primary red and the N.T.S.C. primary blue. The three lines joining the N.T.S.C. primary colours form a triangle, as illustrated in Fig. 6. If the *three* N.T.S.C. primary colours are mixed additively, it then becomes possible to reproduce any of the colours which are contained within this t riangle.

Whilst the N.T.S.C. primary colours can provide reproduction of any of the colours inside the triangle of Fig. 6, they are incapable of reproducing colours which fall outside. They can allow the *hue* of colours outside the triangle to be reproduced,

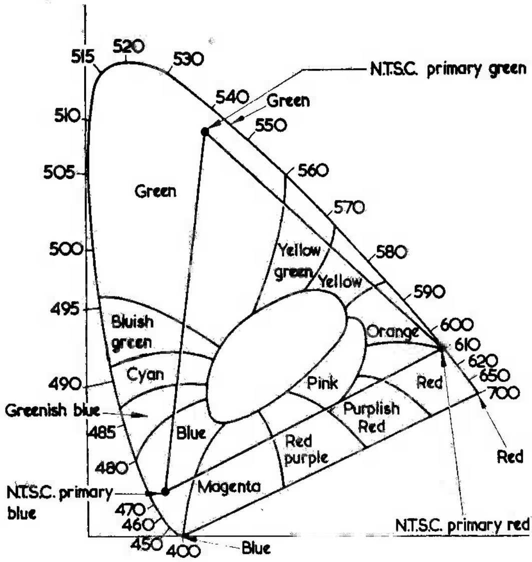


Fig. 6. The positions which the N.T.S.C. primary colours take up on the C.I.E. Chromaticity Diagram. By means of additive mixing, it is possible to reproduce any of the colours which lie within the triangle

but at reduced saturation only. This state of affairs is not as serious a disadvantage as it may at first sight appear, because the deeply saturated colours around the edge of the Chromaticity Diagram are, in any case, seldom encountered in natural life. In practice, the range of colours enclosed by the triangle joining the N.T.S.C. primary colours is significantly greater than that which can be given by colour reproductions employing established printing techniques. The latter are, as we know, quite capable of offering adequate reproductions.

The I and Q Signals

We have seen that it is possible to transmit colour information in the N.T.S.C. system by way of the Y, the R-Y, and the B-Y signals. At the same time, we have noted that colour information is carried by the chrominance subcarrier, this being amplitude modulated in quadrature (i.e. at 90° phase difference) by the I signal and the Q signal. We shall now examine the form which the I and Q signals take up in relation to the R-Y and the B-Y signals, dealing also with the modulation of the chrominance subcarrier.

It is most convenient to start with the R-Y and B-Y signals, introducing the I and Q signals later. It is helpful, further, to make the temporary assumption that it is the R-Y and B-Y signals which modulate the chrominance subcarrier in quadrature, and not the I and Q signals.

The statement concerning quadrature modulation may be more clearly understood if we say that we have two chrominance subcarriers which have the same frequency, but which differ in phase by 90°. One of these subcarriers is then modulated by the R-Y signal and the other by the B-Y signal. We may represent the phase relationship between the two subcarriers by means of a vector diagram, as in Fig. 7 (*a*), this clearly demonstrating the 90° phase difference. The length of each vector then corresponds to the amplitude of the modulating signal.

As in any similar vector diagram, we may obtain a single vector which indicates the resultant phase and amplitude given by the combination of two out-of-phase quantities. Thus, if the transmitter camera were to scan a colour which caused the R-Y signal to be equal to the B-Y signal, we would obtain a resultant vector lying midway between them, as in Fig. 7 (*b*).

Let us next examine what resultant vector we obtain when the transmitter camera scans a fully saturated colour, such as red.[1] A fully saturated

[1] It is assumed here that there is negligible difference between a fully saturated colour and the corresponding N.T.S.C. primary colour.

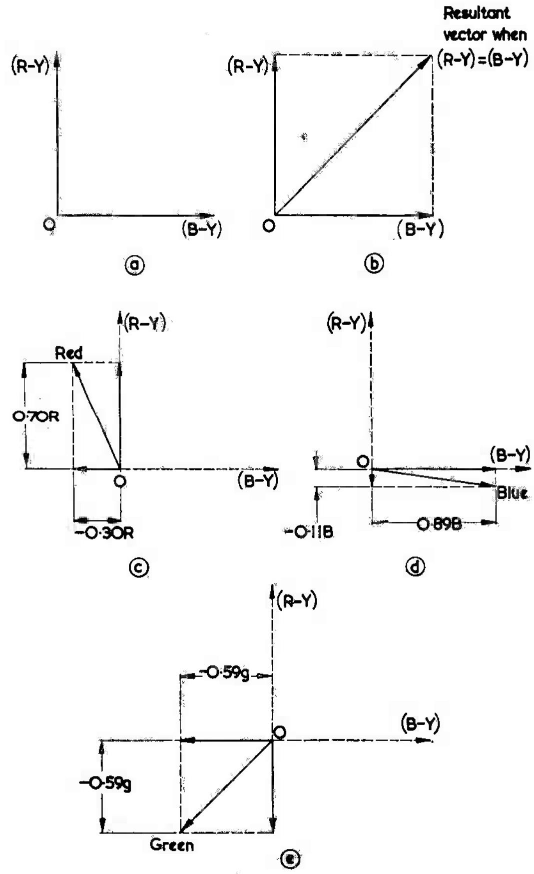


Fig. 7 (a). If the chrominance subcarrier were modulated by the R-Y and B-Y signals, the phase relationship and modulating amplitude could be represented by a vector diagram, as shown here
(b). The resultant vector given when the amplitudes of the R-Y and B-Y signals are equal
(c). The resultant vector for fully saturated red
(d). The resultant vector for fully saturated blue
(e). The resultant vector for fully saturated green

red contains no green or blue information, with the result that, in the equation

$$Y = 0.59G + 0.30R + 0.11B,$$

both G and B are equal to zero.

We then have

$$Y = 0.30R,$$

so that

$$R - Y = R - 0.30R = 0.70R.$$

At the same time, since B is equal to zero,

$$B - Y = 0 - 0.30R = -0.30R.$$

The resultant corresponding to fully saturated red then appears in the position shown in Fig. 7 (*c*), and it corresponds to 0.70R on the R-Y axis and −0.30R on the B-Y axis.

It is worthwhile repeating this exercise with another colour, such as fully saturated blue. A fully saturated blue contains no red or green information, so that, in the formula

$$Y = 0.59G + 0.30R + 0.11B,$$

both G and R are equal to zero.

As a result,

$$Y = 0.11B,$$

and

$$B - Y = B - 0.11B = 0.89B.$$

Also, since R is equal to zero, we have

$$R - Y = 0 - 0.11B = -0.11B.$$

The resultant which corresponds to fully saturated blue may then be drawn as shown in Fig. 7 (*d*).

If we carry on to a fully saturated green, we have the case where both R and B are equal to zero, whereupon

$$Y = 0.59G,$$

$$R - Y = 0 - 0.59G = -0.59G,$$

and

$$B - Y = 0 - 0.59G = -0.59G.$$

The resultant for fully saturated green then appears midway between the negative sections of the R-Y and B-Y axes, as illustrated in Fig. 7 (*e*).

Since all other colours are the result of combinations of two or three of the primary colours, it is possible to similarly plot these about the R-Y and B-Y axes, giving us a diagram such as that shown in Fig. 8 (*a*). It is interesting to note that these colours appear around the R-Y and B-Y axes in the same order as they appear around the centre of the C.I.E. Chromaticity Diagram.

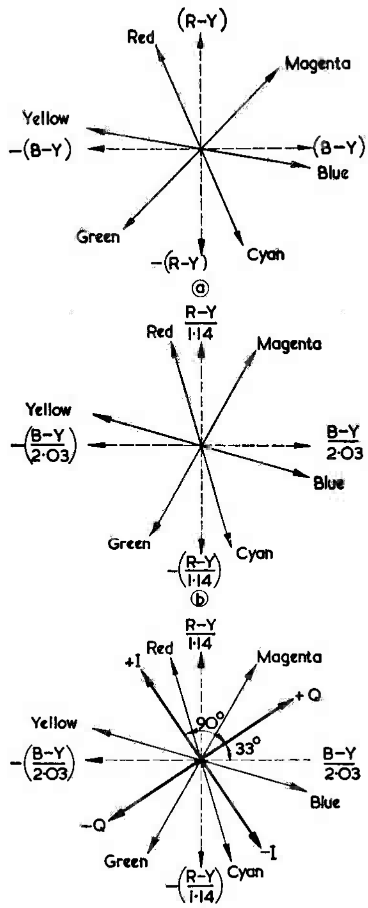


Fig. 8 (a). Since other colours may be formed by combinations of the primaries, it becomes possible to show these as vectors on the R-Y and B-Y axes. Each colour then corresponds, in hue, to the angular position of its vector and, in saturation, to the length of its vector

(b). Before transmission, the R-Y and B-Y signals have to be weighted by dividing them by 1.14 and 2.03 respectively

(c). Adding the I and Q signals to the R-Y and B-Y axes. It is the I and Q signals which actually modulate the chrominance subcarrier

Fig. 8 (*a*) illustrates the fact that any colour may be represented as a single resultant vector indicating the phase of a single chrominance subcarrier. The length of the resultant vector then corresponds to the modulation amplitude and, in consequence, to the saturation of the colour. Since the colours appearing around the intersection of the R-Y and B-Y axes correspond to the colours which appear around the centre of the C.I.E. Chromaticity Diagram, it follows that any colour in that Diagram (within the triangle joining the N.T.S.C. primary colours) may be represented by the phase and length of a resultant vector.

