THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 16 NUMBER 9
A DATA PUBLICATION
PRICE TWO SHILLINGS

April 1963

A 6-Transistor Printed Circuit Superhet

Also featured

Comprehensive Studio Control Unit

●

Add-On Stage for F.M. Tuners

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Photo-Sensitive Relays

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Light-Beam Transmitter-Receiver

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1-Valve (12AT7) T.R.F. Receiver

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Some U.H.F. Amplifier Circuits

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etc., etc., etc.

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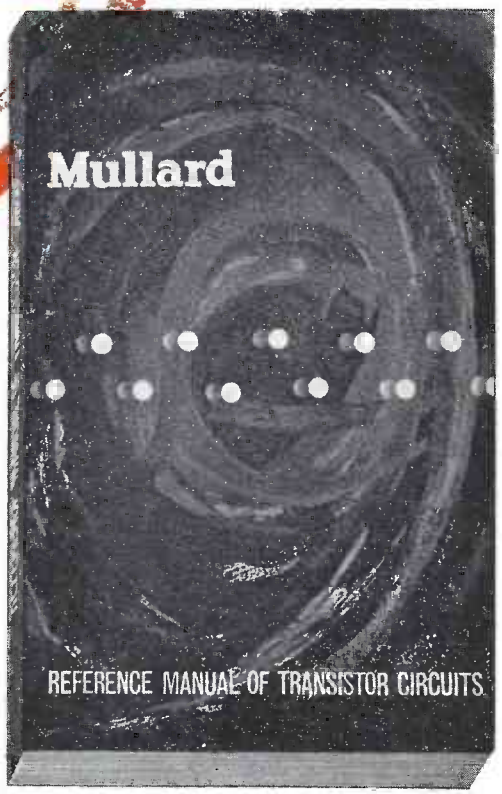

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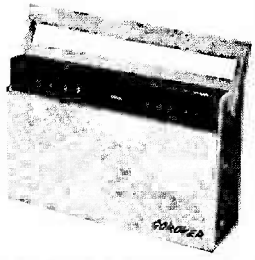
THE COROVER "6"

as featured on Page 603 of the March issue of RADIO CONSTRUCTOR

A 6 TRANSISTOR PLUS TWO DIODE RECEIVER USING THE LATEST CIRCUITRY.



★ Three Mullard AF117 alloy diffused transistors are used with OA79 and OA91 diodes, followed by OC81D and two OC81s in push-pull. I.F. Frequency 470 kc/s.

★ Covers the full medium and long wavebands.

★ Sockets are provided for a personal earpiece or tape recorder, and car radio aerial. Large internal ferrite rod aerial gives high sensitivity. Operates from four 1.5 volt pen torch batteries.

★ All components mounted on a single printed circuit. Easy to build from simple stage-by-stage instructions.

★ Cabinet size 6½" x 4" x 1½". With carrying handle. All coils and if.s ready wound.

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BUILD IT YOURSELF

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The finest receiver at present available for home construction. Fully tunable long and medium wavebands. Uses 7 Mullard Transistors: OC44, 2 OC45s, OC71, OC81D and 2 OC81s, plus Crystal Diode OA70.

£5.19.6

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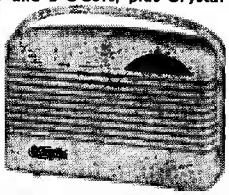

7 Transistor Superhet. 350 milliwatt output into 4" high flux speaker. All components mounted on a single printed circuit board, size 5½" x 5½", in one complete assembly. Plastic cabinet with carrying handle, size 7" x 10" x 3½", in choice of colours: red/grey, blue/grey, all grey. Easy to read dial. External socket for car aerial. I.F. frequency 470 kc/s. Ferrite Rod internal aerial. Operates from PP9 or similar battery. Full comprehensive data supplied with each Receiver. All coils and I.F.s, etc., fully wound ready for immediate assembly.

CAN BE BUILT FOR £5.19.6

PP9 Battery 3/9 extra. *P. & P. 4/6 extra.*

Data and instructions separately, 2/6, refunded if you purchase the parcel.

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A 6-Transistor Superhet Miniature Personal

POCKET RADIO

★ Fully tuneable over Long and Medium wavebands ★ Uses single PP3 battery ★ Ferrite Rod aerial ★ High sensitivity circuit ★ I.F. Frequency 470 kc/s ★ Transistors used: 3 x Philco 2067's, 2 x Mullard OC81 M, OC81 DM and OA90 diode ★ 3" speaker ★ Printed circuit 2½" x 2" ★ Slow Motion Drive ★ In very attractive plastic case, size 4" x 2½" x 1".

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★ Covers full medium and long wave band ★ All-transistorised superhet ★ Internal ferrite rod aerial ★ Press button wave change ★ All connections to car battery—booster speaker—car aerial automatically accomplished by sliding into metal car-tray.

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LASKY'S PRICE £10.19.6

complete with tray, all car fittings, 8" x 5" car speaker and baffle. **Carr. and Pack 7/6 extra.** PP9 Battery 3/9 extra, supplied with full fitting and installation instructions.

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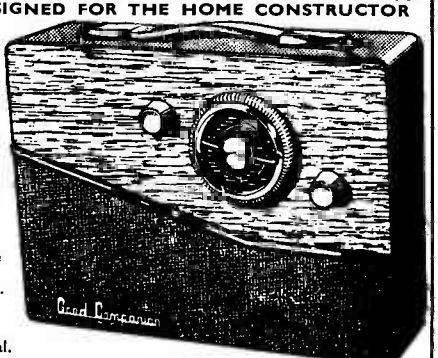

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O-12U

S-33

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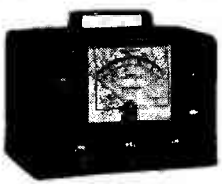
AG-9U

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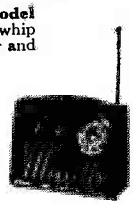
MA-12


RSW-1

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UJR-1

HI-FI FM TUNER. Model FM-4U. Also available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and amplifier unit, with power supply and valves (£12.6.0). Total **£15.1.0**

TRUVOX D83 & D84 TAPE DECKS. High quality mono/stereo tape decks.
D83, 2 track, for highest fidelity. **£31.10.0**
D84 (identical presentation), 4-track. **£29.8.0**

STEREO CONTROL UNIT. Model USC-1. Push-button selection, accurately matched ganged controls to ±1dB. Negative feedback, rumble and variable low-pass filters. Printed circuit boards. **£19.10.0**

S-99

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

ELECTRICITY MAINS EXTENSION KIT. Model PUE-1. Completely safe, conforms fully to I.E.E. Regulations, ideal light and power source to out-buildings (or for soil heating). Complete with sockets, cables, switches, lampholder, junction box, etc. **£4.15.6**

MAINS POWER SUPPLY—BATTERY ELIMINATOR KIT. Model UBE-1. Designed to supply 9V or 12V d.c. to transistor receivers. Many other uses. Sizes: 3$\frac{3}{32}$" x 2½" x 1⅝". **£2.17.6**

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" x 4" loudspeaker. Real hide case. **£12.11.0**

TELEPHONE AMPLIFIER. Model TTA-1. Easy-to-assemble. Transistorised, enables hand-free conversation. Ivory toned cabinet. **£7.9.6**

THE "COTSWOLD"

THE "COTSWOLD". This is an acoustically designed enclosure 26" x 23" x 15½" housing a 12" bass speaker with 2" speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 32–20,000 c/s. Capable of doing justice to the finest programme source, its polar distribution makes it ideal for really Hi-Fi Stereo.
COTSWOLD "MFS" SYSTEM. Specially developed to give best possible results in small rooms. This minimum floor space model is based on standard Cotswold. Size: 36" high x 16½" wide x 14½" deep. Either Model, **£23.4.0**

UXR-1

TTA-1

★ **Assembled** *models also available* — **prices** *on request.*

Without obligation please send me (Tick here)
FREE BRITISH HEATHKIT CATALOGUE ☐
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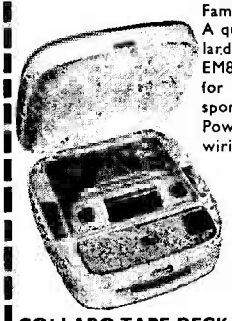
COLLARO STUDIO TAPE RECORDER KIT

SPECIAL BARGAIN OFFER. Comp. Kit only **£25** *Carr. 12/6*



Famous mfr's. surplus offer—listed 42 gns. A quality Tape Recorder Kit based on Mullard's famous design—EF86, ECC83, EL84, EM81 and Rectifier. Specially designed Kit for Collaro latest Studio Deck, freq. response ±3dB, 60 c/s–10 kc/s. Amp. and Power Pack already wired, inter. unit wiring only required. Cabinet size: 18" x 16½" x 6" finished in contemp. 2-tone blue Rexine with gilt Speaker Escutcheon. Magic Eye indicator. Circuit and Tech. H/book, supplied free with kit. *Send 3d. stamp now for full details of today's outstanding Tape Recorder Bargain.*

COLLARO TAPE DECK
£12.10.0 Carr. 7/6

CABINET **£3.15.0.** *P. & P. 6/6*
AMPLIFIER KIT **£8.19.6.** *P. & P. 5/–*
SPEAKER 7" x 4" **16/6.** *P. & P. 2/–*
If above items are purchased together **£12.19.6** *P. & P. 10/–*

VALVES

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

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

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

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

Post and Packing, per reel, 1/–, plus 6d. each for additional reels.
SPECIAL OFFER—3" mfrs. surplus tape, Std. 150 ft. **3/9**, L.P. 225 ft. **4/9**, D.P. 300 ft. **6/6**. P. & P per reel 6d. Plastic Tape Reels 3" **1/3**, 5" **2/–**, 5¾" **2/–**, 7" **2/3**. Plastic Spool Containers 5" **1/6**, 5¾" **2/–**, 7" **2/3**

Jack Plugs. Standard 2¼" 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.

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1½" 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% ¼ and ½W **3d.**, ¾W **5d.** (Midget type modern rating) 1W **6d**, 2W **9d. Hi-Stab** 10% ¼W **5d.**, ½W **7d.** 5% ¼W **9d.**, 1% ¼W **1/6. W/W Resistors** 25 ohms to 10K 5W **1/3**, 10W **1/6**, 15W **2/–**. **Preset T/V Pots. W/W** 25 ohms.– 50 K **3/–**. 50 K–2 Meg. (Carbon) **3/–**.

JASON FM TUNER UNITS
Designer-approved kits 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 bronze anodised metal ½" x ½" diamond mesh, **4/6** sq. ft., multiples of 6" cut. Max. width 4 ft.
TYGAN FRET (contemp. pat.) 12" x 12" 2/–. 12" x 18" 3/–, 12" x 24" 4/–, 18" x 18" **4/6**

BARGAINS 4-SPEED PLAYER UNITS

Single Players	carr. 3/6
Garrard SRB10	**£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/–**; 30g-40g, **3/9.** Other gauges quoted for.

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

TRANSISTOR COMPONENTS

Midget I.F.'s—465 Kc/s ⅞" diam. **5/6**
Osc. Coil—⅞" 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 12V 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. ⅖" 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		

SPECIAL OFFER
OC44 / 2/OC45 } **21/6** OC81D / 2/OC81 } **19/6**

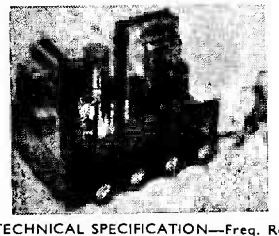
TRIMMERS, Ceramic (Compression Type)—30pF, 70pF, **9d.**; 100pF, 150pF, **1/3**; 250pF, **1/6**; 600pF, **1/9.**

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; 1⅜", 1/– each; Brown or Ivory with Gold Centre, 1" dia., **10d.** each; 1⅜", **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.**

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**, WBHFI0–12 **£4.10.0**, Goodmans Axiette **£5.5.0**, Axiom 10 **£6.5.0.**

RECORD PLAYER CABINETS

Contemporary style, rexine covered cabinet in mottled red and white polka dot. Size 18½" x 13½" x ht. 8¼", 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 £11.19.6. Carr. 7/6.

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Stern's

MULLARD DESIGNS

COMPLETE KITS OF PARTS

Designed by MULLARD—presented by STERNS strictly to specification

MULLARD 3-VALVE PRE-AMPLIFIER CONTROL UNIT

Designed mainly for Mullard Range of Amplifiers, also suitable for any Amplifier requiring input up to 250 mV. Incorporates 5 input channels, including for Tape and Magnetic Pick-ups. Separate Bass and Treble controls. High pass filter 20 to 160 c/s. low pass filter 5–9 Kc/s. Totally enclosed in case, size 11¼" x 4½" x 4".

KIT OF PARTS **£10.10.0** ASSEMBLED AND TESTED **£13.13.0**

MULLARD "5-10" MAIN AMPLIFIER

For use with MULLARD 2-stage pre-amplifier with which an undistorted power output of up to 10 watts is obtained. SPECIFIED COMPONENTS AND MULLARD VALVES including PARMEKO MAINS TRANSFORMER and choice of PARMEKO or PARTRIDGE Output Transformer.

COMPLETE KIT (Parmeko Output Trans.) **£10.0.0**

ASSEMBLED AND TESTED **£13.10.0**

ABOVE INCORPORATING PARTRIDGE OUTPUT TRANSFORMER **£1.6.0** extra.

THE MULLARD 510/RC AMPLIFIER

The popular complete "5-10" incorporating Control Unit providing up to 10 watts. Specified components and new MULLARD VALVES. Includes PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE output Transformers.

Price : COMPLETE KIT **£12.0.0**

ASSEMBLED AND TESTED **£16.0.0**

with PARTRIDGE OUTPUT TRANSFORMER **£1.6.0** extra.

MULLARD'S 2-VALVE PRE-AMPLIFIER TONE CONTROL UNIT

Employing two EF86 valves and designed to operate with the Mullard MAIN AMPLIFIER but also perfectly suitable for other makes.

★ Equalisation for the latest R.I.A.A. characteristic.
★ Input for Crystal Pick-ups and variable reluctance magnetic types.
★ Input (a) Direct from High Imp. Tape Head. (b) from a Tape Amplifier or Pre-Amplifier.
★ Sensitive Microphone Channel. ★ Wide range BASS and TREBLE Controls.

KIT OF PARTS **£6.6.0** ASSEMBLED AND TESTED **£9.10.0**

COMBINED PRICE REDUCTIONS

(a) The KIT OF PARTS to build both the "5-10" **Main Amplifier** and the **2-Stage Pre-Amplifier** **£15.15.0**

(a) The "5-10" and the **2-Stage Pre-Amplifier** both **Assembled and Tested** **£21.10.0**

With PARTRIDGE OUTPUT TRANSFORMER **£1.6.0** extra.

(b) The KIT OF PARTS to build the "5-10" **Main Amplifier** and **3 Valve Pre-Amplifier** **£19.10.0**

(b) The "5-10" and **3 Valve Pre-Amplifier** both **Assembled** and **Tested** **£25.10.0**

THE MULLARD 33/RC

HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-WATT MULLARD "3-3" DESIGN.

KIT OF PARTS **£8.8.0**

ASSEMBLED AND TESTED **£11.10.0**

Complete to the MULLARD specification including PARMEKO OUTPUT TRANSFORMER. Switched inputs for 78 and L.P. records plus a Radio position. Extra power to drive a Radio Tuning Unit is also available.

RECORD PLAYERS

THE COLLARO "JUNIOR" 4-speed single player with separate crystal pick-up **£3.10.0**

GARRARD Model SRP10. Single Record Player fitted with high output crystal pick-up **£5. 0.0**

THE NEW GARRARD "AUTOSLIM" 4-speed Autochanger with crystal pick-up **£7.10.0**

GARRARD "AUTOSLIM DE LUXE" 4-speed Autochanger, incorporates transcription Pick-up Arm **£11. 8.0**

THE COLLARO "C60" 4-speed autochanger unit with Studio "C" pick-up **£6.19.6**

B.S.R. Model UA14, a 4-speed Mixer Autochanger with crystal pick-up **£6.10.0**

The new **GARRARD Model 4HF** High Quality Single Record Player fitted with the latest T.P.A. 12 pick-up arm and G.C.S. crystal Cartridge **£16.17.6**

PHILIPS Model AG1016. A 4-speed Player which can be operated both manually and automatically. Suitable for Mono or Stereo operation **£12.12.0**

Carriage and insurance on each above, 5/– extra.