If the R-Y and B-Y signals are handled by the colour television system at their correct amplitude (relative to the luminance signal) the combined signal amplitude given when saturated colours are transmitted becomes excessive and cannot be handled without distortion and possible transmitter overload. In consequence, the R-Y and B-Y signals have to be reduced in amplitude, relative to the luminance signal, at the transmitter. In practice, the R-Y signal is divided by 1.14 and the B-Y signal by 2.03. The necessary correction for this reduction is then made at the receiver. The R-Y and B-Y signals are described, after reduction, as being *weighted*.

Because of the weighting factors introduced at the transmitter, our diagram of Fig. 8 (*a*) must now become altered to that of Fig. 8 (*b*), wherein the R-Y axis changes to $\frac{\text{R-Y}}{1.14}$ and the B-Y axis changes to $\frac{\text{B}-\text{Y}}{2.03}$. In all other respects, however, Fig. 8 (*b*) offers the same information as Fig. 8 (*a*). Since the B-Y axis is divided, in length, by a larger number than the R-Y axis, all that has happened is that the diagram of Fig. 8 (*b*) has been compressed horizontally. The result is a shifting of the angular positions of the vectors which represent the various colours.

We may now introduce the I and Q signals.

It is always desirable to keep the information in the chrominance subcarrier as small as possible. At the same time, we know that the eye is capable of defining some colours in fine detail considerably more readily than it can define other colours. The I and Q signal rechnique takes advantage of this characteristic of the eye, and allows a high level of useful chrominance information to be transmitted with maximum economy of bandwidth.

The I and Q signal vectors appear on the R-Y and B-Y axes in the manner shown in Fig. 8 (*c*). These signals may be obtained, at the transmitter, by suitable manipulation of the colour signals from the camera.[2] It is the I and Q signals which actually modulate the chrominance subcarriers, and not the R-Y and B-Y signals, as we have assumed up to now. It will be seen that the I and Q vectors are displaced from each other by 90°, in just the same manner as are the R-Y and B-Y axes. They may, in consequence, similarly modulate two subcarriers having a phase difference of 90°, and enable single resultant vectors (corresponding to the amplitude and phase of a single subcarrier) to be obtained.

The positive I vector has a direction lying between red and yellow, and it corresponds, in fact, to a reddish-orange. If this particular colour, in its fully saturated state, were presented to the transmitter camera, only the I subcarrier would be transmitted, as there is no colour information for the Q signal. The negative I vector has a direction corresponding to a colour in the greenish-blue range. If this colour, in its fully saturated state, were presented to the transmitter camera, the I subcarrier would, again, be the only one transmitted. However, since the negative I vector is in the opposite direction to the positive I vector, the chrominance subcarrier will have suffered a phase reversal of 180°.

The same points apply to the Q signal. The positive Q signal vector corresponds to colours in the magenta range, and the negative Q signal vector corresponds to colours in the yellow-green range.

The colours which the eye can detect most readily in fine detail are the reddish-oranges and the greenish-blues. The magentas and the yellow-greens can, on the other hand, only be distinguished in coloured areas which are much larger. Because of this, we have the case where the I signal corresponds to colours for which the eye has maximum discrimination, whilst the Q signal corresponds to colours for which the eye has minimum discrimination. It is for this reason that the I and Q signals are employed, and the angular position of their vectors has been purposely chosen to take full advantage of these characteristics of the human eye. The I and Q signals are given bandwidths which ensure that the optimum amount of useful colour information is transmitted without any wasteful expenditure in bandwidth. This requirement is achieved by giving the I signal a bandwidth of 1.5 Mc/s and the Q signal a bandwidth of 0.5 Mc/s.[3]

[2] Such manipulation can, indeed, be given by combining the colour signals in simple matrices employing resistive networks.

[3] These figures apply to the American 525 line system. Other systems, with different video bandwidths, may employ different I and Q bandwidths also.

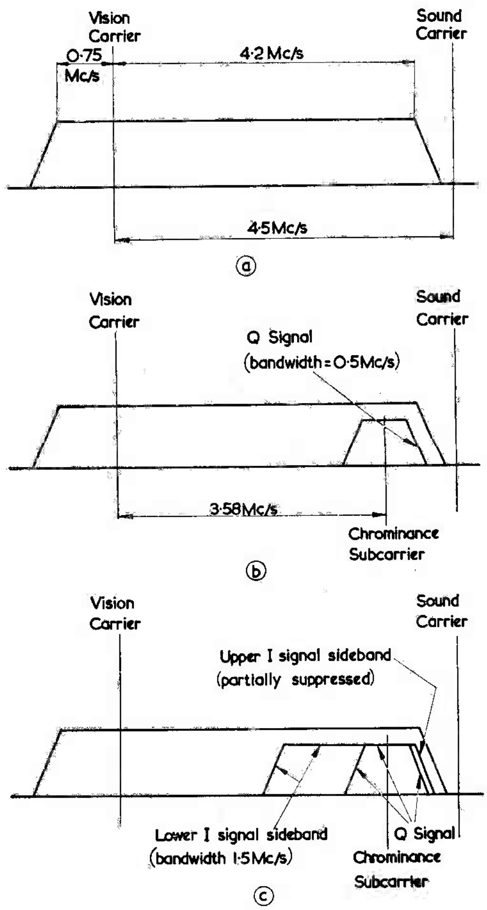


Fig. 9 (a). The ideal transmitter characteristic for monochrome transmission in the American 525 line system. (A nominal video bandwidth of 4.2 Mc/s is assumed.)
(b). Adding the Q signal. There is room inside the video passband for both sidebands of the Q signal
(c). The lower sideband of the I signal may also be transmitted in full, but the upper sideband has to be partially suppressed

We may now consider what occurs when a scene is scanned by the colour television camera. All colour information in the scene which gives chrominance signals having frequencies lower than 0.5 Mc/s are handled by both the I and Q signals, thereby allowing full colour reproduction to be achieved at the receiver. Where there is fine colour detail which results in a chrominance signal having a frequency in excess of 0.5 Mc/s the Q signal disappears, because it corresponds to a range of colours over which the eye is least sensitive. Chrominance signals between 0.5 and 1.5 Mc/s are then handled by the I signal on its own, this providing the reddish-oranges and greenish-blues to which the eye is most sensitive.

The Transmitted Signal

The ideal transmitter characteristic for a monochrome American 525 line signal has the appearance shown in Fig. 9 (*a*). (A nominal video bandwidth of 4.2 Mc/s is assumed). Let us now add the chrominance subcarrier signals, employing the bandwidths and frequencies pertaining to the American N.T.S.C. system.

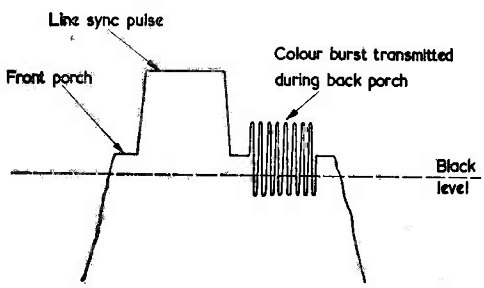


Fig. 10. The colour burst, which is superimposed on the back porch of the line sync signal

In Fig. 9 (*b*) we introduce the Q signal with its bandwidth of 0.5 Mc/s. The suppressed chrominance subcarrier appears at 3.58 Mc/s (corrected to 3 significant figures), and it is possible for both sidebands of the Q signal to be transmitted whilst still remaining within the confines of the overall 4.2 Mc/s video bandwidth.

The I signal has a bandwidth of 1.5 Mc/s. Its upper sideband would extend to 5.08 Mc/s if it were transmitted in full, and would appear outside the overall video bandwidth. In consequence, part of the upper sideband of the I signal has to be suppressed, whereupon it takes up the appearance shown in Fig. 9 (*c*). The lower sideband of the I signal is transmitted in full.

In Figs. 9 (*b*) and (*c*) we see that, if the chrominance subcarrier were not suppressed, it would be capable of beating with both the vision carrier and the sound carrier, causing interference to appear in monochrome or colour receivers in the form of patterning. The use of a suppressed subcarrier reduces the interference by a considerable amount. The energy in the chrominance subcarrier sidebands may still cause interference beat signals, however, these increasing in intensity as the saturation of the colours presented to the transmitter camera increases. It is possible to reduce the visible effect of such beat signals by a suitable choice of chrominance subcarrier frequency. In the American N.T.S.C. system, the chrominance subcarrier frequency is 3.579,545 Mc/s.

The Colour Burst

Because the chrominance signal is transmitted on a suppressed subcarrier, it is necessary for the subcarrier to be reinserted at the receiver before detection can take place. The subcarrier frequency at the receiver is obtained from a local oscillator, and it is essential that this be synchronised with the transmitter subcarrier not only in frequency but also in *phase*. The importance of obtaining correct phase relationship is immediately evident from an examination of the vector diagrams of Fig. 8. If the reinserted subcarrier were not synchronised in phase with the transmitter subcarrier, the transmitted colours would not be accurately reproduced by the receiver.

The local oscillator in the receiver is synchronised by means of a transmitted *colour burst*; this consisting of approximately 9 cycles at subcarrier frequency which are superimposed on the back porch of the line sync pulse, as shown in Fig. 10. These bursts may then be employed for synchronising the local oscillator, using principles which are similar to those encountered in line flywheel sync circuits. The colour burst is not transmitted during vertical sync pulses.

Part of the colour burst cycles appear above black level. It is possible, as a result, for these to become visible on the receiver cathode ray tube screen if there is inadequate blanking during the line retrace period. The visible effect under these conditions is at a minimum when the phase of the colour burst frequency corresponds to that of the negative B-Y vector of Fig. 8. In consequence, the phasing of the colour burst is made equivalent to $-(B-Y)$.

(To be continued)

INDEX VOLUME 16

The index for Volume 16 (August 1962–July 1963) of *The Radio Constructor* is now available. Direct Subscribers will receive a copy of the index with this issue of the magazine.

Copies of the index are available direct from us, 6d each plus 3d postage, etc.

Kit Review

The Hiker

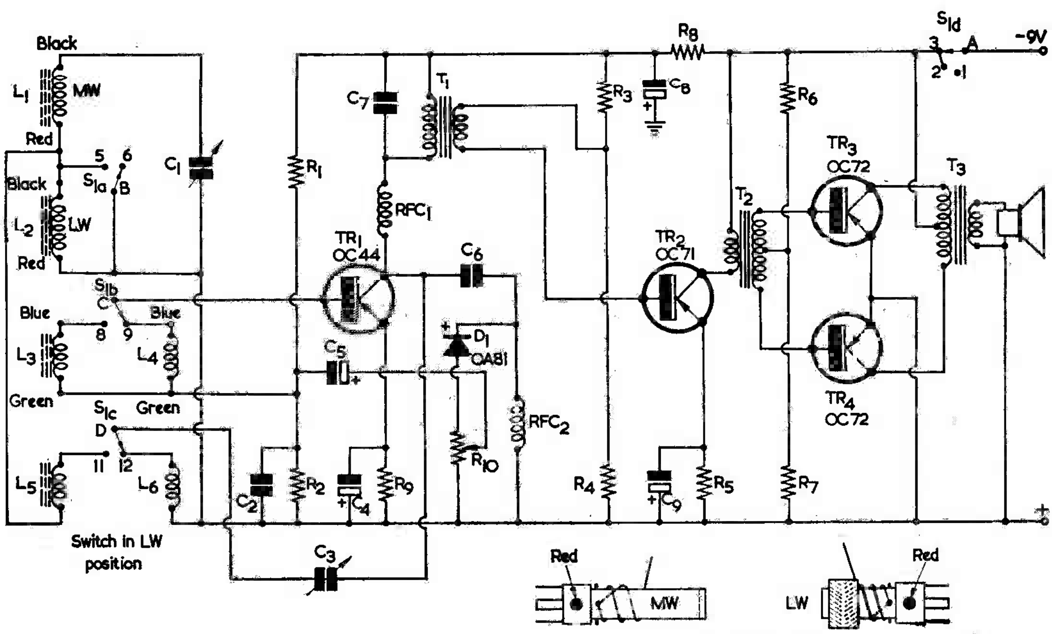
4-Transistor Portable Receiver

THE "HIKER" 4-TRANSISTOR RECEIVER HAS BEEN designed to cover both the Medium and Long waves and also to be contained within any case or cabinet of the user's choice. A small front panel is fitted to the printed circuit board, on which the majority of the main components are fitted—see illustration.

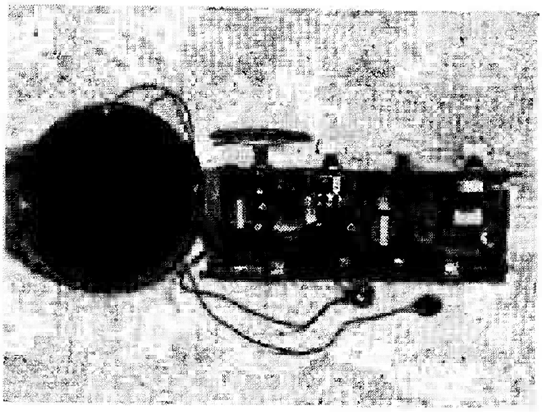
The construction process is easily carried out and takes only a couple of hours or so to complete, the printed circuit considerably assisting in this respect.

Circuit

This is shown in the accompanying diagram, from which it will be seen that TR_1 operates as a reflex amplifier with reaction. The coils shown are mounted on a ferrite rod and the 4-pole 3-way switch is illustrated in the Long wave position. $S_{1(a), (b), (c)}$ of the switch operates as the wavechange control, whilst the remaining part of the switch ($S_{1(d)}$) is utilised as the on/off control. In the Long wave position, both L_1 and L_2 are tuned by the variable capacitor C_1 (300pF); the reflex winding (L_4) and the reaction winding (L_6) both being brought into circuit. On Medium waves, L_1 is tuned by C_1, L_2 (Long wave winding) being short-circuited by $S_{1(a)}$. The switches $S_{1(b)}$ and $S_{1(c)}$ respectively bring into circuit the windings L_3 (reflex) and L_5 (reaction). The amount of positive feedback (reaction) applied to L_1, L_2 from the collector of TR_1 (OC44) is controlled by C_3. The potentiometer R_{10}, connected between diode D_1 (OA81) and chassis, acts as the volume control by varying the rectified signal voltage applied (via L_3 or L_4) to the base of TR_1. The inclusion of RFC_1 and RFC_2 ensures that the required r.f.



Reaction windings
MW—2·5turns
LW—10 turns
Wound in the opposite direction to the aerial coil with cotton covered enamel copper wire. approx. 30swg.



General view of the "HIKER" transistor receiver

voltage is applied to C_3 and diode D_1. The resultant rectified and amplified audio signal is next fed, via the transformer T_1, to the base of the following transistor TR_2 (OC71). Operating in the earthed emitter mode, TR_2 acts as the driver stage, its output signal being applied to both TR_3 and TR_4 (OC72) via the driver transformer T_2. T_2 provides the correct impedance match into the push-pull output pair of transistors. The output from TR_3 and TR_4 is finally fed to the primary of T_3 (output transformer) and thence to the speaker.

The coils are shown as an inset in the diagram, the illustration clearly showing the correct method of assembly with respect to these components.

Operating Hints

Once completed, the receiver should be operated as follows. Fully open the reaction capacitor (C_3) and turn the switch S_1 to the centre position (Medium wave). Tune in the desired station by rotating the variable capacitor C_1 and increase gain by closing C_3 until the receiver is just below the point of oscillation. Adjust the volume control R_8 for the required amount of audio output. It will be found that the receiver has good selectivity characteristics for a single tuned circuit design, this being due to the high Q of the FR_2 ferrite aerial and the use of reaction. The aerial assembly can be utilised to improve selectivity by altering the orientation of the receiver.

The "Hiker" receiver is available direct from Repanco Ltd, O'Brien's Buildings, 203–269 Foleshill Road, Coventry, complete constructional details being provided with each kit of parts.