THE MONO-GRAM

A small Amplifier of genuine high quality performance. Incorporates new MULLARD ECL86 Valve, separate BASS and TREBLE controls and produces up to 3 watts undistorted output.

KIT OF PARTS **£4.10.0** ASSEMBLED and TESTED **£6.10.0**

Perfectly suited for Portable Installations for which purpose we offer . . . PORTABLE CASE **£3.10.0**, the AMPLIFIER (Kit) and 8 x 5 in. SPEAKER (£1). All for **£9.0.0**. Alternatively with ASSEMBLED AMPLIFIER **£10.0.0.**

The case quoted above will accommodate some 4 speed Single Record Units. A larger model for autochanger is available for extra 10/–. With this Equipment a COMPLETE PORTABLE RECORD PLAYER CAN be built for from **£14.0.0.**

THE "TUDOR" STEREO AMPLIFIER

PRICE ONLY **£15.0.0**

A self-contained Amplifier designed to provide high quality stereophonic and monophonic reproduction. Each channel provides a rated output of 6 watts and for monophonic operation approx. 12 watts is produced. Separate BASS and TREBLE CONTROLS.

Stereo Amplifiers

MULLARD'S "10+10" STEREO AMPLIFIER

A HIGH FIDELITY DESIGN PROVIDING UP TO 10 WATTS (per channel). SUPERB REPRODUCTION FREQUENCY RESPONSE FLAT TO WITHIN 3dB from 3 c/s to 60 Kc/s at 50mW. TOTAL HARMONIC DISTORTION AT 10 WATTS, 0.1%.

PRICE : (a) ASSEMBLED AMPLIFIER (As illustrated). **£24.0.0**

(b) KIT of PARTS **£20.0.0** Built to the highest technical standards and presented strictly to MULLARD'S specification. Two specially designed GILSON OUTPUT TRANSFORMERS with 20% taps are used.

We can also supply the assembled MAIN AMPLIFIER only for operation with our DUAL CHANNEL PRE-AMPLIFIER ; this provides for a more versatile Installation and be essential if a low output Magnetic Pick-up is to be used. When ordering, specify loudspeaker impedance.

(a) **THE ASSEMBLED MAIN AMPLIFIER and ASSEMBLED DUAL CHANNEL PRE-AMP £34.0.0**

(b) KIT of PARTS for both Units **£27.0.0**

THE "TWIN THREE" STEREO AMPLIFIER

ASSEMBLED AND TESTED for (Carr. & Ins. 7/6 extra) **£9.0.0**

Based on a recent design by MULLARD LTD., is ideally suited for use in PORTABLE RECORD PLAYERS for which purpose we offer a specially designed case :

It incorporates MULLARD ECL 86 Valves, separate BASS and TREBLE CONTROLS and produces up to 3 watts per channel. Frequency response 40 c/s to 30 Kc/s, size 11½ in. x 3 in. x 5 in.

To construct a STEREO PORTABLE RECORD PLAYER we offer :— Assembled AMPLIFIER with two ROLA 8 in. x 5 in. LOUDSPEAKERS and PORTABLE CASE for **£16.10.0** (Carr. and Ins. 7/6 extra).

MULLARD DUAL CHANNEL PRE-AMPLIFIER

A four Valve design for both STEREOPHONIC and MONOPHONIC operation. Operate equally well with any make of Amplifier requiring input of up to 250 m/v.

KIT OF PARTS **£12.10.0**

ASSEMBLED AND TESTED **£15.0.0**

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- ★ Separate local oscillator in first converter stage, and triode hexode for second converter stage
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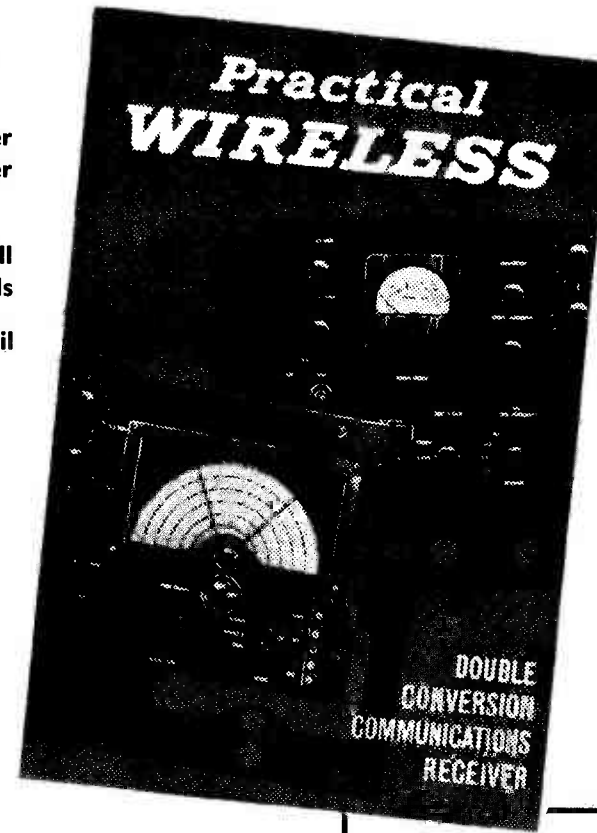
- ★ Beat frequency oscillator
- ★ Noise limiter



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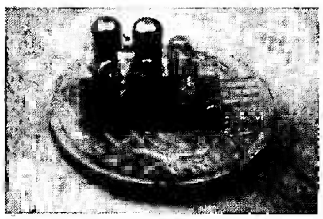

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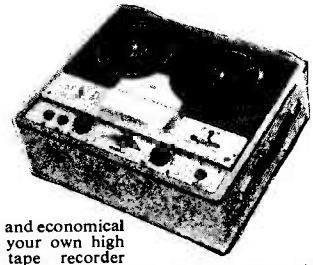

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APRIL 1963

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TECHNICAL QUERIES must be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

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 the 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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Comprehensive
Studio Control Unit

By M. J. Pitcher, B.Sc. **Part 1**

In which the author describes a compact and self-contained unit which provides "professional" control facilities for tape recording. It may also be employed with public address systems

THE CONTROL EQUIPMENT DESCRIBED IN THIS article was designed after a close inspection of similar equipment manufactured for professional use. Much of the versatility of the unit derives from the facilities which the author observed, and has resulted in the production of tape recordings superior in every way to those made with many separate pieces of apparatus joined together by confusing masses of tangled wire.

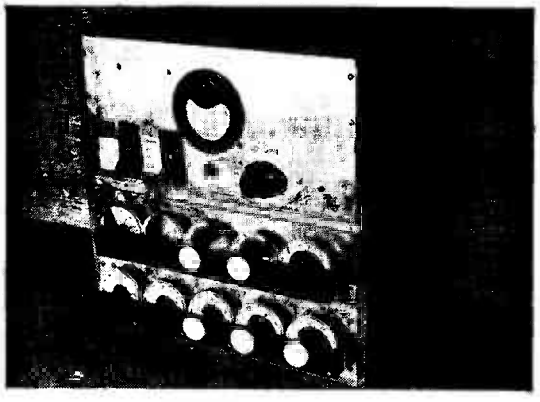
Stereo enthusiasts should note that the provision of two identical high quality mixing channels permits the unit to be used for stereo working, with monaural monitoring. The author has not, so far, been bitten by the stereo bug and cannot write from experience of this application.

The unit has also been used as a pre-amplifier to feed the public address system of a theatre, the object being to mix a number of microphones, tape recorders and turntable. Very satisfactory results were obtained.

In this article, the unit is discussed from the viewpoint of the tape recording application.

Design Considerations

Control equipment must be capable of performing many functions. Signals must be accepted from a wide variety of sources, amplified if necessary, controlled and mixed. The output level of the unit should be of the order of half a volt so that it can be fed into almost any make of tape recorder or amplifier.



Front view of unit

It is desirable to have monitoring facilities, both by meter and loudspeaker. The really enthusiastic amateur will devise a control room separate from the studio to permit the use of the loudspeaker at reasonably high power, but headphones can be used for monitoring in the studio if need be.

Signals to the studio can be arranged by using a cue-light, but a more satisfactory arrangement is to incorporate an "inter-com" (which is called, in professional jargon, "talk-back".) This allows the operator to talk to the studio through a loudspeaker.

Fig. 1 illustrates the possible inter-connections of the various sections of the unit. Both mixing channels A and B have duplicate output sockets, so that it is possible to connect them to other equipment, such as tape recorders, without mutual interference. The provision of these sockets enables the user to employ each section on its own independently of the use being made of other sections. It was felt that the construction of a fully integrated amplifying system, having built-in connecting leads, would detract from the general usefulness of the unit.

The sound sources for which any individual constructor must make provision depend on the accessories at his disposal. In this design, which aims at being comprehensive, provision has been made for the acceptance of microphones of either low or high impedance. Additional inputs can be taken from (*a*) radio, (*b*) crystal pick-up (with built-in compensating network), (*c*) tape recording, and (*d*) electric guitar pick-up.

The circuit diagram, shown in Fig. 2, is drawn with two outlet sockets for each of the mixers in channels A and B. While virtually any socket may be used, the author fitted coaxial sockets and normal jack sockets; the former are used to make the semi-permanent connections between the various sections of the unit and the latter to make connection with external equipment such as a tape recorder or

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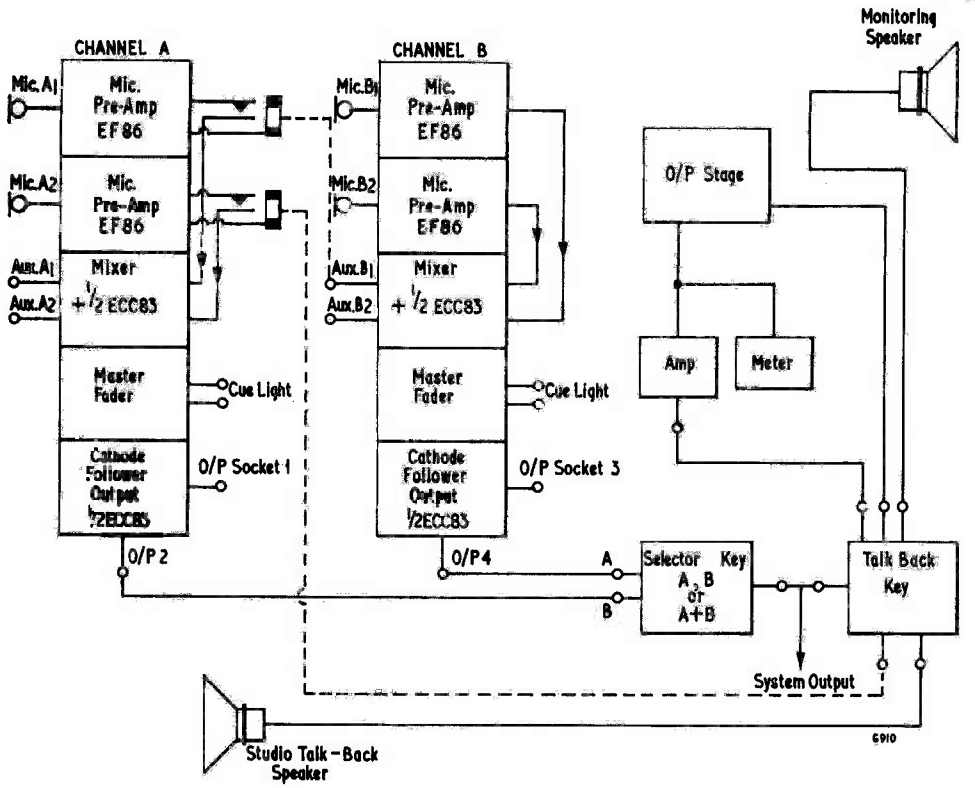

Fig. 1. Block diagram for the complete control unit

a public address system. Each pair of sockets is wired in parallel and, providing that each socket terminates in a high impedance, two identical signals can be obtained from each mixer.

It will be seen from Fig. 5 that the two mixers can be operated independently when required and monitored separately by moving the selector key to the required channel. One instance of this might be the attachment of radio tuners, or crystal feeders, to each channel so that each mixer is supplying a separate programme. These can in turn be fed from the mixer by means of the auxiliary sockets to a tape recorder and external amplifier each programme being monitored at choice. In this application the selector key shorts the signal from one mixer to ground to prevent cross talk in the monitoring amplifier. The resistors R_{17} and R_{18} prevent the signal output from the mixer stage from being short-circuited.

For more ambitious forms of studio working both channels can be combined by depressing the channel selector key. This provides four low-level microphone channels together with four high level inputs. The outputs from the auxiliary sockets are now strapped and both supply a combined signal. Extremely professional mixing can now be carried using "close microphone" techniques and accurate control of balance can be maintained. The monitor, of course, carries the combined signal but is also of great use in its ability to monitor the channels separately when it is necessary to locate microphone faults without the need of fading the volume settings which have probably been set with some care.

A "system output" socket is shown in the monitoring amplifier circuit. This socket supplies a signal identical to that being fed to the monitoring amplifier and can be used to supply external equipment. It may be of some use to supply an amplifier having a greater power output when the available outlets on the mixers are in use and high power is required for some special purpose. The internal amplifier has ample power for normal requirements.

Telephone keys were chosen for the selector and talk-back switches. These are less cumbersome to use than rotary switches, although some care is needed in wiring to avoid capacitative coupling. So far as is possible the "live" contact leaves should be separated by leaves which are earthed.

A further feature, which has proved to be of great value, is the provision of jack sockets in the output leads from the pre-amplifying valves of channel A. These provide signals which can be fed into the Aux. sockets of channel B. Alternatively, one can be used to feed the talk-back circuit and provide full volume on the studio speaker.

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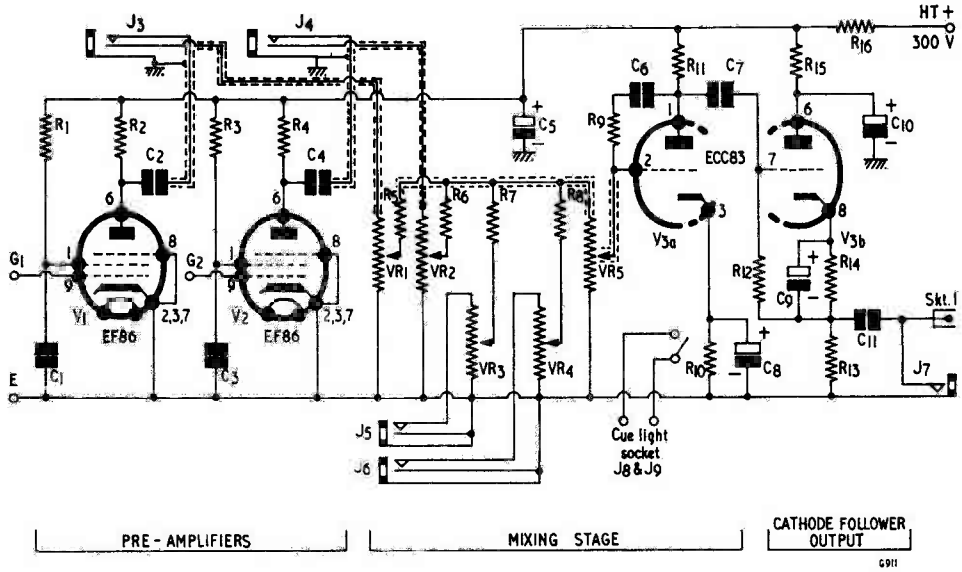

Fig. 2. Circuit diagram of the pre-amplifier/mixing unit. Jacks J_3 and J_4 are required for Channel A only. Inputs to G_1 and G_2 may consist of the circuits shown in Fig. 4

Components List
(Fig. 2)

Resistors. (All fixed values are 10% ½ watt)

R_1	390kΩ high stability
R_2	100kΩ high stability
R_3	390kΩ high stability
R_4	100kΩ high stability
R_5	470kΩ
R_6	470kΩ
R_7	470kΩ
R_8	470kΩ
R_9	1.5MΩ
R_{10}	3.3kΩ
R_{11}	100kΩ
R_{12}	1MΩ
R_{13}	47kΩ
R_{14}	2.7kΩ
R_{15}	27kΩ
R_{16}	15kΩ
VR_1	500kΩ potentiometer, log
VR_2	500kΩ potentiometer, log
VR_3	500kΩ potentiometer, log
VR_4	500kΩ potentiometer, log
VR_5	500kΩ potentiometer, log

Capacitors

C_1	0.25μF
C_2	0.1μF
C_3	0.25μF
C_4	0.1μF
C_5, C_{10}	16+16μF 350 w.v. electrolytic
C_6	0.05μF
C_7	0.1μF
C_8, C_9	50μF 12 w.v. electrolytic
C_{11}	0.1μF

Valves

V_1	EF86 Mullard
V_2	EF86 Mullard
V_3	ECC83 Mullard

Jacks

J_3, J_4, J_5, J_6	With closed circuit leaf
J_7	Jack
J_8, J_9	Miniature jack socket

(NOTE: Jacks J_3 and J_4 are required for Channel A only.)