Components List

Resistors
- R_1 68kΩ
- R_2 10kΩ
- R_3 47kΩ
- R_4 10kΩ
- R_5 680Ω
- R_6 6.8kΩ
- R_7 150Ω
- R_8 470Ω
- R_9 680Ω
- R_{10} 10k potentiometer

Switch
- $S_{1(a), (b), (c), (d)}$ 4-pole, 3-way

Speaker
- 3Ω 5in round

Ferrite Aerial
- FR_2 (Repanco Ltd)

R.F. Chokes
- RFC_1, Type RF_1 (Repanco Ltd)
- RFC_2, Type RF_2 (Repanco Ltd)

Transformers
- T_1 Type TT49 (Repanco Ltd)
- T_2 Type TT45 (Repanco Ltd)
- T_3 Type TT46 (Repanco Ltd)

Capacitors
- C_1 300pF variable
- C_2 0.02μF
- C_3 100pF variable
- C_4 100μF electrolytic 6V wkg.
- C_5 8μF electrolytic 6V wkg.
- C_6 100pF s. mica or ceramic
- C_7 0.01μF
- C_8 100μF electrolytic 9V wkg.
- C_9 100μF electrolytic 6V wkg.

Semi-Conductors
- TR_1 OC44 Mullard
- TR_2 OC71 Mullard
- TR_3, TR_4 OC72 Mullard (matched pair)
- D_1 OA81 Mullard

Printed Circuit Board
- Complete with front panel and brackets (Repanco Ltd)

Battery
- 9V Vidormax type VT9

Miscellaneous
- Battery studs, screws, wire, etc.

Single Transistor Loudspeaker Receiver

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

An ingenious single transistor circuit which offers a loudspeaker output when a strong local signal is available

WHETHER IT IS BEER OR DECIBELS, there is a fascination in getting a quart out of a pint pot. In the 1920s, when valves cost a lot and lit up the room with their heavy current consumption, the single valve reflex was to be seen in many homes which were close to a transmitter. Reflex circuits have come back into vogue with the advent of the transistor, but appear nearly always in the earlier stages of the circuit only. There are difficulties in designing a single transistor reflex circuit capable of giving reasonable results on a loudspeaker, as high frequency transistors can only handle a few milliwatts of power, and most low frequency transistors are useless at frequencies round about 1 Mc/s.

This is a description of a circuit which will give about 20 milliwatts of power output from a local station transmitting in the Medium waveband. Provided a sensitive loudspeaker is used, not smaller than 7 x 4in, or 6½in round, this is sufficient volume for quiet programme value in quite a large room. It is more than enough for bedside listening. As a test whether the local station is local enough, it can be said that the circuit will be satisfactory if even weak headphone signals can be received on a simple crystal set without undue interference from another station. But it is strictly a local station receiver with the tuning pre-set to one frequency.

The Transistor Employed

The transistor used is a GET114 or GET103. There is nothing to choose between these, but one or the other should be used. The advantage of these transistors is that, although they are designed for low frequency use, their α cut-off frequency is about 1 Mc/s for an average specimen. Also, they will oscillate at rather higher frequencies than this, provided, of course, they are used as common base amplifiers.

A common base amplifier gives less gain than a common emitter amplifier, but if high frequency amplification is obtained through reaction there is no difference, as the same maximum reaction amplification is obtained on the threshold of oscillation in each case. If Fig. 1 is studied, it will be seen that L_1 and the section of L_2 between points 3 and 4 provide the necessary coupling, and that the reaction control R_1 will produce oscillation as its slider moves near to C_3 (provided that the capacitance of C_3, in parallel with C_4, is of a suitable value for the particular transistor in use). A total of about 1,000pF will probably be found to be right, but there is sufficient variation in the capacitance of C_3 to compensate for the differences in characteristics of different transistors. This, of course, assumes that a first-grade transistor will be used, of one or other of the two types recommended.

The very considerably amplified signal appearing in the tuned circuit L_1 C_1 is applied to the diode D_1 by way of the whole of the secondary coil, L_2. There is sufficient self-capacitance in the windings of T_1 for rectification to take place, and no external capacitor should be added. The low frequency signal, amplified by T_1, is applied to the base of the transistor which, at low frequencies, will be seen to operate as a common emitter amplifier.

The Aerial

The aerial is connected, through C_6, to the base of TR_1. An alter-

Components List

Capacitors
- C_1 250pF Trimmer (see text)
- C_2 500pF
- C_3 750pF Trimmer
- C_4 500pF (see text)
- C_5 100µF, 12 w.v., Electrolytic
- C_6 0.01µF
- C_7 0.01µF

Resistors
- R_1 250Ω, wirewound pot
- R_2 47kΩ

Transformers
- T_1 Output transformer type MRT/2, Elstone
- T_2 Output transformer type TT5, Repanco

Coil
- L_1, L_2 See text and Fig. 2

Semi-conductors
- TR_1 GET114 or GET103
- D_1 OA81, Mullard

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

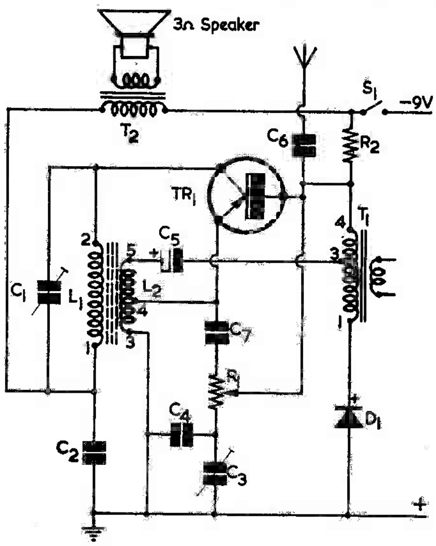


Fig. 1. The circuit of the single transistor receiver

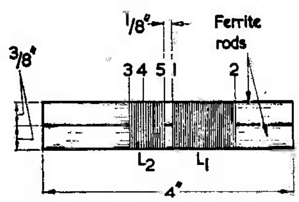
native arrangement would be to use L_2 as an aerial coupling coil, but the connection shown in Fig. 1 works better, particularly with a high capacitance aerial. There is probably very little real (as against regenerative) high frequency amplification, but there is the advantage that the aerial causes very little damping of the tuned circuit and can therefore be tightly coupled—as is required in a simple local station receiver where selectivity is not a problem. The impedance between aerial and earth is low, but so is the internal impedance of the transistor between base and emitter. Indeed, what would normally be a very inefficient aerial can give excellent results, and it will probably be found that a connection to a cold water tap does very well, notwithstanding its own contact with earth. Also, a separate earth should be used and, because of the possibility that both aerial and earth may be at the same direct current potential, C_6 is included to prevent the base of TR_1 finding itself without negative bias on its emitter.

In the case of the prototype, results on a fairly good outside aerial and a very good outside earth are inferior to those obtained using a cold water pipe as aerial and the earth socket of a power plug as earth! One of the reasons for the circuit's predilection for high capacitance aerials is that capacitance between base and earth (and hence between aerial and earth) is necessary for reaction. Within reason, the more capacitance that can be introduced by a signal-producing device the less has to be added externally, and the aerial input impedance of the circuit is consequently not reduced so drastically. For the same reason, the circuit is very demanding in its need for a good earth connection, and functions badly without one.

It will be seen that there is no stabilising resistor in the emitter circuit, but this is not required (and, indeed, cannot be efficiently introduced) because of the effect of the rectifier, D_1. It will be found that, with R_1 at its minimum position, some 8 to 12mA will flow through TR_1 (depending on the exact characteristics of TR_1 and D_1). As the local station is brought up by reaction the current will drop until, near the point of oscillation and assuming a strong signal, it may be as little as 2 to 3mA. This drop in current is due to the positive potential applied to the base of TR_1 by D_1, in opposition to the standing negative bias provided by the potentiometer formed by R_2, T_1 and D_1. If TR_1 heats up and tends to take more current, increased reaction takes place owing to the increased efficiency of TR_1. A larger positive potential is produced by D_1, and the current drops. The circuit has pre-set tuning, so there will always be a signal for D_1 to rectify. It is presumed that the listener will not leave the receiver switched on when the transmitter is not operating. However, even if he did go to sleep before the programme finished, it is doubtful whether TR_1 would suffer!

Specified Components

This is a circuit which requires certain specified components and may not work with substitutes. The author has tried several different transistors, and the only one which worked anything like as well as the GET114 and the GET103 was, curiously enough, a very cheap Red Spot surplus type without any branding. D_1 should be a first grade OA81 and not a surplus type. It is important that its resistance should not vary beyond the normal limits of an OA81.



1-2 30turns of 32swg wire
3-4 6turns of 32swg wire
4-5 9turns of 32swg wire

Fig. 2. Winding details for L_1 and L_2

T_1 plays a very important part. It should be an Elstone valve type output transformer No. MRT/2, and is connected to give a step-up ratio of 3:1. A transistor transformer does not work as well in this position. Although other valve output transformers might be satisfactory, the circuit has been designed round the MRT/2, which costs no more than some transistor transformers. It is, of course, rather larger, though still small for its type. The numbers shown in Fig. 1 will be found stamped on the transformer. Its secondary is left disconnected.