Switch

S_1	Ganged with VR_5

The Mixer Circuit

The mixing circuit, shown in Fig. 2, is based upon the Mullard circuit for a "Four Channel Input-mixing Pre-amplifier".[1] The wiring layout used by the author is shown in Fig. 3. The microphone switch and transformer visible in the photograph are not shown in this diagram (nor in Fig. 2). They are sited to the left and right of the EF86 amplifying valves. The valve panel, shown in Fig. 7 (*b*), has provision for the fixing of two switches and two

[1] Chapter 10, *Circuits for Audio Amplifiers*, published by Mullard Ltd. The author offers grateful acknowledgments to Mullard Ltd. for their consent to the publication of the circuit in modified form. Mullard Ltd. are in no way associated with, or responsible for, the modifications which have been made.

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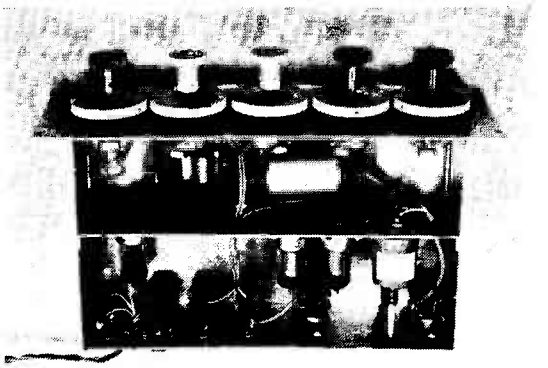
transformers. The layout adopted produces a very clean appearance and no trace of instability has been detected. All mains wiring to the valve heaters should be kept as close to the chassis as possible and clear of other wiring; similarly all signal-carrying wiring should be kept short.

The only difference between channel A and channel B mixing sections is that one of them has two extra jack sockets, shown as J_3 and J_4 in Fig. 2. The provision of microphone transformers, for ribbon and moving-coil microphones, is purely optional on either channel. A circuit by means of which both high and low impedance microphones can be switched into use from a single socket is shown in Fig. 4 (*c*). This is presented separately from the main circuit for the sake of clarity and the switches and transformers are those indicated in Fig. 7 (*b*).

Only one snag has appeared as a result of adopting the circuit design shown in Fig. 4 (*c*) and that is that under certain circumstances the amplifier suffers from radio breakthrough. This can only happen when the high impedance connection is used and the equipment is operated near a high-powered transmitter. The fault can be cleared by cleaning up all dry joints, and ensuring reliable connections at plugs, sockets, and valve pins. The fault is, however, not likely to occur if the microphone and cables are efficiently screened and properly earthed.

Alternative arrangements for microphone connections without a switch, are shown. Fig. 4 (*a*) illustrates a method of connecting a crystal micro-



An interior view showing the layout

phone. It will be noticed that the 10MΩ resistor, R_{27}, appears in Figs. 4 (*b*) and (*c*). Exceptionally good results can be obtained if high quality crystal microphones are used because the input impedance is very high.

The arrangement illustrated in Fig. 4 (*b*) is for low impedance microphones. It will be essential here to use a low impedance connection through *screened* balanced line, and a 3-pole jack and jack plug will be needed.

The levels of each of the four channels is controlled by VR_1, VR_2, VR_3 and VR_4. Overall control

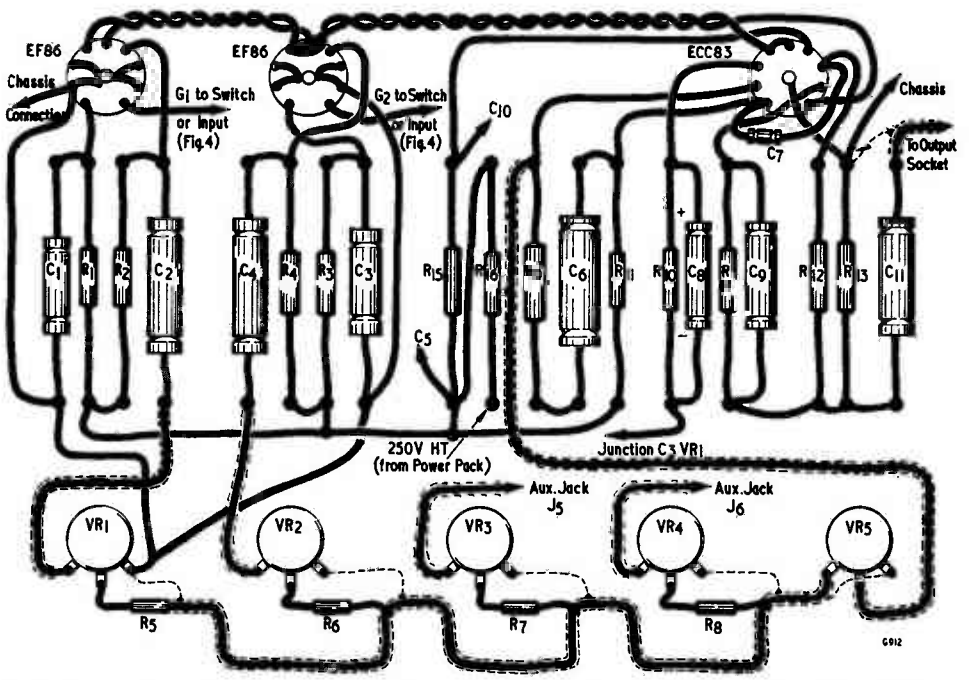


Fig. 3. Tagboard and associated components showing wiring. The front and middle panels have been folded down in this diagram. The microphone input components of Fig. 4 are not shown here, nor is the wiring to jacks J_3 and J_4

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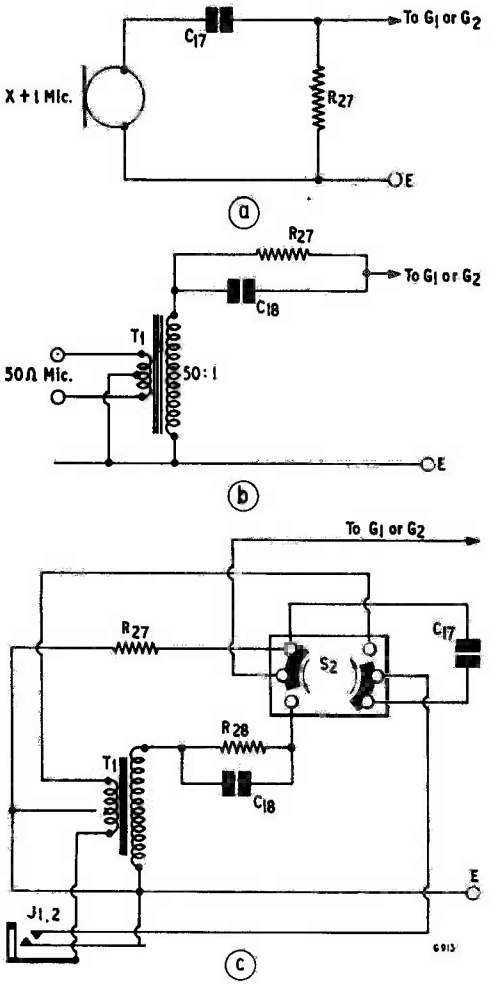

Fig. 4 (a). High impedance input arrangement suitable for crystal microphone; (b) low impedance input arrangement suitable for microphones of 30–50Ω impedance; (c) circuit which switches from high to low impedance input and uses only one input jack socket

is obtained by VR_5; this is the channel "master control".

"On the air" cue-lighting can be provided by employing a potentiometer fitted with a switch in the VR_5 position. As already noted, the author considers this facility to be of doubtful value for, working with amateur performers, there seems to be more attention paid to scripts and instruments than to the winking light. The talk-back key has proved to be of much more value.

Monitoring

The loudspeaker monitoring circuit should, ideally, be taking a signal from the tape, amplifying it to the strictest of hi-fi standards, and delivering

Components List
(Fig. 4)
(Component references apply to Figs. 4 (*a*), (*b*) and (*c*))

Resistors
R_{27} 10MΩ high stability ½ watt
R_{28} 10MΩ high stability ½ watt

Capacitors
C_{17} 0.05μF
C_{28} 0.005μF

Switch
S_2 d.p.d.t., make before break (Radiospares)

Transformer
T_1 Mic transformer, single hole mounting

Jacks
J_1, J_2 3-pole, insulated mounting

power to a perfect loudspeaker. The writer has no wish to dissuade really keen types from going to such a length, especially if they possess recording equipment to justify the expense. The simple amplifier shown in Fig. 5 can, however, be used with equipment costing less than, say, £100 to produce first class results. The reason is that the level of power is so low that such distortion as exists is not objectionable.

About one and a half watts is available at maximum power. This, delivered to a good speaker in a properly designed enclosure, is more adequate for monitoring. In fact, that amount of power let loose in a small control room can have a shattering effect on one's ears. Admittedly, the power is not enough to "shout down" a noisy hall-full of chattering performers, but it is quite sufficient for talk-back in large rooms and small halls.

The gain of the monitoring amplifier is very high and care is needed in wiring to keep grid leads short and efficiently screened. The purpose of using the highest possible gain (negative feedback is avoided for this reason) is to enable the talk-back system to be operated from a crystal microphone directly. The sound level is sufficient for talk-back to a small room, full power requires the insertion of a plug in one of the pre-amplifiers to provide extra boost.

The monitoring meter circuit is conventional. An audio signal is taken from the anode of the triode $V_{4(a)}$ and, after rectification, is applied to the grid of $V_{4(b)}$. This triode is self-biased to pass a current of 1mA by virtue of the high resistance, R_{24}, in its grid circuit. The current can be varied to be slightly in excess of 1mA by altering the value of R_{25}, final adjustments being carried out by the shunt potentiometer, VR_6.

The needle of the meter shows full-scale deflection under no-signal conditions and the reading falls to zero when the rectified signal drives the grid sufficiently negative to reach cut-off.

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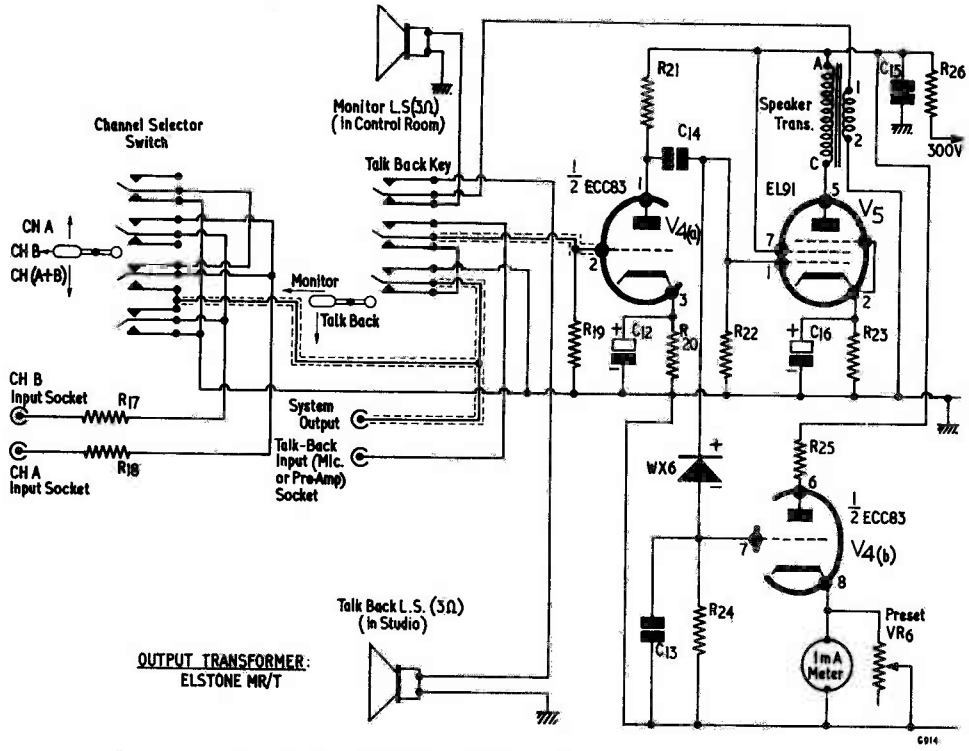

Fig. 5. Circuit of the switching and monitor section

Components List
(Fig. 5)

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

R_{17}, R_{18}	100kΩ
R_{19}	1MΩ 20%
R_{20}	1.5kΩ
R_{21}	100kΩ
R_{22}	470kΩ
R_{23}	680Ω
R_{24}	4.7MΩ
R_{25}	100kΩ
R_{26}	4.7kΩ 2 watt
VR_6	200Ω (or to suit meter) pre-set

Capacitors

C_{12}	50μF 12 w.v. electrolytic
C_{13}	0.25μF
C_{14}	0.1μF
C_{15}	50μF 350 w.v.
C_{16}	50μF 12 w.v.

Valves

V_4	ECC83 Mullard
V_5	EL91 Mullard

Rectifier
Diode type WX6

Speaker Transformer
Type MR/T Elstone

Keys
Channel selector and talk-back. See diagram for contact details

Speakers
Monitor and talk-back

Meter
0–1mA moving coil meter

Sockets
4 required. 2 input, 1 talk-back input, 1 system output

Jacks
2 required (for speakers)

Power Unit
To provide 300V at 25mA and 6.3V, centre-tapped, at 1.2A (plus cue-lights, etc.) Components as required.

(To be continued)

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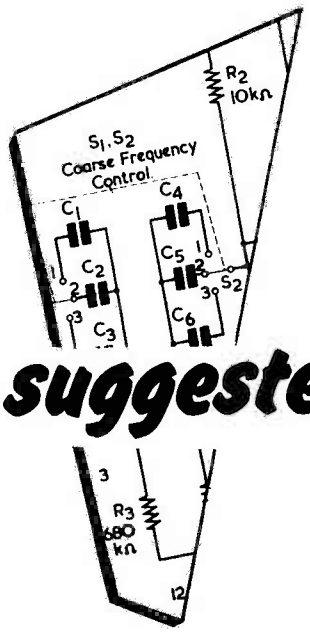

suggested circuits

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. 149 Experimental Regenerative Detector

DESPITE THE ADVENT OF TRANSISTOR receivers, mains operated valve superhets for the broadcast bands still remain popular. The conventional a.m. superhet receiver comprises an h.t. rectifier circuit and four signal-handling stages, the latter consisting of the frequency changer, the i.f. amplifier, the a.f. voltage amplifier, and the output stage. Detection is achieved immediately before the a.f. voltage amplifier, and may be provided by a germanium diode, or by a diode incorporated in either the i.f. or a.f. voltage amplifier valves.

When the full sensitivity of the four valve line-up is not needed (as occurs, for instance, when the main requirement is the reception of local stations only) it would seem that an economy could be effected by omitting one of the stages. This month's circuit suggests an approach along such lines, and the accompanying diagram depicts a possible method of obtaining detection immediately after the frequency changer. The loss of the i.f. amplifier is partly made good by the use of a regenerative detector circuit, which has the secondary advantage of improving i.f. selectivity despite the fact that only a single i.f. transformer is retained. The complete receiver may then contain two valves only, one of these being the frequency changer, and the other a triode-pentode which combines the functions of a.f. voltage amplifier and output stage.

Before proceeding further, it must be stated that the present circuit is entirely experimental in character and that, despite its apparent simplicity, it may well prove tricky to put into practical operation. The circuit should only be tackled by the experienced constructor who is prepared to experiment with components and component values, and who fully understands the principles involved. Different layouts and i.f. transformers may cause varying results, and this fact must similarly be borne in mind.

Operation

The circuit of the regenerative detector appears in the accompanying diagram, which also includes the output stage and some of the power supply components.

V_1 is a standard frequency changer of the ECH81 class, and it is anticipated that this will employ coils which enable it to tune over the medium and long wavebands, or over the medium waveband only. The anode of V_1 connects to the primary of a standard 465 kc/s (nominal) i.f. transformer, the secondary of which couples to the grid of $V_{2(a)}$ and R_1C_2 in parallel. $V_{2(a)}$ functions as a leaky-grid detector, the grid leak and capacitor being provided, at the earthy end of the secondary, by R_1 and C_2. Since detected a.f. appears on its grid, $V_{2(a)}$ also provides a.f. amplification, and the a.f. at its anode is passed to the volume control by way of an r.f. filter which will shortly be discussed.

In addition to a.f., amplified r.f. appears at the anode as well, and this is fed back to the earthy end of the i.f. transformer secondary by way of trimmer C_1. When C_1 is adjusted to give a high capacitance, $V_{2(a)}$ functions as a Colpitts oscillator in which the earthy tap into the capacitances across the coil is given at the junction of C_{gk} and the combination C_{ak}, C_1 and C_2. The purpose of the circuit is that C_1 be adjusted such that $V_{2(a)}$ is just below oscillation point, whereupon both sensitivity and selectivity are enhanced by the regenerative effect which results. It should be noted that the circuit allows a standard i.f. transformer to be employed, and that no feedback winding or tap in the secondary is required.

The r.f. at the anode of $V_{2(a)}$ has to be bypassed to chassis in the coupling circuit to the volume control, and this is achieved initially by the low-pass filter R_3C_3. A further filter is given by R_4, the resistance in R_5 above the slider, and the C_{gk} of $V_{2(b)}$.

$V_{2(b)}$ is connected in a conventional output circuit, its anode being supplied from the reservoir capacitor C_8, and its screen-grid from the smoothed supply following R_6. The presence of a rectifier is indicated by the cathode of V_3, but a metal rectifier or contact-cooled rectifier could, of course, be employed just as readily as a

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valve rectifier. It is assumed that the power supply will be of a simple nature, employing, say, a half-wave rectifier and a 6.3 volt heater transformer. If an ECL86 is employed in the V_2 position, the h.t. current consumption of this valve would be of the order of 30mA for a potential of 250 volts.

Experimental Points

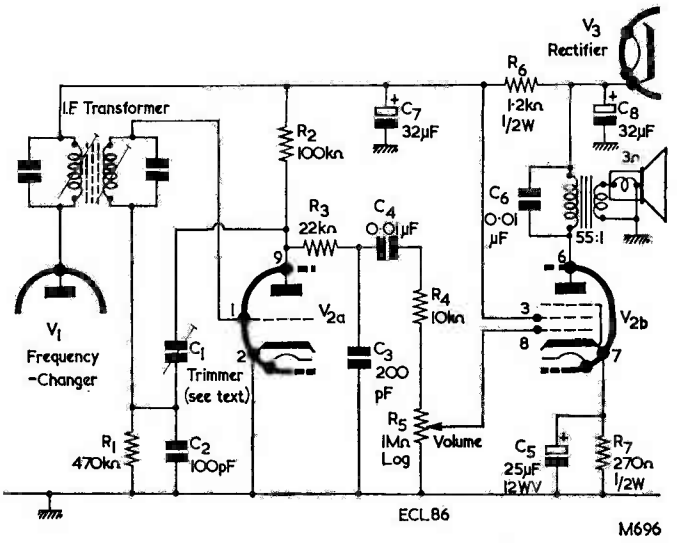
Due to the experimental nature of the circuit, a number of factors have to be discussed.

An ECL86 is shown in the diagram, but practically any other triode-pentode of similar type should function equally well. The pentode bias components and speaker transformer ratio specified apply only to the ECL86, and may require modification if other triode-pentodes are used.

The i.f. transformer would, best, be of the type which is intended to feed into a diode detector, rather than the type which, in a normal line-up, would appear between the frequency changer and i.f. amplifier. The reason for this is that such an i.f. transformer usually has a tighter coupling between the two windings to make up for damping losses in the detector circuit. In the present application, the secondary is loaded by what is virtually a standard diode circuit.

Whilst it is probable that little difficulty will be experienced in obtaining oscillation in $V_{2(a)}$, it is very desirable for C_1 to be capable of bringing the detector stage smoothly up to the point at which oscillation commences. As readers who have had experience with a t.r.f. receiver having a good reaction circuit will appreciate, the whole value of an arrangement such as that shown here lies in smooth control over regeneration.

A factor which may cause "fierce" regeneration as C_1 is increased in capacitance is that the C_{gk} of $V_{2(a)}$ offers a higher reactance than does the capacitance combination between the anode and chassis. In consequence, the oscillatory voltage applied to the grid will tend to be *higher* than that appearing on the anode, instead of lower. If it appears that this state of affairs is resulting in "fierce" reaction, or in reaction with backlash, it may be alleviated by connecting a capacitor of some 5 to 10pF between the grid of $V_{2(a)}$ and chassis. This will, of course, necessitate realignment of the i.f. transformer secondary. Further alleviation may be given by reducing the value of C_2, and this could, in practice, be as low as 25pF without excessive loss of detection efficiency. The value of the trimmer itself is also subject to experiment, but it would probably be adequate to commence with a standard 60pF mica component here.



The circuit of the experimental regenerative detector

Other factors affecting the operation of the regeneration circuit will be given if a high level of r.f. is passed to $V_{2(b)}$. This condition will be indicated when variations in the volume control setting modify the reaction adjustment, and could be cleared by adding a further 200pF filter capacitor between chassis and the junction of R_4 and R_5.

Although it would, at first sight, worsen the ratio between anode and grid oscillatory voltages, it might be found helpful in practice to add a capacitor of some 20 to 100pF between the anode of $V_{2(a)}$ and chassis. This point may readily be checked by experiment.

Setting Up The Circuit

The best method of setting up the circuit initially would consist of applying an amplitude modulated signal generator to the signal grid of the frequency changer. The generator should be set to the intermediate frequency, whereupon the detector circuit may be set up and final adjustments made to C_1 and the cores of the i.f. transformer.

After this process has been completed the oscillator and signal frequency circuits for the frequency changer could then be connected up and aligned. Care should be taken to ensure that coils and wiring operating at frequencies approaching the intermediate frequency are kept well away from the detector components. This point applies, in particular, to medium wave signal circuits, which may resonate around 500 kc/s when the tuning capacitor is at maximum capacitance.

Normal aerial and oscillator coils may be employed. It is possible that the overall receiver may not have sufficient sensitivity to operate satisfactorily with a ferrite frame aerial. In consequence, a conventional aerial coil, used in conjunction with a small aerial, would be preferable.

Advantages and Disadvantages

The main advantage offered by the detector circuit is that its use results in a fairly sensitive superhet which employs only two valves in addition to the h.t. rectifier. A very compact layout can, in consequence, be employed. Also, the fact that a Colpitts combination is employed for regeneration allows the use of a conventional i.f. transformer.

One disadvantage of the circuit is its experimental nature: it may be necessary to adjust component values in order to obtain smooth regeneration. A further point is that, if C_1 is set very close to the oscillation point, the circuit may go into oscillation at a later time if, say, the h.t. voltage rises. Again, it is not feasible to obtain an a.g.c. voltage from the detector. A negative voltage which is proportional to signal strength is available at the junction of R_1 and C_2, but the low degree of amplification before

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this point limits the effectiveness of any a.g.c. loop which can be set up. Also, this negative voltage will increase by a large amount if the circuit goes into oscillation, whereupon the setting up of C_1 on received signals (a process which may be required occasionally) would become difficult to carry out.

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.

Grateful Thanks.—J. Gearing, "The Swallows", Hammond Road, Hatfield Broad Oak, Nr. Bishops Stortford, Herts, would like to thank all those readers who replied to his request for a circuit of the Philips type L2G77B-01 receiver. So many replies were received that it would, in fact, take a long time to reply individually. The receiver is now complete and working.

* * *

Audiomaster Conway Stereo Pre-Amplifier.—L. F. Keel, 40 Chandlers Road, St. Albans, Herts, would appreciate the loan of a circuit diagram or manual of this unit—or would purchase.

* * *

Mine Detector No. 4 or 4A.—R. A. Pyatt, 23 Arundel Drive, Orpington, Kent, wishes to borrow the official instruction book. Alternatively, will any reader who has used this unit successfully please write.

* * *

Canadian Marconi 52 Receiver.—W. Pszczola, 203 Chepstow Road, Newport, Mon, urgently requires the service manual for this receiver. Borrow or purchase.

* * *

Ferguson 16in Console TV Model 989.—G. Ridgeway, 72 Nailcote Avenue, Tile Hill, Nr. Coventry, Warks, requires the manual or service sheet of both the above (Serial 11215) and the Tuner Unit B1 Serial 28397.

* * *

Hallicrafters S27 Receiver.—J. C. Knight, The Corner House, Manor Road, Tongham, Surrey, wishes to obtain the circuit diagram or manual.

* * *

Regentone Tape Recorder RT51.—C. Fish, 8 Roxeth Green Avenue, Harrow, Middlesex, requires on loan for one week the service sheet for this equipment.

Adaptor Frequency Range No. 1— A16051/1.—E. W. Sprigg, 3 Somerset Road, County Bridge, Willenhall, Staffs, requires information on the power socket connections at the rear of this unit and also the power requirements.

* * *

Surplus Tubes.—A. Basden, 7 Leyden Park, Bonnyrigg, Midlothian, would like to obtain full data on the following—3EG1, 3AP1, 5BP1, 5CP1, 5NP1, VCR97 and VCR138.

* * *

Philips Radio Type 209U-19.—A. Purcell, 28 Cranfor Avenue, Knutsford, Cheshire, would like to obtain the circuit diagram complete with components list for this receiver—serial number NR.E. 78108Eo2.

* * *

Radio Compass Receivers BC433C, BC433G, Monitor Type 25.—B. F. Baker, Wellington Street, Russell, New Zealand, requires to purchase the manuals or circuit diagrams of these equipments. Serial number of the latter unit is 10T/90 TS273.

* * *

Receiver W5737.—M. Gibbs, 81 Selsdon Road, South Croydon, Surrey, wishes to obtain any information, circuit, etc., on this receiver—especially the power requirements.

* * *

Linear L50 50 Watt Amplifier.—P. Wood, 28 Robertson Road, Lhanbryd, Nr. Elgin, Morayshire, Scotland, would like to obtain a circuit diagram of this amplifier, loan or purchase.

* * *

Transmitter/Receiver Type TR3576.—A. F. Harrison, "Woodlands", Drury Lane, Mortimer, Berks, requires the circuit or manual or any other available information on this unit (Ref. No. 10DB/6477).

* * *

Miller "English" or "Martinette" Organs.—W. R. Seymour, Park Cottage, Mill Lane, Blackpill, Swansea, wants the loan or purchase of the service manuals for these instruments.

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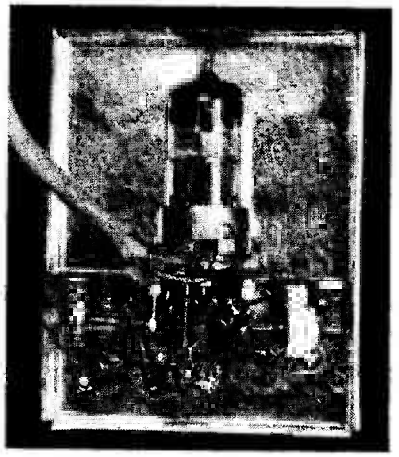
Add-on R.F. Stage for F.M. TUNERS

by

K. D. RENDALL



THE ADD-ON R.F. STAGE TO BE described is suitable for any f.m. tuner covering the standard f.m. band of 87.5 to 100 Mc/s. It was designed to help increase the signal to noise ratio of a commercial tuner currently used in an area which is most unfavourable for reception on the v.h.f. bands. The add-on unit may also be of use to those who experience a lot of flutter, etc., due to the passage of heavy vehicles near their home.

The gain is of the order of 10, as measured with an "S" meter over the range 88–97 Mc/s and this was found to be quite enough to overcome the low signal strength. As will be seen from the circuit in Fig. 1, the amplifier consists of the Mullard double triode ECC88 used as a cascode amplifier. There are two tuned circuits and one neutralising coil; this latter does not appear to be a critical component as the author wound half a dozen of various sizes and could detect no significant change in performance.* Increased gain can be obtained by varying the windings on the input and output coils; this was tried and then rejected as the increased gain can only be obtained with a loss of bandwidth, and an external tuning knob would then be needed to peak the amplifier for a particular frequency. The final result is a small unit that is merely left on a shelf at the back of the receiver and which requires no adjustment at all since the bandwidth is broad enough to make the problem of drift assume no importance.

* The coil between the two triodes of the ECC88 takes up the position normally occupied by the "peaking coil" in conventional v.h.f. cascode circuits. The latter can be made to offer regeneration with consequent loss of bandwidth, and this would be undesirable in the present application.

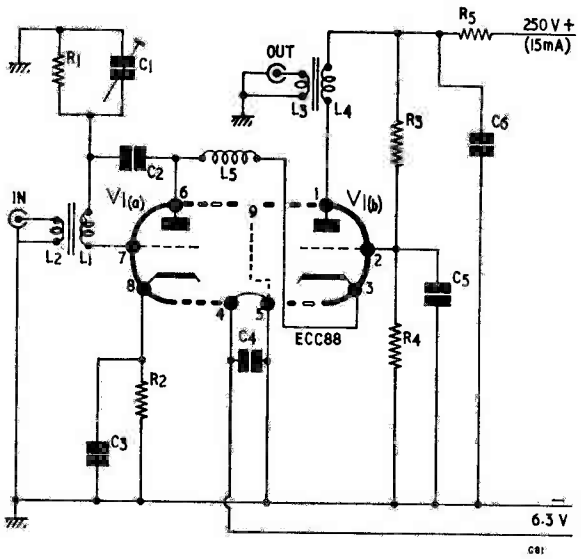


Fig. 1. The circuit of the add-on unit

Layout

The layout of the various components can be seen from the photograph of the interior, wherein the aerial components are to the

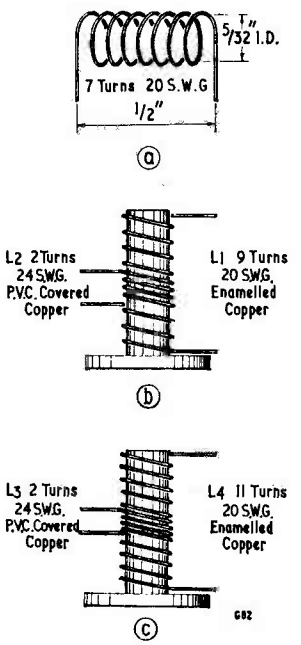


Fig. 2. Winding details for (a) L_5, (b) the input coil and (c) the output coil

Components List

Resistors (All ¼ watt 10%)

R_1	27kΩ
R_2	82Ω
R_3	100kΩ
R_4	100kΩ
R_5	1.5kΩ

Capacitors

C_1	5–15pF pre-set, silvered disc (see illustration)
C_2	4.7pF
$C_{3, 4, 5, 6}$	1,000pF

Valve

ECC88 Mullard

Miscellaneous

2 coil formers, dia. $\frac{8}{16}$ in, length $\frac{3}{4}$ in, $\frac{3}{8}$ in fixing centres
2 dust cores to fit formers
1 B9A valveholder, 2 coaxial sockets
Chassis, case, etc.