T_2 is a Repanco TT5, and if a different transformer is used it should have similar characteristics. The whole of the primary winding is used. The coil L_1 L_2 is non-standard and must be made. As it is essential for it to have a high Q in order to encourage TR_1 to oscillate in the Medium waveband, the coil is wound on ferrite rod, but there is no intention that the circuit should be used without an external aerial and earth. Two 4in lengths of $\frac{3}{8}$in rod are required, and can be made by snapping a standard 8in rod in two. The two rods are bound together with Sellotape, as shown in Fig. 2. L_2 is wound on first, consisting of 15 turns of wire, close wound, with a tapping at the end of the sixth turn. L2 follows in the same direction after a gap of $\frac{1}{8}$in, and consists of 30 turns, close wound. 32 s.w.g. wire is used for both windings, which should be roughly at the mid-point of the rods. The windings are covered with Sellotape.

C_1 is specified as a 250pF trimmer, and this value is suitable for most local stations likely to be used. But 100pF would be more suitable for stations below about 260 metres, and 500pF for the North Home Service on 434 metres.

It has been emphasised that this circuit is only suitable for local station reception in fairly good reception areas. More distant stations can be received, weakly, but cannot be brought up satisfactorily in strength as there will be instability and backlash in the reaction circuit on weak carrier waves. With a strong signal the reverse bias produced by D_1 results in a smooth build up.

Setting Up

In order to set the receiver up for the local station, R_1 should be adjusted to its maximum position (i.e. with its slider at the end connected to C_3) and C_3 opened right up. C_1 should be adjusted until signals are heard and then C_3 tightened gradually, C_1 being simultaneously slackened off a little to keep the signal in tune, since there is interaction between the two trimmers. This process should be continued until the signal is at its loudest without oscillation. If there should be oscillation on the local station with C_3 wide open, C_4 should be removed from the circuit.

It is up to the constructor to decide whether he wishes to arrange things so that R_1 can just be taken to its maximum position without oscillation, or whether he prefers oscillation to set in near the maximum setting. The second alternative allows for a fall in voltage of the battery as it ages.

For good results there should be a drop of at least 4mA in the current taken by TR_1 as R_1 is advanced from its minimum position to a position just short of oscillation, and this will be achieved unless the local station is too far away or the aerial or earth not up to requirements. With a strong signal from the local station the current may drop to as little as 2mA, which is too low to provide reasonable output; and in these circumstances listening should be done at a setting of R_1 rather below the maximum possible. About 5 to 6mA provides an output of 20 milliwatts and is easy on the battery. Because of the a.g.c. action produced by D_1, there is little increase in amplification if reaction is increased to a point where the current drops below 5mA.

It is, no doubt, obvious that a milliameter with a maximum reading of about 15mA is very useful in setting up this receiver, as the a.g.c. effect makes audible effects a little difficult to judge. But a meter is by no means essential.

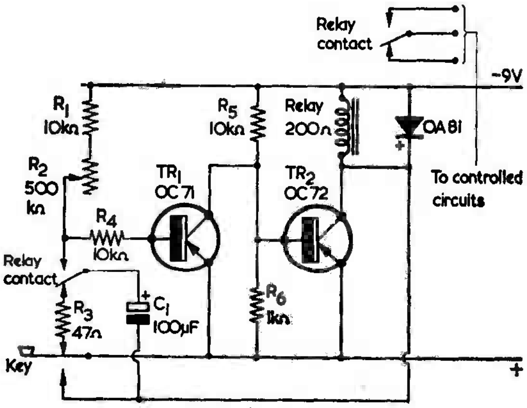
Two-Transistor Timer with Positive Feedback

By M. D. DEVENISH

An ingenious timing circuit which offers consistent timing periods with very quick relay operation

A RECENT ARTICLE IN THE "SUGGESTED CIRCUIT" series* describes a two-transistor timer which offers quick de-energising of the relay at the end of the timing period. This is achieved by connecting a battery in series with the capacitor in the time constant circuit, this battery maintaining the first transistor in a cut-off condition until the period is nearly complete.

The timer circuit described in the present article employs a somewhat similar basic principle. However, a positive feedback circuit has been incorporated which makes relay operation very much quicker than in the earlier design. Also, the circuit may be operated from a single 9 volt battery, instead of the two batteries previously required.



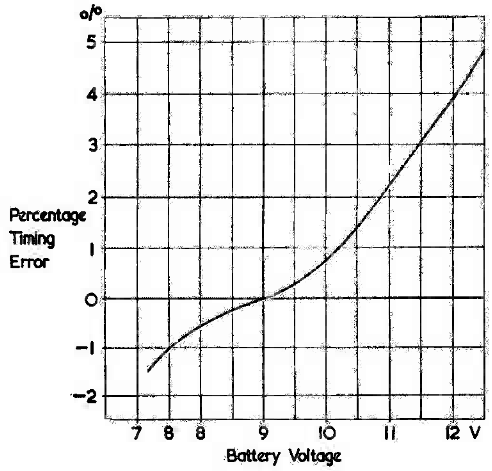
The Circuit

The writer's circuit appears in Fig. 1. The relay employed has two sets of contacts (shown "detached" from the coil and in the de-energised condition), one of these appearing in the base circuit of TR_1 whilst the other controls the external circuit. The operation of the timer may be described in the following manner.

Initially, TR_1 is conducting and TR_2 non-conducting, the base current of TR_1 through R_1, R_2 and R_4 being such that the collector current passing through R_5 produces a large enough voltage drop across this resistor to cut off TR_2. The relay is thus de-energised. Also, the upper plate of C_1 is returned, via the relay contact, R_3 and the operating key, to the positive battery potential. The lower plate of C_1 is at the collector potential of TR_2. As TR_2 is non-conducting, this plate will be nearly at the negative battery potential. Upon depression of the key to initiate the timing cycle, the upper plate of C_1 is first isolated from the positive battery terminal by the key contact. The positive potential is then applied both to the lower plate of C_1 and to the lower end of the relay coil. This causes a change of potential of nearly 9 volts on C_1, driving the upper plate nearly 9 volts positive relative to the positive battery potential, and it also energises the relay. When the relay makes its contacts, the upper plate of C_1 is connected to the base of TR_1, thus cutting off the collector current of this transistor, and allowing TR_2 to draw base current through R_5. Thus the feed to the relay is maintained via TR_2. When the key is released the voltage on the lower plate of C_1 is maintained by the direct connection from the collector of TR_2, which is now nearly at the battery positive potential.

The capacitor C_1 next proceeds to discharge through R_1 and R_2 via the relay contact. The timing period is determined by the time constant of this circuit, and may be altered by varying R_2.

*"Suggested Circuit" No. 143, "Electronic Timer with Fast Relay Operation", *The Radio Constructor*, October 1962.



As soon as the potential on the upper plate of C_1, and therefore the base of TR_1, rises above the positive battery potential, TR_1 starts to conduct. This, in turn, reduces the base current of TR_2, which starts to cut off. As it does so, its collector begins to go negative. This negative voltage is fed back via C_1 to the base of TR_1, causing a very rapid build-up of current in TR_1, and, consequently, a very rapid cut-off in TR_2. This action results in extremely fast relay operation. As soon as the relay de-energises, the upper plate of C_1 is returned to postive battery potential via R_3, and the unit is automatically reset for subsequent use.

In view of the extremely fast relay operation, it is essential that a diode be connected across the relay coil to prevent high voltages being induced at the collector of TR_2. Also, with the large amount of positive feedback, a limitor resistor, R_4, is essential in series with the base of TR_1.

It is impracticable to draw a graph of relay current versus time, as was given for the previous design, because the change in current is too rapid for any meter to follow. To verify this point, the writer increased the value of C_1 to 5,000μF and connected a meter across TR_2. The timer ran for 39 minutes and then the relay contacts snapped open, apparently absolutely simultaneously with the first hint of movement of the meter needle.

Tests

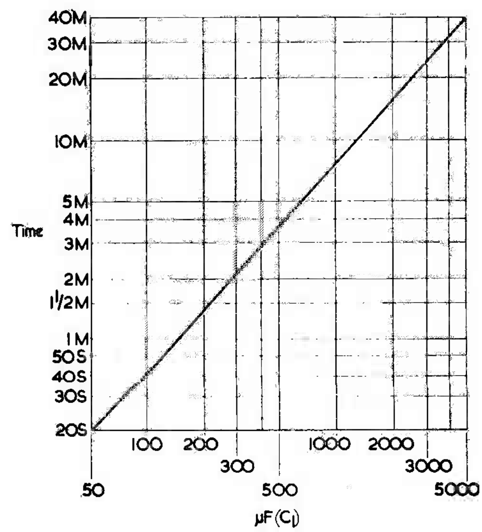
A series of tests were carried out for a fixed setting of R_2. The timings were found to be consistent to within $\pm 0.75\%$.