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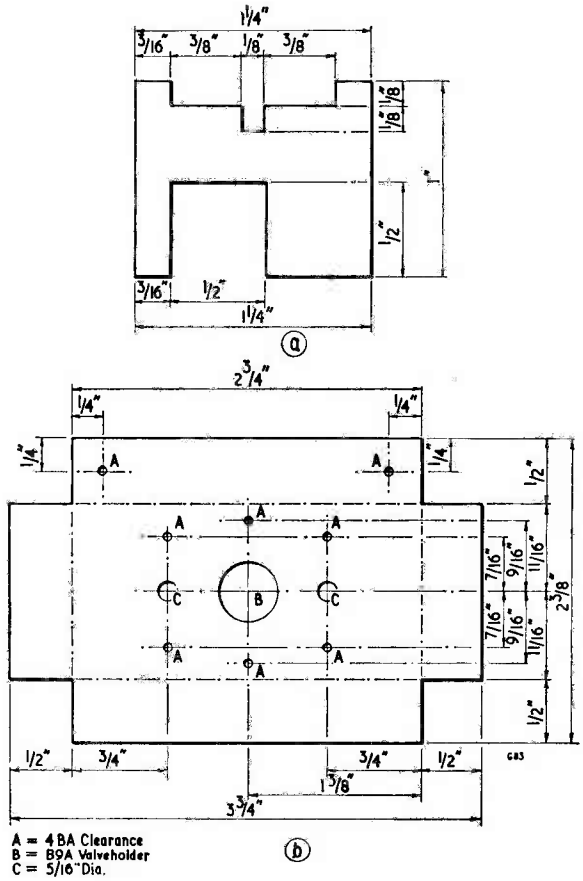


Fig. 3 (a). Dimensions of the screen (b). The main holes in the chassis. The ¼in sides are bent up (the rear side does not appear in the photograph of the prototype). The holes for the coil assume ⅞in fixing centres

right. Due to the frequencies involved it is necessary to keep wires short. Even half an inch of wire has a high inductance at 100 Mc/s, and if wiring is too long the whole circuit might have to be redesigned in order to make the amplifier tune to the desired band.

The coils are wound on Aladdin formers having a diameter of $\frac{5}{16}$in and a length of $\frac{3}{4}$in (See Fig. 2). L_1 consists of 9 turns of 20 s.w.g. enamelled copper wire. L_2 is 2 turns of 24 s.w.g. copper wire with a p.v.c. covering—this is interwound with L_1. The coil L_5 is 7 turns of 20 s.w.g. enamelled copper wire wound with a $\frac{5}{32}$in internal diameter. L_4 is 12 turns of the same wire as is used for L_1. L_3 is 2 turns of 24 s.w.g. gauge p.v.c. covered copper wire interwound with L_4.

Chassis

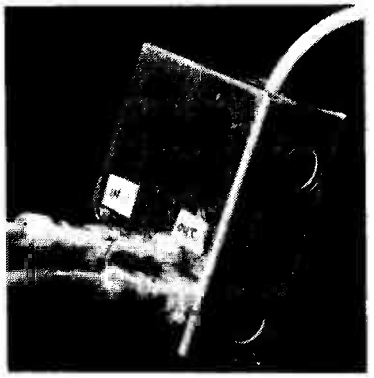
The chassis and screen are preferably made of tin plate to the dimensions shown in Fig. 3. Although it is slightly harder than aluminium to work, tin plate is suggested since one is able to make connections as short as possible by soldering to the nearest point rather than looping them around the chassis to an earth tag. The valveholder should be mounted first, followed by the valve screen between the two halves of the valve. The screen is best mounted by soldering it to the centre spigot first, then to pins 5 and 9, and finally soldering the two ends to the chassis. The coil formers are mounted next, their bases being on the top of the chassis. This is partly to save space and partly to ensure that they do not become damaged when components are soldered to the chassis. The coils may be wound with the formers *in situ*. All the capacitors used are ceramic and the resistors are all ¼ watt 10%. The power supply leads are brought through the chassis by means of lead-through insulators. This has been done so that the tuned circuits are not affected if the leads are moved around. The power leads are then fed through one of the ventilating holes in the case.

When all the wiring has been completed and checked it is advisable to insert a meter in the h.t. lead before switching on. If the current consumption is more than 15mA then the constructor must switch off and check for short-circuits in the wiring or in the valve. When all is as it should be, the only thing left is to line up the amplifier. The unit output is coupled to the receiver and its input connected to the aerial.

TABLE

(Voltages measured on prototype with Avo Model 8. Supply volts 250)

Valve Pin	*Voltage above chassis*
1	200
2	90
3	90
4	6.3 (a.c.)
6	90
8	1.4



Tune the receiver to a weak signal, adjust the input and output coils for maximum gain, then set the pre-set capacitor C_1 for maximum signal in the centre of the band of frequencies to be received. The gain should then be of much the same amplitude all over this band. If this is not so, then the coils should have their coupling varied by opening or closing the turns until the requisite results are obtained.

The author has had one of these units in use for the last six months. It has been no trouble at all and it has enabled him to fully enjoy reception of the f.m. bands in a fringe area.

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NEWS AND COMMENT . . .

A Growing Hobby?

As the years go by one sees changes gradually taking place in the interests of people, this often being reflected in the type of hobby being pursued. Increased leisure and living standards have given a great boost to spare-time activities, none the less hobbies to some extent compete with each other and not all spare-time activities are as flourishing as they once were.

Radio, as a hobby, still seems to be expanding and membership of societies such as the Radio Society of Great Britain continues to grow. In this country there are approaching 10,000 licensed amateur transmitters and, rather surprisingly in view of the costs involved, more than 100 amateur TV licence holders. The news that a seventeen-year-old schoolgirl recently obtained her amateur transmitting licence may be an indication of a widening field from which recruits to radio may in future be found.

The schoolgirl who achieved this distinction, usually reserved for the stronger sex, was Miss Beatrice Whitaker of Kensal Rise, London. We understand from a newspaper report that G3RIW, Miss Whitaker's call sign, also collects lizards and goes in for photography. She is studying physics, chemistry and zoology at Haberdasher's Aske's school in preparation for G.C.E. "A" level examinations in June. We wish her every success.

Chromasonics

Readers who expressed interest in the articles on the above subject by F. C. Judd, A.Inst.E., which recently appeared in this magazine, will be interested to learn that Mr. Judd is giving demonstrations of this new art form in the Stuzzi Demonstration room at the International Audio Festival and Fair to be held at the Hotel Russell, Russell Square, London, from 18th to 21st April.

Chromasonics has been described as "a new and exciting form of art which employs sound as the artist and uses a special electronic impulse generator as a palette." For those who missed the articles a brief description of what happens is that a generator accepts music or other sounds which it scans for signals and then interprets these signals into shape, colour and movement. Instructions in the form of electrical impulses for entire programmes can be recorded on magnetic tape.

Mr. Judd is Technical Editor of *Amateur Tape Recording* and author of our recently published *Radio Control for Models.*

I.S.W.L. Contest

We congratulate the International Short Wave League on the success of their listening contest run in co-operation with *The World Radio Television Handbook* organisation.

The contest took place between 1st November and 2nd December. During this period 13 international short wave stations broadcast programmes containing questions on radio, and listeners were invited to enter the competition by submitting answers to either of the above organisations. No fewer than 510 entries were received from 51 different countries.

Due to the generosity of manufacturers some valuable receivers were donated as prizes, and 62 runner-up awards were also given. It was the first international short wave listening contest organised by the League and was the largest competition of its kind to have been held; we look forward to hearing about their next venture.

Warning

Messrs. Stratton & Co. of Birmingham, who incidentally provided one of their famous Eddystone 840C communications receivers to the I.S.W.L. contest, have been troubled by the illicit use of the call sign of their amateur radio station, G6SL, by a person calling himself "Bill".

We gladly give publicity to this matter as illegal transmitting not only interferes with the pleasure of the genuine amateur, but also to warn anyone who may be tempted to transmit without a licence, that severe penalties can ensue from a G.P.O. prosecution, including the confiscation of the offending apparatus.

Electronic Organs

The secretary of the Electronic Organ Constructors' Society has informed us that as a result of articles on the construction of a transistor organ by S. Astley, the society has welcomed quite a number of new members. He states that it says much for the distribution of our magazine that enquiries have come from all over the world. Any reader interested in the programme and activities of this society should write to the Honorary Secretary, D. J. Tanner, 56 Leadale Avenue, Chingford, London, E.4.

R.A.I.B.C.

The following amusing "jingle" appeared in a recent number of *Radial*, the monthly journal of the Radio Amateur Invalid and Bedfast Club.

ELECTRIC LOVE

If she wants a date	—Meter
If she comes to call	—Receiver
If she wants an escort	—Conductor
If she's slow of comprehension	—Accelerator
If she goes up in the air	—Condenser
If she gets hungry	—Feeder
If she's a poor cook	—Discharger
If she eats too much	—Rectifier
If her hands are cold	—Heater
If she fumes and splutters	—Insulator
If she wants a holiday	—Transmitter
If she is narrow in her views	—Amplifier
If she stays out late	—Controller
IF G3XYL's TX flares up	—Fader out

The Radio Amateur Invalid and Bedfast Club is an excellent voluntary organisation for the benefit of radio amateurs who are physically handicapped. Both transmitters and listeners are catered for and there must be many stories of great courage where members have not allowed their handicaps to interfere with the pursuit of their hobby. As evidence of this, we notice that in the latest list of members issued there are no fewer than 20 blind members who are licensed transmitters. Amateur Radio seems an ideal interest for those who might otherwise feel cut off from their fellows.

It is of interest to learn that the Club now has 170 eligible members and a further 100 local representatives and supporters. Membership is free, the monthly newsletter entails a minimum subscription of 4s. per annum. The secretary is Mrs. Frances Woolley, of 10 Sturton Road, Saxilby, Lincoln, and she would be pleased to supply details to any of our readers.

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Simple Ratemeter for Radioactivity Measurements

By M. J. DARBY

REGULAR READERS WILL REMEMBER THAT A simple Geiger-Müller counter using a loudspeaker was described in the February issue of this magazine.[1] The present article describes an instrument which employs one of the three types of Geiger tubes previously suggested, but the method of counting is completely different.[2]

The Ratemeter

A Geiger counter is employed when it is desired to count each individual ionising particle or gamma ray photon entering a Geiger tube. A loudspeaker may be employed to convert the electrical impulses into audible impulses or "clicks" which can then be counted. If, however, the number of particles entering the Geiger tube per second is so great (i.e. more than a few per second) that a person cannot count the clicks, a fairly expensive piece of electronic equipment known as a scaling unit must be employed. This automatically counts the impulses and displays the total number of counts, usually by means of a neon counter plus a mechanical register.

A ratemeter is a piece of apparatus which does not register each individual particle entering the Geiger tube, but merely shows (by means of a meter) the approximate total number of particles entering the tube per second or per minute at any given time. It is the simplest and cheapest method of measuring count rates which are too large for human counting.

Principle of Operation

Each time a particle of ionising radiation enters a Geiger tube which has the normal operating potential applied to its electrodes, a small current pulse will pass through the tube. This was explained in the previous article. When a reasonably large number of pulses are entering the tube per second, the pulses can be smoothed out or integrated electrically to give a fairly steady current which is then measured. This is the principle of the ratemeter. The faster the count rate, the greater the current indicated.

In actual practice the current passing through the Geiger tube (a fraction of a microamp, except at high count rates) is too small to be measured by merely connecting the output to an ordinary meter. A transistor is used in the ratemeter described here in order to amplify the current from the Geiger tube. Despite this, a fairly sensitive meter is required to measure the current, as it is still comparatively small.

The Circuit

The circuit of the ratemeter, excluding the h.t. supply for the Geiger tube, is shown in Fig. 1. The transistor is used in a grounded emitter circuit so that it can act as a current amplifying device.

The output current from the transistor passes through the meter, M. When the switch S_1 is open no resistor shunts the meter and, if M is a 0–50 microammeter, the scale will range from zero to approximately 6,000 counts per minute.

The shunt resistor, R_2, has a value equal to one quarter of the resistance of the meter. When the switch S_1 is closed, four fifths of the total current will pass through R_2 and only one-fifth through the meter. In this case the scale will read from zero to approximately 30,000 counts per minute.

R_2 may be made from a suitable length of insulated resistance wire. If the meter and a suitable resistor in series with it are connected across a d.c. supply voltage so that a full scale deflection is obtained, the shunting of R_2 across the meter terminals should reduce the deflection by a factor of five, that is from 50 to 10μA. S_1 may be either a toggle or rotary switch.

Integrating Capacitor

The electrolytic capacitor, C_1, should have a value of at least 1,000μF. This capacitor integrates the current pulses and causes a fairly steady current to flow through the meter. It is essential that a large value component be used for C_1 or extremely violent meter fluctuations will occur and the sensitive movement may be damaged. A large value of capacitor is, in any case, essential or the meter fluctuations will virtually prevent any useful reading from being obtained.

A larger value of capacitor than that specified smooths out the fluctuations rather more efficiently but each measurement will take longer, as the larger the value of the capacitor used the longer it takes to charge to a steady voltage. A suitable working voltage for C_1 is 6.

Safety Resistor

The resistor R_1 is a current limiting component.

1. "A Simple Geiger-Müller Counter" by J. B. Dance, M.SC. *The Radio Constructor*, February, 1962.

2. The instrument described in this article is based on a design published by the Mullard Educational Service.

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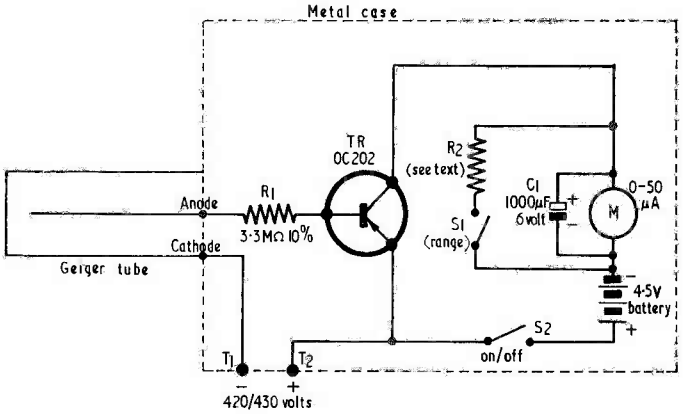

Fig. 1. Circuit diagram of the Ratemeter

It prevents the Geiger tube and the transistor base-emitter circuit from passing excessive currents during periods of very high radiation intensity. It is important that the value of R_1 should not be less than about 3MΩ or the tube may not be adequately protected.

The Geiger Tube

Halogen quenched Geiger tubes are recommended for use in the ratemeter because they require less than half the h.t. voltage which is required by organically quenched tubes. The halogen quenched tubes suggested below also have the advantage that they give comparatively large output pulses.

The Mullard Geiger tube type MX108 is recommended for measuring total beta and gamma activity. It has a thin mica end window through which beta particles can enter. An alternative version of this tube, the MX108/01, is available; it has an even thinner mica end window than the MX108 and can therefore be used to detect very low energy beta particles. The MX108 is to be preferred unless very low energy beta particles are to be detected.

The MX115 is suitable for measuring gamma radiation only. It has no end window and is therefore cheaper than the MX108.

The MX142 is suitable for measuring the activity of liquid samples.

Further details of these Mullard Geiger tubes were given in the previous article. They all fit into the same type of base (Belling-Lee type L773) and are interchangeable.

The Transistor

The higher the gain of the transistor used, the more sensitive the ratemeter will be. A high gain transistor is desirable so that the meter need not have a full scale deflection of less than 50μA—which would make it very expensive.

Although high gain germanium transistors are available, it is unfortunate that they have a high leakage current which would introduce a zero error in the meter reading. This could be eliminated by using the transistor in a bridge circuit with stabilisation against temperature change.

A rather simpler solution involves the use of a silicon transistor which has a much lower leakage current (less than 1μA) than germanium transistors. The Mullard silicon transistor with the highest current gain (α') is the OC202 (typical $\alpha'=70$) and this type is therefore the one recommended for use in the ratemeter. The OC202 gives over twice the sensitivity of the OC201 (typical $\alpha=30$) and over three times that of the OC200 (typical $\alpha=20$), but the OC201 or the OC200 could be used in the ratemeter with a more sensitive meter.

The usual precautions should be taken when soldering the transistor into circuit.

Battery

A small 4.5 volt battery is required. The current drain does not exceed 250μA at any time and therefore any small battery of the correct voltage is satisfactory; it should have a very long life. A "flat" torch battery is convenient.

An on/off toggle switch (S_2) is included, but it is doubtful whether this is worthwhile, as the leakage

Components List—Fig. 1

1 metal box (see text)
1 meter, 0–50μA (see text)
1 battery, 4.5 volt (see text)
R_1 3.3MΩ, ¼ watt, 10% (see text)
R_2 See text
C_1 1,000μF, 6 volt working electrolytic
TR Mullard OC202 silicon transistor
S_1 Two-way, single-pole switch (rotary or toggle)
S_2 Two-way, single-pole switch (rotary or toggle)
1 Geiger Müller tube type MX108, MX115 or MX142 according to type of work required. Mullard. (See text)
1 tube holder, Belling and Lee type L773.

A two way non-reversible connector will be required for the h.t. connections if the power pack is external to the ratemeter.

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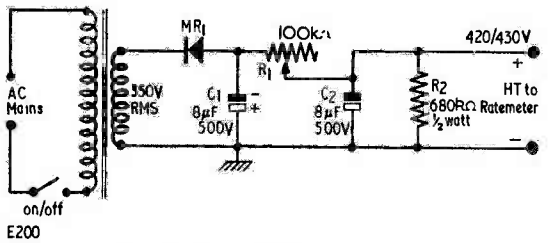

Fig. 2. Circuit of a suitable power supply for the Geiger tube. MR_1 should be rated at not less than 1kV P.I.V.

current of the silicon transistor is so very small that the permanent drain would probably not affect the life of the battery appreciably.

H.T. Supply

The h.t. supply voltage should be adjusted to between 420 and 430 volts. A stabilised supply is desirable, but not essential. If an unstabilised is used, some variations in the meter readings will occur if appreciable mains voltage fluctuations take place. The h.t. current required is very small—only a few μA.

A suitable unstabilised supply is shown in Fig. 2. Either a valve or metal rectifier may be used. The transformer h.t. secondary winding is 350 volts r.m.s., but half of a 350–0–350 volt winding could be used. When capacitor input is used, such a transformer provides about 500 volts at no load.

The variable resistor R_1 of Fig. 2 acts both as a smoothing resistor and also as a variable voltage control which enables the h.t. voltage to be adjusted to the required value of 420 to 430 volts. R_1 and R_2 act as a potential divider. When the h.t. voltage is being adjusted a high resistance voltmeter should be used, or the voltage will rise excessively above the required value when the meter is disconnected after the measurement. A 20,000 ohms per volt meter (e.g. a Model 8 Avometer) or a valve voltmeter is suitable.[3]

[3] It might be advisable to employ the Model 8 Avometer on the 1,000 volt range so that it presents 20MΩ to the circuit. Even so, a rise of several volts is possible when the meter is disconnected.

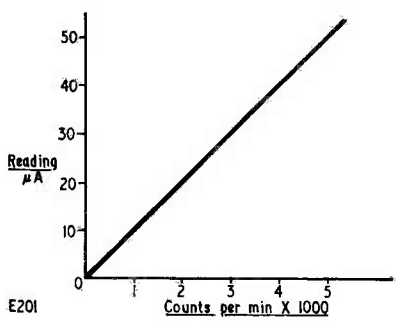

Fig. 3. Typical calibration graph for the more sensitive range

Construction

The individual constructor must decide whether the h.t. supply is to be mounted inside the ratemeter or whether it is to be in a separate unit. It may be considered desirable to construct a separate h.t. supply in order to enable the ratemeter itself to be of the smallest possible weight and size. The Geiger tube itself will normally be mounted on the outside of the ratemeter case, but it could be fitted at the end of a separate lead.

The size of the metal box required for the ratemeter will depend very much on the size of the meter used. If great accuracy is not required a small 1 11/16 in square 0–50 microammeter (obtainable from Henry's Radio Ltd.) may be used. The ratemeter itself (excluding h.t. supply) could then be mounted in an Eddystone diecast box of dimensions 4 11/16 x 3 11/16 x 2 1/16 in (manufactured by Stratton and Co. Ltd., Cat. No. 650).

If a larger and more expensive meter is used or if the power supply is mounted in the same case as the ratemeter, a larger box will probably be

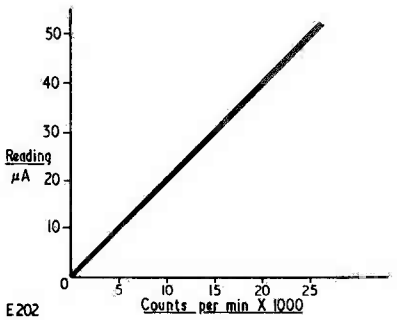

Fig. 4. Typical calibration graph for the less sensitive range

required. Thediecast box of dimensions 7 3/8 x 4 11/16 x 2 1/16 in, also manufactured by Stratton and Co. Ltd. (Cat. No. 845), may be suitable.

The base for the three Geiger tubes suggested is the Belling-Lee type L773 which fits into a 1 1/8 in diameter hole (the same diameter as that required for an international octal valveholder).

The appearance of the finished instrument may be much improved by fitting a small chromium plated carrying handle such as those manufactured by Stratton and Co. Ltd. (Cat. No. 608).

Calibration

For any specified count rate, the current passed by the Geiger tube varies according to the characteristics of the individual tube used. It will also vary widely with the applied h.t. voltage. Again, the gain of silicon transistors varies between individual components of the same type. Before really accurate readings can be obtained it is therefore essential to calibrate the ratemeter for the particular transistor and Geiger tube used at a definite value of h.t. voltage. If the Geiger tube or transistor are

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ever replaced or if the h.t. voltage is changed, re-calibration is necessary.

Ideally the instrument should be calibrated by taking connections from the Geiger tube electrodes to both the ratemeter and to a decade scaling unit. When a radioactive source is brought near the Geiger tube the number of counts per minute can be found from the scaling unit and the reading of the ratemeter noted. Thus, by repeating this process at various count rates a calibration graph for each range of the ratemeter can be drawn.

If no scaling unit is available, the ratemeter may be calibrated by means of an audio amplifier and a radioactive gamma emitter. The Geiger tube should be connected to an audio amplifier as described in the previous article so that a click is heard from the speaker each time a particle of ionising radiation enters the tube. The tube should be moved to such a distance from the radioactive material that the pulses are not too fast to be counted, although the ratemeter will indicate practically zero because the count rate is so low. The distance of the tube from the radioactive material is then measured.

The Geiger tube can then be moved closer to the radioactive material until a reasonable deflection (about 10 to 20μA) is obtained on the ratemeter. The pulse rate will now be too great for auditory counting. The distance of the tube from the active material and the meter reading are noted. As the count rate is inversely proportional to the square of the distance between the radioactive material and the Geiger tube, the fast counting rate at the smaller distance can be found. Hence a few calibration points can be obtained for the more sensitive range of the ratemeter.

Calibration need only be carried out for the more sensitive range of the ratemeter, as the other range will be exactly five times less sensitive if the value of R_2 has been chosen correctly.

Performance

Two typical calibration graphs, one for each range, are shown in Figs. 3 and 4. It can be seen that the rate is accurately linear with respect to the meter reading up to at least 25,000 counts per minute—a very desirable feature in a ratemeter. This high count rate is unlikely to be exceeded by any reasonably safe radioactive material which the normal amateur experimenter will meet. Another range could be added if desired, but at higher counting rates the current indicated by the meter would be somewhat smaller than expected from the linear relationship existing at the lower count rates shown in Figs. 3 and 4.

Caution

All radioactive materials should be regarded as highly toxic—even the material on a luminous watch—and great care should be taken to ensure that no fine radioactive particles are inhaled. The hands should always be washed after experiments with radioactive substances.

The ratemeter described is not designed for alpha particle detection; the absence of a reading on the ratemeter does not therefore necessarily imply that the material being examined is not radioactive, as it might be an alpha emitter.

R.S.G.B.

CONTESTS DIARY

April 6–7	Low Power Contest	July 6–7	Second 144 Mc/s Portable Contest
April 21	D/F Qualifying Event	July 21	D/F Qualifying Event
May 5	First 144 Mc/s Portable Contest	September 7–8	V.H.F. National Field Day
May 12	D/F Qualifying Event	September 15	D/F National Final
May 19	D/F Qualifying Event	September 22	Low Power Field Day
May 26	First 420 Mc/s Contest	October 6	R.A.E.N. Rally
June 8–9	National Field Day	October 19–20	7 Mc/s DX Contest (phone)
June 15–16	70 Mc/s Contest	October 27	Second 420 Mc/s Contest
June 23	1,250 Mc/s Tests	November 2–3	7 Mc/s DX Contest (c.w.)
June 30	D/F Qualifying Event	November 9–10	Second 1.8 Mc/s Contest
		November 16–17	R.S.G.B. 21/28 Mc/s Telephony Contests

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

part 20

understanding radio

By W. G. MORLEY

IN LAST MONTH'S CONTRIBUTION TO THIS SERIES WE examined the relationship between wavelength and frequency, after which we returned to the tuned circuit, dealing with skin effect, iron dust and ferrite cores, and circuit symbols.

We shall now carry on to a consideration of dielectric losses in both the capacitor and the inductor of a resonant circuit.

Capacitor Dielectric Loss

In our examination of tuned circuits we have, up to now, assumed that the major "losses" which occur are due to the inductor, the "losses" offered by the capacitor being very small in proportion. This assumption is quite adequate for normal practical work, provided always that a capacitor type suitable for the resonant frequency of the tuned circuit is employed.

Before proceeding further we shall now briefly examine the causes of "losses" in a capacitor, as these "losses" also have an important bearing on the design of the inductor.

Several effects occur in a practical capacitor which prevents it from functioning as a perfect component. One set of effects may be described as being purely "resistive" in character, and they are given by the inevitable resistance in the plates, terminations and connections to the capacitor, together with the resistance of the dielectric. By the choice of suitable materials it is, however, possible to keep the resistance of the plates, terminations and connections at a very low value, and the resistance of the dielectric at a very high value.

Another effect is known as *dielectric absorption*, and its presence may be demonstrated very effectively with practical capacitors. If a capacitor having a relatively large capacitance (around 2μF) is charged so that a potential of several hundred volts appears across its plates, a spark will appear if its terminals are momentarily short-circuited because of the heavy discharge current which flows. Although it would seem that the capacitor is then discharged, it will often be found possible to obtain a further spark if the terminals are short-circuited again a few seconds later. Sometimes, it may even be possible to obtain a third or a fourth spark in this manner.[1]

The reason for the second and subsequent sparks is that not all the energy stored in the dielectric is released during the intitial heavy discharge. After a few seconds have elapsed the remanent energy becomes available as a further charge on the plates, whereupon a second spark may be given.

A reverse effect (which may not be demonstrated so effectively) appears when a source of e.m.f., such as a battery, is connected to the capacitor. We first of all have the charge current with which we are already familiar, and this is followed by a much smaller current which gradually decreases. This second flow of current does not cause an increase in the charge on the plates; it is, instead, "absorbed" by the dielectric. Thus, we have the overall effect where, due to dielectric absorption, a capacitor absorbs a greater quantity of electricity than may be held as a charge on its plates. This additional quantity of electricity may, then, only be released at a similarly slow rate.

Dielectric absorption, together with the "resistive" effects discussed previously, make up the major part of the overall "losses" which occur in a practical capacitor. Also, dielectric resistance, plus dielectric absorption, make up the major part of the overall *dielectric loss.*

[1] It would be preferable not to employ an electrolytic capacitor for this experiment, as such a capacitor may be damaged by the heavy discharge current which flows when the terminals are short-circuited. Paper capacitors will normally give the effect.

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In normal radio work with tuned circuits it is possible to keep capacitor losses at a much lower level than inductor losses by the simple process of selecting a capacitor type which is suitable for the frequency at which the tuned circuit is resonant. For a number of insulating materials dielectric loss increases with frequency, with the result that the choice of a suitable capacitor at a particular frequency may be almost entirely governed by the dielectric material itself. Speaking in very general terms, it can be said that the dielectric loss in ceramic capacitors is acceptably small for frequencies up to 1,000 Mc/s, and that the corresponding maximum frequencies for mica and polystyrene capacitors are of the order of 100 Mc/s. Paper capacitors would not normally be employed in tuned circuits at frequencies above 100 kc/s. So far as variable capacitors are concerned, "air-spaced" components with ceramic mountings for the fixed vanes (a conventional construction) would be suitable at all frequencies up to 1,000 Mc/s. Pre-set variable capacitors, or trimmers, could employ mica or ceramic as the dielectric or mounting material for frequencies up to 100 Mc/s, and a purely ceramic construction for frequencies up to 1,000 Mc/s. In practice, however, mica trimmers are rarely used above 30 Mc/s or so because of the mechanical limitations in their performance. These maximum frequency figures are intended only to apply to capacitor types in terms of the dielectric employed, and they do not take into account the mechanical design of individual capacitors. The latter may limit the maximum frequency of an individual capacitor for reasons of layout, excessive lead length or excessive inductance.[2]

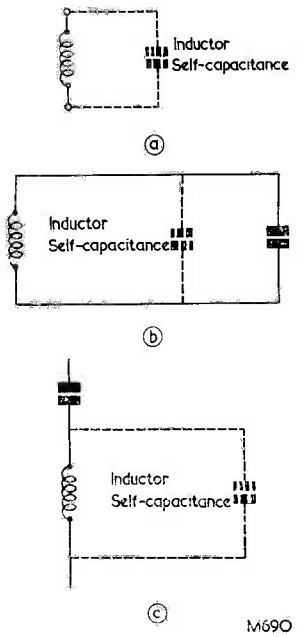

Fig. 115 (a). The self-capacitance of an inductor may be represented as a single capacitor connected across its terminals

(b). Part of the circulatory current in a parallel resonant circuit may flow through the self-capacitance of the inductor

(c). Current may similarly flow through the self-capacitance when the inductor is connedted in a series resonant circuit

Inductor Dielectric Loss

As we have noted earlier,[3] capacitance exists between the turns of a coil. It can be assumed that all the individual capacitances appearing between all parts of the wire in the coil form one single capacitance across its terminals, this being known as the self-capacitance of the coil. This self-capacitance is shown in Fig. 115 (*a*), wherein it appears as a single fixed capacitor connected across the coil. If the inductor is employed in a parallel resonant circuit, as in Fig. 115 (*b*), the self-capacitance will be in parallel with the external capacitor, whereupon the resonant frequency will be lowered and part of the circulating current will flow in the self-capacitance. If the inductor is employed in a series resonant circuit, as shown in Fig. 115 (*c*), we may again have an undesired current flow through the self-capacitance.