Tests were also conducted on the effect of varying battery voltage, and the results are shown graphically in Fig. 2, in the form of percentage timing variations from the time obtained with a 9 volt supply. It will be noted that this error is within $\pm 1\%$ from 7.5 to 10 volts. It should therefore be reasonable, assuming the battery to be within 0.5 volt of its nominal value, to claim an overall accuracy of $\pm 1\%$.

Fig. 3 is provided to give an idea of what maximum timings may be expected from various values of C_1. The precise timings obtained will of course depend upon the leakage resistance of the capacitor actually used for C_1.

Points of Design

A 9 volt supply was employed for the timer because of the wide variety of batteries of this voltage available. It was also felt that a mains version might be constructed, using one of the advertised 9 volt battery eliminator packs.



A 200Ω P.O. type 3000 relay was chosen, it being fitted with two change-over contacts. This relay was found to operate at 7.2 volts, and it gives very reliable operation on the 9 volt supply. It is well within the handling capabilities of the OC72 transistor. The values of the bias resistors were decided on the basis of a current gain of 50 per transistor.

In the author's finalised design it is proposed to use a capacitor of approximately 200μF, to give about 1.5 minutes time. It is also felt that a logarithmic potentiometer in the R_2 position would be an asset, as the non-linear scale resulting would provide for greater accuracy in setting the shorter timings.

Next Month . . .

3-TRANSISTOR RECEIVER

ELECTRICAL SPEEDOMETER

Preparing Radio Panels

By J. Anderson

PREPARING RADIO PANELS MAY, AT first sight, seem rather a strange subject for an article, and the reader may feel that such a topic barely merits writing about. However, the average constructor takes pride not only in the performance but in the appearance of his equipment, and it is worth spending a little more than the usual time on preparing a panel which is not only clearly labelled and well laid out, but which is also pleasing to the eye.

Panel Material

The first concern, of course, is the material of which the panel is to be made. Assuming access to a suitable drill, there is no material to equal hard steel, especially if the panel is to play a part in supporting the internal chassis and controls. If, on the other hand, the controls are to be mounted on a frame, with only the spindles projecting through the panel, then dural or aluminium is better, as it will save a surprising amount of weight.

The layout of the controls must be planned before the panel is prepared. In many cases, and particularly in high-frequency equipment, layout will be in part dictated by the internal screening and the necessary shortness of all leads. If complete flexibility is available, it is usually better to have sockets at the foot or at one end of the panel to keep trailing leads out of the way, and controls which require delicate adjustment at the top for the same reason. "Logical progression" of controls is also sensible, as is given by placing the controls in rough order of their position in the circuit, starting at one end. It is worthwhile noting here that the more delicate controls, such as tuning, are often placed at the right-hand end, as most people are right-handed.

When the control layout has been planned, the panel should be well sandpapered down, back and front, and then washed with spirit or petrol to ensure a grease free surface for painting. Drilling, of course, will be carried out at this stage. If the reader wishes to smarten-up an item of ex-Government equipment, then the sanding down stage will be an ideal starting place.

Painting

Paint is best applied in two coats to allow for greater permanency, and a hard lacquer is best. Plastic enamels, whilst cheap and smart, wear and scratch quickly.

The colour of the panel will, of course, be dictated by the taste of the individual although, in general, light grey or black are good choices from the point of view of cleanliness and clarity. If the case around the unit is separate, then the panel can be the same colour or a few shades darker.

When the second coat of paint has hardened the control wording should be applied. "Panel Sign" transfers are ideal for this, being very easily applied. A small pair of tweezers may be a useful aid here. For knobs which operate "click switches" with several positions, it is wise to fit the control temporarily in place with its knob, this ensuring absolute accuracy in positioning the markings.

After the transfers have had a period of drying out, a coat of clear varnish makes an ideal finish, either over the transfers alone, or over the entire panel as an additional protection. If the panel has been finished in matt paint (which is very liable to collect dust) then matt varnish can be obtained to cover the transfers, but this should be applied thinly. Convention dictates that the transfers be above the controls, but if the apparatus is to be placed permanently on a shelf above the work bench, or at the top of a rack, it should be obvious as to where the transfers are best sited.

Knobs and Sockets

"Handles", or knob-protectors, at each end of the panel (or one horizontal in the middle for a small panel) are an excellent idea, and look attractive if finished several shades lighter than the panel itself. A final touch is provided by a set of matching knobs, skirted knobs being best for keeping dust out of the hole behind them, and for keeping fingers off the paint. High-voltage switches and plugs are often painted red for safety reasons, but this is of doubtful value and usually succeeds in giving a rather garish overall effect.

Many items of ex-Government equipment have small test panels on them, these carrying a row of studs or sockets. The test panel on the R107 is an example in point, and is one which is probably quite well known. This sort of dust collector can be replaced with a small panel carrying only two meter sockets and a Yaxley switch to select the metering point, giving thereby a much more "hand-built" appearance to the entire set. The balancing of large panel components should be borne in mind. A large mains plug should obviously be at the opposite end of the panel from a large vernier tuning dial, and if the unit carries two meters they are best placed one on each side of the mid-line rather than one above the other. Large labels and a multiplicity of red lights are to be avoided, and so are over-large ventilating apertures because of the effects of hand capacitance. If a loudspeaker is to be fitted directly to the front panel, the latter must be very securely fixed to prevent rattling. It should also be attached at several points to the chassis or frame to "kill" the metallic sound which usually results from using the panel as a baffle.

In conclusion, when finishing off your next construction job think of the effect the remark, "I made it myself" will have on a non-technical person—and aim for that professional finish.

Identifying Surplus American Electronic Equipment

By Ken Greenberg

AMERICAN MILITARY ELECTRONIC EQUIPMENT IS designated by a series of letters and numbers which often can tell you much about its original use and purpose. Presently available surplus radio equipment is designed according to one of three systems.

Signal Corps System

This is the oldest equipment coding system and has been discontinued because there was no way of knowing from the designations which individual equipments belonged to a complete system. Here are some of the most common prefix letters used and their meanings:

SCR	Set Complete Radio
AN	Antenna
BC	Basic Component
DM	Dynamotor
VT	Vacuum Tube
PL	Plug
FT	Mount, Rack or Adapter
RA	Rectifier Power Supply
TS	Test Set

Under this designation system an overall equipment was SCR, followed by an arbitrary number and suffix letter which represented the model or modification. However, using this system there was no way to determine, for example, whether the BC-453A is the receiver or the BC547A the transmitter in the SCR-274N. Also, you could not tell from the designation that the SCR-274N was used in aircraft for two-way radio communications. As you can see, this system does not have much identification value.

Navy Model Letter System

Although no longer used to any extent, there is still much naval equipment in use identified by this system. The assignment of letters depends on the primary function of the equipment. The first letter indicates th basic purpose of the equipment, except where the word "MARK" is used to indicate Bureau of Ordnance equipment.
These first letters are explained in Table I.

The second letter indicates the order the designation was assigned, except for the letter X which is used to indicate experimental equipment. The letters TA, for example, would indicate the first transmitting equipment assigned, TB the next and so on. Triple letters like TAA, TBA, etc., are used when the alphabet is exhausted.

"AN" System

All American military services are now using the Joint Nomenclature System ("AN" System) to identify electronic equipment, including independent units that are not parts of specific equipment. Complete systems are designated by three equipment indicator letters that follow AN/, and signify kind of installation, type of equipment and its purpose. These indicator letters are explained in Table II.

Using the letters in Table II, the AN/ARC-3 is, for example, identified as follows. The A means it is installed in an aircraft, the R means it is radio equipment and the C means it is used for transmitting and receiving communications. The number 3 indicates this was the third equipment designated with the letters ARC. System indicator letters "AN" do *not* mean that the Army, Navy and Air Force all use the same equipment, but simply that the type number was assigned in the "AN" system.

Independent units not part of, or used with, specific sets have a type number consisting of a component indicator letter, a number, the slant (/), and whatever equipment indicator letters (from Table II) apply. Using the R44/ARR-5 as an example, R44 is the independent component designation of an Airborne Radio Receiver (No. 5 in the ARR series). The "AN" system component indicator letters are listed in Table III.

From the preceding information, you should be able to identify much of the American surplus equipment you come in contact with personally, or see advertised in publications. Knowing the original installation, use and purpose may very well prevent you from acquiring a worthless piece of equipment.

TABLE I

Navy Model Letter System

A	Airborne installations
B	IFF
CX	Commercial experimental
D	Radio direction finding
E	Emergency power
FS	Frequency shift keying
G	Aircraft transmitting (superseded by "A")
J	Sonar listening (receiving)

K Sonar transmitting
L Precision calibrating
M Combined radio transmitting and receiving
MARK Fire control radar
N Sonar navigational aids (echo sounding)
O Operator training and measuring
P Automatic transmitting and receiving
Q Sonar ranging
R Radio receiving
S Search radar
T Radio transmitting (includes combination transmitting and receiving)
U Remote control (automatic keyers)
V Radar repeaters
W Combined sonar ranging and sounding
X Experimental
Y Navigational and landing aids
Z Navigational and landing aids (superseded by "Y")

In sonar equipment, the first letter indicates the general use of the equipment. The second designates the type of projector used as follows:

QA Quartz steel
QB Rochelle salt
QC Magnetostriction
QD Depth determining
QG Magnetostriction (split-lobe)

TABLE II

"AN" System Equipment Indicator Letters

Installation

A Airborne (installed and operated in aircraft)
B Underwater mobile (submarine)
C Air transportable (obsolete)
D Pilotless carrier
F Ground fixed
G Ground, general ground use
K Amphibious
M Ground mobile
P Ground, pack or portable
S Water surface craft
T Ground, transportable
V Ground, vehicular (in vehicles not primarily designed for carrying electronic equipment)
U General utility (two or more general installation classes. Airborne, shipboard and ground)
W Underwater, fixed

Type of Equipment

A Invisible light, heat radiation
B Pigeon
C Carrier (wire)
F Photographic
G Telegraph or teletype (wire)
I Interphone and public address
K Telemetering
M Meteorological
N Sound in air
P Radar
Q Underwater sound
R Radio
S Special types (magnetic, etc.)
T Telephone
V Visual and visible light
X Facsimile or television

Purpose

A Auxiliary assemblies (not complete operating sets)
B Bombing
C Communications (receiving & transmitting)
D Direction finder
G Gun directing
H Recording (sound, photographic & meteorological)
J Countermeasures (receiving & transmitting)
L Searchlight control
M Maintenance & test assemblies
N Navigational aids (altimeters, beacon compasses, depth sounding, instrument landing)
P Reproducing (photo and sound)
Q Special (or combination of types)
R Receiving or listening
S Detecting and/or range and bearing
T Transmitting
W Remote control
X Identification and recognition

TABLE III

"AN" System Component Indicator Letters

AB Supports, antenna
AM Amplifiers
AS Antenna assemblies
AT Antenna
BA Battery, primary type
BB Battery, secondary
BZ Signal devices, audible
C Control articles
CA Commutator assemblies, Sonar
CB Capacitor bank
CG Cables & transmission line (R.F.)
CK Crystal kits
CM Comparators
CN Compensators
CP Computers
CR Crystals
CU Coupling devices
CV Converters (electronic)
CW Covers
CX Cords
CY Cases
DA Antenna, dummy

DT	Detecting heads
DY	Dynamotors
E	Hoist assembly
F	Filters
FN	Furniture
FR	Frequency measuring device
G	Generator
GO	Goniometers
GP	Ground rods
H	Head, hand and chest sets
HC	Crystal holder
HD	Air conditioning equipment
ID	Indicating devices
IL	Insulators
IM	Intensity measuring device
IP	Indicators, cathode-ray tube
J	Junction devices
KY	Keying devices
LC	Tools, line construction
LS	Loudspeakers
M	Microphones
MD	Modulators
ME	Meters, portable
MK	Maintenance kits or equipments
ML	Meteorological devices
MT	Mountings
MX	Miscellaneous
O	Oscillators
OA	Operating assemblies
OS	Oscilloscope, test
PD	Prime drivers
PF	Fittings, pole
PG	Pigeon articles
PH	Photographic articles
PP	Power supplies
PT	Plotting equipments
PU	Power equipments
R	Radio and radar receivers
RD	Recorders and reproducers
RE	Relay assemblies
RF	Radio frequency components
RG	Cables and transmission line, bulk R.F.
RL	Reel assemblies
RP	Rope and twine
RR	Reflectors
RT	Receiver and transmitter
S	Shelters
SA	Switching devices
SB	Switchboards
SG	Generators, signal
SM	Simulators
SN	Synchronisers
ST	Straps
T	Radio and radar transmitters
TA	Telephone apparatus
TD	Timing devices
TF	Transformers
TG	Positioning devices
TH	Telegraph apparatus
TK	Tool kits or equipments
TL	Tools
TN	Tuning unit
TS	Test equipment
TT	Teletypewriter and facsimile apparatus
TV	Tester, tube
U	Connectors, audio and power
UC	Connectors, R.F.
V	Vehicles
VS	Signalling equipment, visual
WD	Cables, two conductor
WF	Cables, two conductor
WM	Cables, multiple connector
WS	Cables, single conductor
WT	Cables, three conductor
ZM	Impedance measuring device

Radio Topics . . .

By RECORDER

MORALITY.

This is a word which, until recently, many of us have rarely considered or even thought about. At the time of writing these notes—and due to events outside this column's range—the subject of morality (not entirely unalloyed by cant) has been continually and insistently hammered home to every one of us in every newspaper we pick up. We have suddenly realised that morality is important.

My own thoughts on morality have run largely on the subject of petty theft, and follow my reading about a series of shop-lifting cases reported in a local newspaper. After consideration I have found, somewhat to my surprise, that peccadilloes of this type are judged, so far as generally accepted ethics are concerned, not by their nature at all but by their *degree*. That this state of affairs is true can, I feel, be borne out very well by taking examples from the field of manufacture, wherein small and relatively inexpensive parts are handled in large numbers at a high rate of consumption. I don't think that modern mass-production methods have resulted in the unanticipated appearance of a self-regulating level which divides acceptable behaviour from the non-acceptable, because a self-regulating level of this type has been in existence for many years. Few people raised an eyebrow if, a hundred years or so ago, the butler retired to bed slightly squiffy on his master's port. Nevertheless, I do feel that modern mass-production methods have spread the opinion that "perks are legitimate" over a far wider range than has ever existed before.

"It Won't Be Missed"

Should you ever call on a large factory which produces radio or television receivers, you may find it instructive to keep an eye on the pavement over the last fifty yards or so before you arrive at the gate. If you look hard enough, it is very probable that you will see at least several small resistors and capacitors lying around on the ground. These will have reached the street because, during working hours, they fell into the trouser turn-ups of men employees—or were caught in the skirts or dresses of female employees —and then became subsequently dislodged as the employees walked home after the end of work. The important point is that nobody at the factory will have missed these odd few components at all. This is because, when high quantity mass-production schedules are in operation, small resistors and capacitors are, quite simply, not counted!

Let us assume that one of the production lines in the factory is turning out a sub-assembly which requires, amongst other things, one 27kΩ 10% ½ watt resistor. Production is aimed at 2,000 per day, and those responsible for keeping the line provisioned have to ensure that the operator who fits the resistors always has a good supply of them available. The resistors will be kept in a small bin, or container, in front of the operator, and we could say that a line-feeder (i.e. a person whose job it is to keep all bins on the line replenished) drops 200 resistors into this bin ten times a day. Now, these 27kΩ resistors will be received in quantities of, say, 1,000 from the resistor manufacturer. The boxes in which the resistors arrive will each be marked as containing 1,000, and nobody would doubt this marking. To make up 200 resistors for the line-feeder, the storeman then takes advantage of a 99-to-1 scale. Two resistors from the box are placed in the "1" pan of the scale, and the box is then emptied into the "99" pan until the scale balances. There should then be 99 times as many resistors in the "99" pan as there are in the "1" pan, with the result that the two pans now provide 198 plus 2 resistors for the line-feeder. Since the resistors are selected by weight, it is quite possible that the line-feeder may take with him several resistors too many or several resistors too few.

The resistors are dropped into the operator's bin from time to time as production proceeds, and no sleep is lost if one or two drop on to the floor or get lost in any other way. So long as the number of resistors entering the factory corresponds *approximately* to the number of sub-assemblies leaving it, everyone is happy. The system is perfectly economic since it is cheaper to lose a few resistors than it is to employ someone to count them individually.

Let us next assume that one of the men working at the factory has a faulty television receiver at home in which a 27kΩ 10% ½ watt resistor has gone open-circuit. He can, of course, buy a replacement resistor at a radio shop for some 3d. to 6d. Alternatively, he can pick one out of the operator's bin and take it home for nothing. He could, even, pick the resistor up off the factory floor, whereupon he would have obtained a component which might otherwise have been swept up and thrown away. The man is, let's face it, *stealing* that resistor from the factory, but generally accepted morality would not be censorious of his action. Generally accepted morality would, instead, take the view that the factory "won't miss it"; an opinion which is, as we have just seen, perfectly true. The resistor *won't* be missed.