With a component which is *designed* to offer capacitance we are able to choose a dielectric material which has a very low dielectric loss at the frequency at which it is intended to work. In the case of the self-capacitance of an inductor, however, our choice of dielectric is largely restricted to the insulating material on the winding wire itself; and this will usually be enamel and/or a covering of cotton, rayon or silk, all of which present relatively high dielectric losses. In consequence, the self-capacitance of the coil not only appears as a capacitor but it also appears as a capacitor which can introduce high "losses" into the resonant circuit. These are known as the *dielectric losses* of the inductor. It should be added that, if the inductor consists of a single-layer coil wound on a former, the latter forms part of the dielectric between turns and may add to the dielectric losses.

In order to reduce dielectric losses in a coil, it is helpful to keep the self-capacitance to a low value. With coils requiring a relatively large number of turns, this can to a certain extent be achieved by wave-winding, which may cause adjacent wires in each layer to be partly spaced away from each other. In addition, the wires in each layer of the wave-winding cross those in the previous layer at an angle, instead of running parallel to them. The additional spacing and angled crossings reduce self-capacitance, the additional spacing also allowing

[2] See "Understanding Radio" part 9, May 1962 issue, which discusses the inductance of paper and plastic film capacitors. It should be noted that all practical fixed capacitors exhibit a very small amount of inductance, this being provided largely by the inductance of their wire lead-outs or other terminations. This very small inductance can become troublesome at frequencies above 20Mc/s or so, and is kept to a low level by connecting the capacitor into circuit with as short a lead length as is possible.

[3] In "Understanding Radio" part 13, September 1962 issue.

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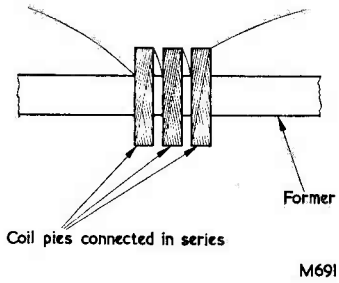

Fig. 72. The self-capacitance of a wave-wound coil may be reduced by splitting the winding into separate "pies". (This diagram is reprinted for convenience from the September 1962 issue)

the dielectric between the wires to consist in part of air, which exhibits low losses. The wave-winding technique ensures, further, that turns at one end of the coil are kept well away from turns at the other end, a factor which is of considerable value in keeping self-capacitance down. Unfortunately, it is often desirable for wave-wound coils to be protected from the atmosphere, whereupon a subsequent impregnating operation in wax or varnish is required after winding. The impregnant then replaces the air between the turns, with the result that its greater dielectric constant will cause an increase in self-capacitance. Also, the impregnant will present a higher dielectric loss than the air it replaces. Perhaps the best impregnating material is polystyrene, which offers a low dielectric loss, and this is frequently employed instead of wax or varnish in wave-wound coils intended for use in radio frequency resonant circuits.

The self-capacitance of a wave-wound coil may be significantly decreased by winding it in "pies", or sections, as shown in Fig. 72.[4] Each individual pie has its own self-capacitance, and the total self-capacitance, given by the individual self-capacitances in series, is less than that which would be offered by a single-pie coil wound for the same inductance with the same wire. On the other hand, the mutual inductance between turns in separate pies is lower than that between turns in a single pie, with the consequence that a coil wound in two or more sections requires more turns to achieve the same overall inductance than does a single-pie coil. Because of this effect, the introduction of pies causes an increase in winding wire resistance which offsets the advantage given by reduced self-capacitance and, in most cases, it is undesirable to employ more than three pies for resonant circuit inductors. Many wave-wound coils intended for tuned circuits have, in practice, a single pie only.

Wave-wound coils are usually encountered in tuned circuits operating at frequencies from some 50 kc/s to 5 Mc/s or so. There is little advantage in wave-winding a coil having less than about 25 turns, as such a coil does not allow an adequate "build-up" of the wave-winding pattern to be given, and it tends to consist of little more than two or three layers which are uneconomical to wind and which have little advantage over single-layer coils.

Single-layer coils are wound directly on to the former, in which case dielectric losses in the latter contribute towards the overall dielectric loss of the coil. Where high Q values are required, it is usual to employ a former made of "low-loss" material such as ceramic or polystyrene. It is advantageous, also, to space the turns so that each is separated from its neighbour by air or by a "low-loss" impregnant or protective coating such as polystyrene. An alternative construction is shown in Fig. 116 (*a*), in which the coil is wound on a ribbed former. In this instance the only points at which the coil wire closely approaches the former are at the ribs, whereupon the coil becomes almost entirely suspended in air. This technique may be taken further by making the coil entirely self-supporting, as in Fig. 116 (*b*). The coil of Fig. 116 (*b*) is wound with a heavy-gauge (i.e. thick) wire for mechanical rigidity (and low resistance) and it may be provided with two or three strengthening strips of low-loss insulating material to give final support. In practical radio work where single-layer coils are required to have high values of Q, it is common practice to wind these on ceramic formers, or ribbed formers of the type shown in Fig. 116 (*a*). The self-supporting coil of Fig. 116 (*b*) is more usually found in transmitters than in receivers. Where high values of Q are not required, a single-layer coil may be close-wound on an inexpensive former made of materials which fall into the Bakelite or Paxolin categories. Adjustable iron dust cores are normally provided. Such coils may be found in the short-wave tuned circuits of domestic "all-wave" receivers, in which

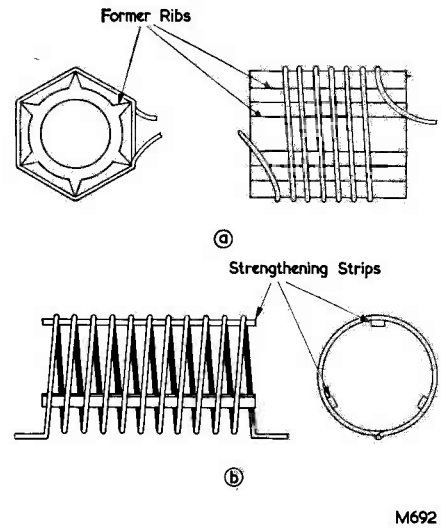

Fig. 116 (a). Dielectric loss may be reduced by winding a coil on a ribbed former
(b). A further reduction in dielectric loss may be achieved by making the coil almost entirely self-supporting as shown here

[4] See "Understanding Radio" part 13.

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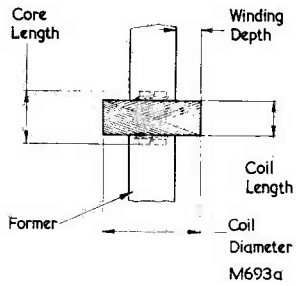

Fig. 117. The dimensions of a wave-wound coil

a high level of Q is not expected, and they are much cheaper to produce than spaced coils wound on low-loss formers.

Inductor Efficiency

Up to the present, we have referred to inductor "losses" without itemising the factors which make up such losses. We can now see that the major constituents of inductor losses are skin effect and dielectric loss. When the coil has an iron dust core we have to add the losses due to eddy currents in the core.

In addition to losses, the Q of a coil may be affected by its *shape* and *dimensions*. With air-cored single-layer coils it is usually desirable to ensure that the length is not greater than one and a half times the diameter nor less than one half of the diameter. Shapes within these limits will, in general, ensure that optimum Q is approached. With air-cored single-layer coils it will generally be found that increases in diameter result in increased values of Q.

The optimum shape for a coil is qualified when iron dust cores are used, as these modify the magnetic field about the windings. Nevertheless, it is usual for single-layer coils with cores to be wound such that the length is, very approximately, equal to diameter. For best results the core should always be longer than the length of the coil. Wave-wound coils are generally designed to have a depth which is roughly equal to, or slightly less than, the length of the coil. See Fig. 117. However, when an iron dust core is fitted it may be desirable to reduce depth and increase length so that more of the winding wire approaches the core. Again, the core should be somewhat longer than the length of the coil. With pot core assemblies the shape of the coil is dictated by the internal shape of the core. The coil is designed so that it nearly fills the space available inside the core.

It should be noted, finally, that the efficiency of a coil may be reduced if large areas of metal are allowed to approach it too closely. Eddy currents are induced in such areas of metal, and there is a consequent loss of energy. Speaking in very general terms, large areas of metal should not be allowed to approach the sides of air-cored coils by less than half the coil diameter, nor approach the ends by a distance less than the diameter itself. When iron dust cores are employed this restriction may be slightly relaxed, because of the partial concentration of the field of the coil inside the core. When a pot core is used, nearly all the field is contained in the dust core material, and large areas of metal may closely approach the outside of the pot core without seriously upsetting coil performance.

Practical Tuned Circuits

Since it is possible to change the resonant frequency of a tuned circuit by altering either the inductance or the capacitance, we have available a means of readily changing the frequency at which a radio receiver is most sensitive. The circuits employed for frequency selection, or *tuning*, in practical radio receivers are almost always of the parallel resonant type, and they may take up the basic form illustrated in Fig. 118 (*a*). In Fig. 118 (*a*) we have an inductor with a variable capacitor in parallel, the combination giving a tuned circuit whose resonant frequency may be varied by turning the spindle of the capacitor. The capacitor spindle is mechanically coupled to a knob on the front panel of the receiver, whereupon

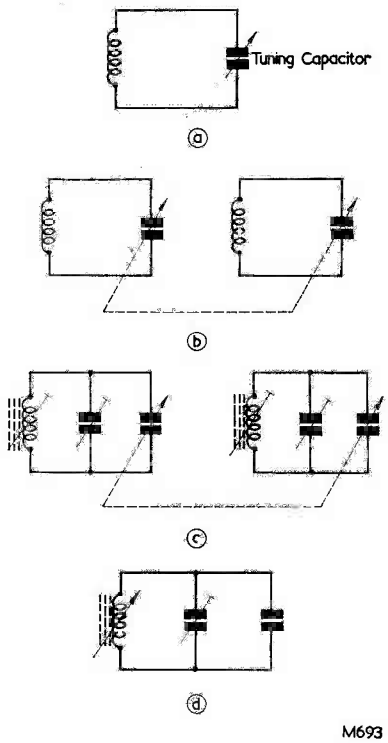

Fig. 118 (a). A simple resonant circuit as employed for tuning a receiver

(b). By using a two-gang variable capacitor two resonant circuits may be kept in step with each other

(c). The addition of trimmers and adjustable iron dust cores allows the two circuits to be kept more accurately in step

(d). The basic permeability tuning arrangement. The coil has an iron dust core whose position can be adjusted by a knob on the front panel of the receiver

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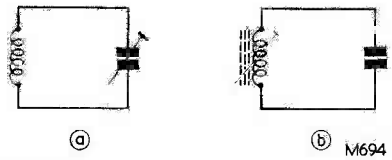

Fig. 119 (a). Resonant circuits which are adjusted to a pre-set frequency may employ a coil and trimmer as shown here

(b). Modern practice tends to replace the trimmer by a fixed capacitor, frequency adjustments being made with an iron dust core

the latter may be employed for tuning the receiver. The variable capacitor in this application is described as the *tuning capacitor*.

A receiver may have two tuned circuits resonant at the same frequency, whereupon these may be tuned in step by means of a two-gang capacitor, as in Fig. 118 (*b*). The dashed line in this diagram indicates that the two capacitors are ganged together. It is very difficult, in practice, to ensure that the two resonant circuits have exactly the same stray capacitances, or that the two inductors have exactly the same inductance. In consequence, it is usual to add low capacitance trimmers to the circuits and to provide the inductors with adjustable iron dust cores, as in Fig. 118 (*c*). The trimmers may be adjusted so that, when the variable capacitor is set to minimum capacitance, both resonant circuits have the same parallel capacitance. Similarly, the two iron dust cores may be adjusted to provide the same inductance in each coil. Usually, the tuning capacitor spindle of a receiver is coupled to a tuning scale calibrated in frequency (or wavelength), whereupon the trimmers may be set up to perform the secondary function of ensuring that the resonant frequencies of the two circuits agree with the tuning scale calibration when the tuning capacitor is at minimum capacitance.[5] Agreement with the tuning scale when the tuning capacitor is at maximum capacitance may afterwards be achieved by adjusting the iron dust cores in the coils. It will be noted that the trimming operation occurs at the high frequency end of the range covered by the tuning capacitor, and that the dust core adjustment occurs at the low frequency end of the range.

A number of radio receivers have been produced in which tuning of the resonant circuits is achieved by varying the inductance instead of the capacitance, as shown in Fig. 118 (*d*). In these receivers a fixed capacitor is employed in parallel with the coil, and the inductance is varied by an iron dust core which moves into and out of its windings. The movement of the core is controlled by a tuning knob on the front panel of the receiver, and it is possible to gang two or more resonant circuits by a mechanical coupling between their cores. Such circuits have trimmers in parallel with the coils to compensate for varying stray capacitances. Arrangements of this type are described as employing *permeability tuning*, and they were quite common in domestic receivers manufactured before the war (particularly on the Continent). They are, however, encountered only infrequently at the present time.[6] It will be noted that the inductor of Fig. 118 (*d*) has an arrow drawn through it, this indicating "variable".

Many receivers employ tuned circuits which are pre-set to a specific frequency and are not adjustable from the front panel at all. In earlier receivers these tuned circuits consisted of air-cored coils with parallel trimmers as in Fig. 119 (*a*), whereas, in present-day receivers, it is almost universal practice to employ fixed parallel capacitors and adjustable iron dust cores, as in Fig. 119 (*b*). The assembly of Fig. 119 (*b*) is cheaper and takes up less space than that of Fig. 119 (*a*). Also, if the assembly of Fig. 119 (*a*) employs a mica trimmer (as would normally be necessary for reasons of cost) its long term frequency drift is worse than that of Fig. 119 (*b*).

[5] Actually, it is better to carry out this trimming process when the tuning capacitor vanes are slightly enmeshed, as discrepancies between the two sections of the capacitor are then taken up more accurately.

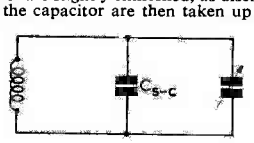

Fig. 120. As explained in the text the self-capacitance of a coil restricts the tuning range of a variable capacitor

Inductor Self-Capacitance and Tuning Range

As we have seen, it is desirable to keep the self-capacitance of a coil to a low level because this assists in reducing dielectric losses. There is a further advantage to low self-capacitance in an inductor which becomes evident when the coil is employed in conjunction with a variable tuning capacitor.

In Fig. 120 we have a coil and variable tuning capacitor in parallel, the self-capacitance of the coil being represented by C_{s-c}. When the tuning capacitor is set to maximum capacitance, the total capacitance across the coil is that provided by the tuning capacitor plus C_{s-c}. C_{s-c} will normally be much lower than the maximum capacitance of the tuning capacitor, with the result that the resonant frequency at maximum capacitance will be only slightly lower than that which would be given by the tuning capacitor on its own. When the tuning capacitor is set to its minimum value, its minimum capacitance will approach, or even be less than, that offered by C_{s-c}. The addition of C_{s-c} across the tuning capacitance may then cause the resonant frequency to drop to a much lower figure than would be given by the tuning capacitor on its own. Thus, whilst a high self-capacitance in the inductor may have little effect at the low frequency end of the range covered by the tuning capacitor, it may seriously limit the range at the high frequency end.

Next Month

In next month's issue we shall carry on to discuss the transformer.

[6] Except in car radio receivers, where permeability tuning circuits are quite often employed.

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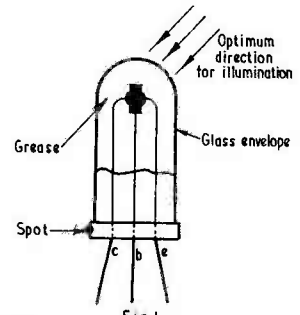
Photo-Sensitive Relays

By **R. C. CRAFER**

It is not generally realised that phototransistors may be employed as self-generating photo-electric cells. The second circuit in this article describes an application of this type

A PHOTO-SENSITIVE DEVICE IS A DEVICE WHICH IS actuated when light falls upon it. It can be an extremely useful piece of apparatus when employed in such systems as burglar alarms, counting circuits, devices for opening garage doors and so on. Such an instrument consists of a photo-sensitive head, a sensitive relay, and the associated circuitry.