So we now have the case where generally accepted morality will not raise a complaint if one resistor is taken home from a factory. Let's raise the ante: our employee takes home two resistors. Is this acceptable behaviour? By taking home two resistors our employee has now entered the domain of the shop-lifter. The retail value of two resistors is approximately the same as that for a small tin of baked beans. If you are caught pinching a tin of baked beans from a Supermarket you may quite possibly find yourself charged, later to appear in court. However, we are still in the range where misdemeanour is heavily qualified by degree. Generally accepted morality would not object very strongly about the two resistors. They still "wouldn't be missed." At the same time, it is fairly easy to explain away the odd tin of baked beans; and a Supermarket manager might think twice before making a court case out of a small theft of this nature. So let us raise our sights again. Our factory employee now walks out with two dozen resistors and a couple of electrolytics. Similarly, the shop-lifter tries to make off with a chicken. Ah, says generally accepted morality, wagging a finger, now that *is* naughty. Someone who tries to take as much as all that *deserves* to be caught!

Logically, there is no sense in this at all. A theft is a theft whether it be of one resistor or five thousand resistors. But generally accepted morality does not take this view, and the single-resistor man remains uncondemned.

I cannot help but feel that this outlook is almost entirely due to the present-day availability of large quantities of relatively inexpensive, mass-produced and *uncounted* items. These items are stored, issued and used on a quantity tolerance basis, and as long as the amount finally emerging agrees, within the tolerance, with the amount which *should* emerge, nobody complains. If a small quantity of the items disappears whilst they are being handled, the output will still be within tolerance and so, says generally accepted morality, no harm is done. This comfortable state of affairs is severely disrupted, however, when the 5,000-resistor man appears on the scene. In this instance we have a quantity discrepancy which is well outside the tolerance. It can be readily spotted, and the result is that we have a criminal.

Generally Accepted Morality

I have been very careful to use the phrase "generally accepted morality" up to now because I feel that the lack of condemnation of the single-resistor man—or of the single-nut and bolt man, or of the single-ball-point pen man—is a phenomenom which anyone with a pair of ears can confirm for himself by listening to normal conversation. I appreciate also that some readers will have standards which are higher than those which are generally accepted. Nevertheless, it should not be forgotten how very easy it is to become a single-resistor man. I should imagine that many of the most saintly of us have been guilty of at least one act of the "it won't be missed" variety, even if it only consists of something as innocuous as taking home a few inches of insulating tape.

It is impossible to get away from the fact that, so far as theft is concerned, what is generally accepted as crime is, in practice, a crime only because of its degree. In modern times we are surrounded by inexpensive mass-produced items which are never counted, and these appear not only in the factory (which I have referred to here only because it offers the most striking illustration) but in almost every other place of work. This environment surrounds far more of us than occurred some fifty years or so ago, whereupon far more of us are subject to the blandishment of "it won't be missed."

Whether this fact has resulted in a shift in our national attitude towards theft is something I would not like to comment on.

Television Society Trophy

Turning to quite a different matter, I have pleasure in including, this month, an illustration of an individual and handsome trophy which will be playing a large part in the future affairs of the Television Society. This trophy will be held each year by the recipient of the Geoffrey Parr International Television Engineering Award. Commencing next year, the International Television Engineering Award will be presented either to an individual or to a team in recognition of an outstanding contribution to television engineering or an associated science.

As some readers will already know, Geoffrey Parr evinced a deep interest in the Television Society over many years. He joined as a Fellow in 1934 and became Hon. Lecture Secretary in 1936 and, later, Editor of the Journal of the Television Society. In 1946 he was elected Hon. Secretary, which position he retained until his retirement on 9th May, 1961. Mr. Parr died soon after this, and the Council of the Society felt that they wished to perpetuate his name by creating the Award.

The Society commissioned John McCarthy, A.R.C.A., to design the trophy. It is executed in stainless steel and depicts two sine waves at right angles to each other. It is based, therefore, on a fundamental aspect of television transmission.

Belling-Lee U.H.F. Field Trials

To hand are the results of the first preliminary series of tests on the new u.h.f. television transmissions which have been carried out by Belling and Lee, Ltd. These tests covered London and the Home Counties, and it is pointed out that the results obtained are given by "spot tests" only. Reception conditions in some places may vary, even from house to house.

The Geoffrey Parr Award trophy, to be presented each year by the Television Society. Executed in stainless steel, it depicts two sine waves at right-angles to each other

Space does not allow the many findings in the Belling-Lee report to be printed here, but I shall quote a few of the results for the North London districts to give an idea of what may be expected when full transmissions commence. Measurements were obtained using an aerial of 6dB gain 36ft above ground level,* and decibel figures are at the receiver aerial terminals, with 0dB = 1μV.

In the North London area, signal strength was 78 to 79dB and quality very good at Highgate Hill and Barnet, dropping to signal strengths between 66 and 77dB, with quality good, at Hoddesdon (High Street), Enfield, Bounds Green and Broxbourne. At Welwyn Garden City (53dB) and Mill Hill (57dB) quality was fair, and at Hertford (36dB) and Finchley (N. Circular Road) (40dB) it was very poot.

* In some instances, 3 and 9dB aerials were tested, the measurements being rationalised to a 6dB aerial to allow comparisons to be made. Results are for Channel 34, which gave better results than Channel 44.

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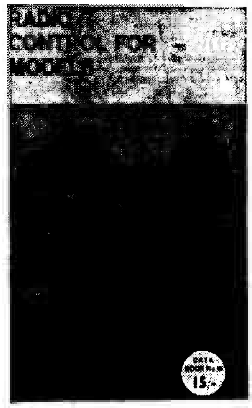

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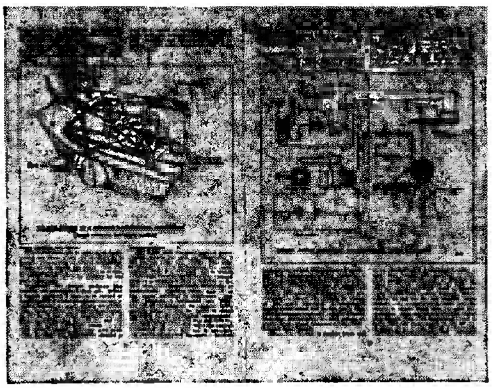

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AMATEUR GIVING UP hobby has following items for sale. Avo valve tester, £6 15s. Multi-range test meter scaled ohms, volts and milliamps, 17s. 6d. Cossor 339 oscilloscope, £9 15s. Two new 12in hi-fi speakers, each fitted with electrostatic tweeter, 50s. each. Reflectograph model 500 professional tape recorder, £50. All items carriage free. Insurance if required, 10s. extra. C.O.D. 2s. 6d. extra.—Box No. F180.

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WANTED. Will purchase knobs and dials for Hallicrafter SX28A also knobs and front panel and case for BC348. Or would swap Hallicrafter S20R.—Bilton, 26 Beulah Hill, London, S.E.19.

FOR SALE. R1155L new valves, £6. Good condition. Also power pack, £3.—W. Iley, Riverside Cottage, Bolingey, Perranporth.

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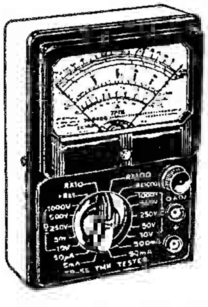

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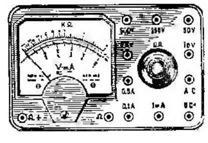

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Ideal pocket size multi-tester for all radio and domestic work.

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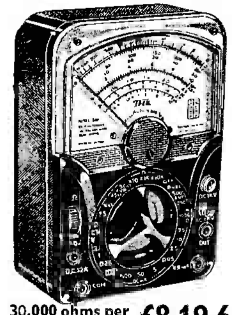

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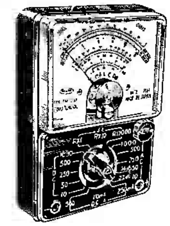

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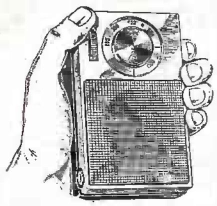

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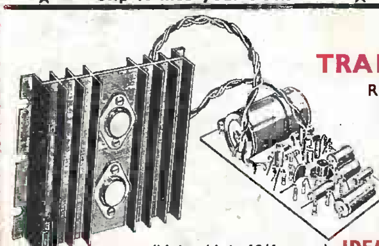

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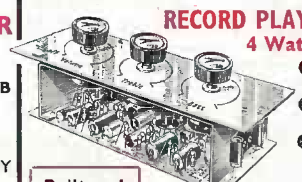

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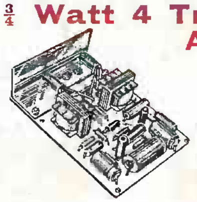

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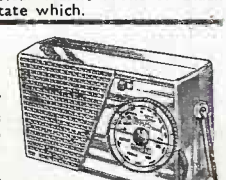

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