E247 Fig.1

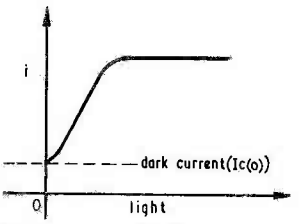
The Photo-Sensitive Head

A suitable photo-sensitive head is provided by an OC71 transistor with the paint having been removed very gently with a knife. (An OC71 is suitable because it is relatively inexpensive and is constructed in a glass envelope.) Removing the paint reveals a cylindrical glass envelope, one end of which is filled with a translucent grease. Embedded in this grease is the transistor junction. This junction responds to light, being most sensitive when it is illuminated as shown in Fig. 1.

Circuits

For a relay which will close at 0.5mA, the circuit shown in Fig. 2 is suitable. It will operate in daylight conditions.

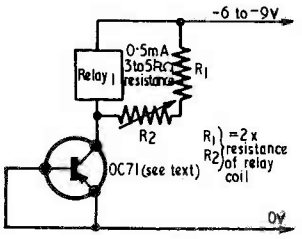
It can be seen from the current-light graph of Fig. 3 that the current through the phototransistor increases as the light falling upon it increases. The operation of the circuit is very simple: light falling



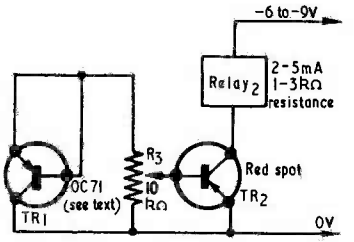
E249 Fig.3

on the transistor causes a current to flow round the circuit which is more or less in proportion to the light intensity prevailing. This current is shared between the relay and the sensitivity network R_1 and R_2. Adjustment of R_2 can set the relay to close over a wide range of light intensities. R_1 is purely a safety resistance to prevent the full supply voltage appearing across the phototransistor when the value of R_2 is zero.

If the circuit were to be used with artificial lighting which could be beamed on to the transistor, the relay could be replaced with a less sensitive type (1.5 to 2mA) and the sensitivity control dispensed with, for it only wastes useful current.



E248 Fig.2



E250 Fig.4

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For conditions where the light used is not so bright as normal daylight, the circuit shown in Fig. 4 would be more suitable.

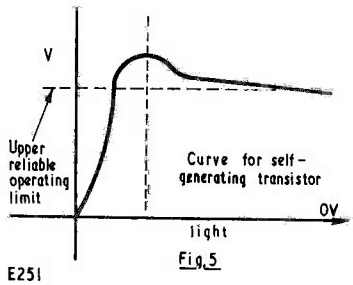

Fig. 5

E251

In this instance, the phototransistor (TR_1) is used to generate its own photo-electric voltage. This appears across the potential divider R_3, which is the sensitivity control. The slider of R_3 is taken to the base of an amplifying transistor TR_2. The relay in the collector circuit may have a sensitivity of up to 5mA, depending on the gain of the transistor. This circuit should only be used for low intensity light because the voltage-light curve of a self-generating phototransistor doubles back on itself at high light intensities. See Fig. 5.

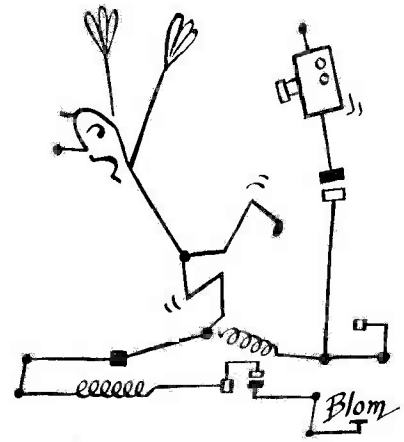

Photo Sensitive Relay

To obtain a rough idea of the self-generating properties of a phototransistor, we connected the collector of an OCP71 to the positive terminal of a 0-100μA meter, and the base and emitter to the negative terminal. The meter gave readings around 50μA when the OCP71 was in sunlight or was close to an electric light bulb.—*Editor.*

FLUX SENSITIVE MAGNETIC HEADS

The normal type of replay magnetic head used in tape recorders has an output which is proportional to the rate of change of the magnetic flux in the head gap. The flux changes as the recording tape passes across the head gap. A completely different type of head is now being manufactured by the M.S.S. Recording Company Ltd., Colnbrook, Bucks, which provides an output directly proportional to the flux in the head gap.

The output of these M.S.S. heads does not depend on the rate of change of flux in the gap and it is therefore independent of the speed of the magnetic tape past the head. The signals on the tape can be read even when the tape is stationary.

Such heads are not used for audio recording but are extremely useful in the data processing field. They can be used for reading instructions from a magnetic store at any desired rate. The linearity is better than 2% for outputs up to 10 millivolts.

The track width is 0.030in and the heads can be made up into multi-track assemblies with any number of tracks up to 16.

The manufacturers can also supply small solid state oscillator and amplifier units for use with the heads; these units give a d.c. output of ±5 volts, the polarity depending on the direction of the saturation magnetisation of the tape.

DOCKING TELEVISION

FURTHER MARCONI MARINE ORDERS

Hard on the heels of the first permanent fitting of closed-circuit television for docking purposes on the Lowland tanker *Border Chieftain* comes news that the Marconi International Marine Co. Ltd. has been instructed to supply similar installations for two 53,000 ton tankers on order with Sasebo Heavy Industries, Tokyo, for the Kuwait Oil Tanker Co. Ltd. These will be similar to that fitted in the *Border Chieftain* and will each employ a fixed-aspect camera mounted on the foremast and a monitor in the wheelhouse.

Each of the two tankers, due for delivery in late 1964 and early 1965 respectively, will also have a very comprehensive range of Marconi Marine communication and navigational aid equipment, including "Oceanspan VII" main transmitter, "Argonaut" VHF radiotelephone, "Lodestar" automatic direction-finder, and the new "Hermes" radar with true motion.

The fitting work will be carried out by the Marconi Marine Company's agents in Japan, Cornes & Co. Ltd.

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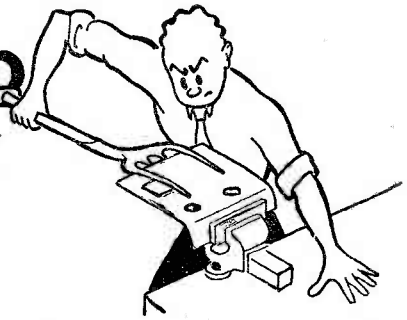
IN YOUR WORKSHOP



This month, Smithy's able assistant Dick decides to break the monotony of servicing television receivers by tackling what appears to be the simplest job in the Workshop. He finds, unhappily, that it is the simplest jobs which usually turn out to be the most complicated!

"I'M FED UP WITH TELEVISION SETS," announced Dick. "Fed up to the teeth!"

"Last month you were complaining," Smithy remonstrated gently, "because there was nothing to do. Now you're complaining because there's *too* much to do."

"I don't mind having plenty to do," replied Dick. "What I'm cheesed off with right now is that, for the past week, I've been doing nothing else but tellys. You'd think that every TV set in the district had chosen last week to pack up in."

"We've certainly had a rush of them," confirmed Smithy, "but I'd prefer things to be busy rather than quiet."

"I couldn't agree more," declared Dick, "but what chokes me is the lack of variety. There is a deadly monotony about the continual stream of duff television sets which arrive on my bench. Besides, what about me?"

"What about you?" asked Smithy unsympathetically.

"I've got my future to consider," protested Dick. "Here am I, a growing lad who is just feeling his way through the intricacies of electronics; and what do I find?"

"I don't know," said Smithy resignedly, "what do you find?"

"I find my path barred," retorted Dick hotly, "by the demands of sordid economics. Instead of gaining experience with the more varied applications of modern electronics I am forced to concentrate in one single arid field."

"To wit?"

"To wit," snorted Dick in disgust, "tellys!"

A Find

With the gait of one who has the chain of the galley slave about his ankle, Dick walked mutinously towards the racks at the end of the Workshop. He gazed scornfully at the unbroken ranks of unserviceable television receivers awaiting repair.

"Well, I don't know," said Smithy helplessly. "By the look of those racks it seems as though you'll have to continue in that arid field of yours for quite a few days yet."

However, his remarks were interrupted by a sudden triumphant yell from his assistant.

"I've found it!" called out Dick exultantly, holding up a small and battered plastic cabinet. "I've found a genuine non-telly repair! Here it is: a real honest-to-goodness sound radio, complete with medium wave tuning scale and three feet of throw-out aerial. It's no wonder I hadn't seen it before—the poor little thing was hidden by hulking great TV cabinets."

Triumphantly, Dick carried his prize back to his bench, where he immediately loosened the two screws securing the back.

"This is a smasher," he said exuberantly, looking inside the cabinet. "It's only got four valves and there's hardly any other works inside the case at all. This is the job for me!"

"Thank goodness you've found *something* that pleases you," remarked Smithy, turning back to his bench. "Even if only because it allows me to get on with some work of my own for a change."

Smithy's comments went unnoticed, because Dick was now completely engrossed in his find. He plugged the little set into the mains, switched on and noted with satisfaction that the valve heaters lit up immediately. Laying the throw-out aerial along his bench he experimentally swung the tuning dial. The faint sound of music reached his ears as he carefully tuned in the local medium wave station, and he experimentally adjusted the volume control. This was, however, already at its maximum setting.

Frowning, Dick quickly disconnected the mains, took off the knobs and removed the chassis from the cabinet. Turning the chassis over he quickly located the tags of the main h.t. electrolytic capacitor. He re-applied the mains supply, switched on and checked h.t. potential, whereupon his meter gave a voltage reading of 100. Scratching his head, Dick applied his finger, held against the blade of a screwdriver, to the grid of the output valve. He was rewarded by a low hum from the speaker. The valve preceding the output stage was unfamiliar to him, and he first of all checked in the valve manual to ascertain its grid pin. He next applied his finger to this pin, via the screwdriver, but all he could hear was a faint crackle in the speaker. He switched off once more and quickly checked the resistance between the grid and chassis. His meter indicated a short-circuit, and a smile of intense satisfaction appeared on his face.

It would be pleasant if, for a while we could now stop and take stock of Dick at this stage of the proceedings, as he sat supremely happy with

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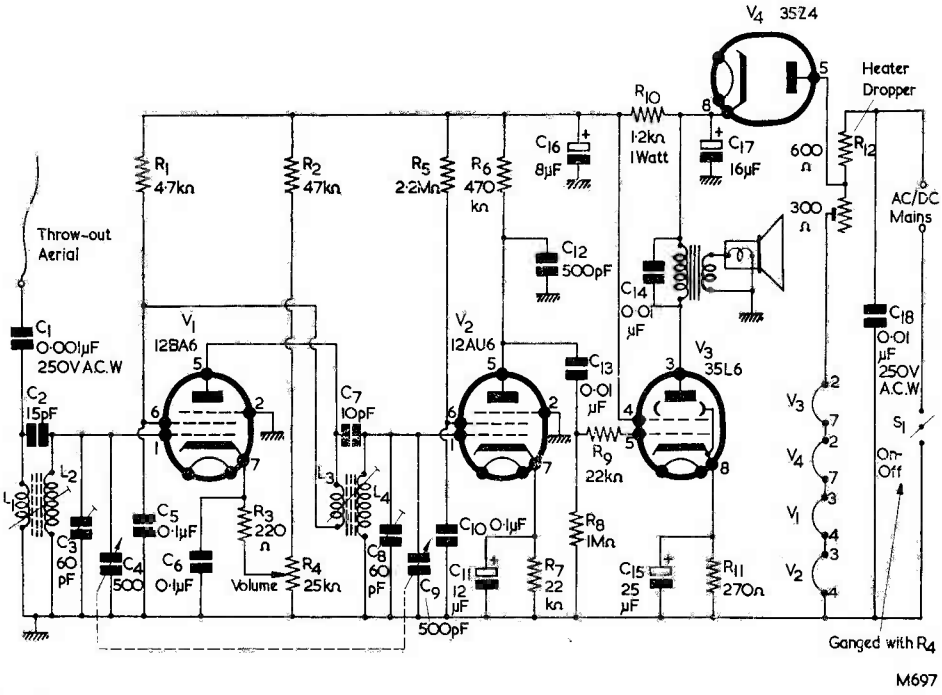

Fig. 1. A typical t.r.f. circuit of the type encountered by Dick. The component values shown here are representative, and alternatives for the V_1 position are 12K7 and 12SK7 and, for the V_2 position, 12J7. (As is explained in the text, coil specifications are critical. Coils equivalent to L_3L_4, as employed in most commercial receivers using this basic circuit, are not available on the home-constructor market)

his findings of apparently low h.t. voltage and an ostensible short-circuit between the grid of the valve and chassis. And how agreeable it would then be if we could carry on to recount the confirmation of Dick's initial diagnosis, the successful repair of the little receiver, and the final jubilant progress with it to the "Repaired" stock. But, unhappily, life for the service engineer rarely proceeds along such smooth and well-oiled tracks and it is, instead, subject to all the vagaries and buffetings of the Fates. So it was to be with Dick—but let us read on.

Dick's smile quickly disappeared as he traced the wiring from the grid of the valve. After several minutes of almost incredulous examination and re-examination, he finally pushed the chassis away from him.

A Simple T.R.F.

"Smithy!"

"Hallo."

"This set," pronounced Dick, "couldn't possibly *ever* have worked!"

"Why not?"

"For a start," said Dick, "the h.t. is purposely kept down to a fantastically low level. Also, it's got no detector in it at all!"

The Serviceman's iron descended upon its rest with unwonted violence, after which he followed the well-worn path over to Dick's side. He gazed dispassionately at the chassis on Dick's bench.

"I *think* I've got a manual for this set somewhere," he pronounced, after a moment. "I can see that we'll have to get a circuit in front of us if you're even going to understand how it works."

After some rummaging, Smithy produced a service sheet, and he laid this down on Dick's bench. His finger hovered over the circuit diagram. (Fig. 1.)

"This class of receiver," stated Smithy, "came into prominence in the boom radio years after the war. So far as I know, sets employing this circuit line-up were still in production a few years ago. As you can see, the circuit uses three valves and a rectifier in a simple medium-wave-only t.r.f. arrangement and the components required are so few that the receiver can be made at an extremely economical price. Despite the apparent simplicity of the circuit, a set of this nature can give a performance which is, from the point of view of sensitivity and selectivity, not so far short of that of a superhet. There are plenty of sets using this basic circuit knocking around these days, although some of them may have alternative valves and slightly different component values."

"There are quite a few things in the circuit which puzzle me," commented Dick, "but, even so, I don't see why it should give such a good performance. After all, it's only a three-valve t.r.f."

"Perhaps so," said Smithy, "but then the circuit doesn't show you all the tricks that are incorporated into the overall design. Actually, this overall design is very clever, because it uses a number of quite ingenious dodges to keep down manufacturing costs."

"I just can't see it," persisted Dick. "For instance, when I checked the h.t. potential just now I found it was only around 100 volts. Now that I've got the circuit diagram in front of me I can see the reason. The h.t. rectifier taps into the heater dropper more than halfway down!"

"That's true enough," said Smithy. "In the days when this type of set first went into production, manufacturers were still using output valves of the 35L6 class, and these

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have a maximum screen-grid voltage of 110. Hence the low h.t. voltage in the chassis you have there. Don't forget that the 35L6 is an American valve which is intended to work in a.c./d.c. receivers operating from 110 volt mains, and so it is quite at home with the somewhat reduced h.t. voltage you've got on that chassis."

"Then 100 volts on the h.t. line is O.K.?"

"I should say so," stated Smithy.

"Very well," continued Dick aggressively, "what do you say about the grid of V_2, the valve preceding the 35L6? When I touched it just now all I got was a faint crackle, and I then found that it had zero ohms down to deck. I've since discovered that it has a tuned circuit which couples it directly to chassis."

"That's right," agreed Smithy. "The tuned circuit is given by L_4 and C_9."

"But it doesn't make *sense*," protested Dick. "You've got a tuned circuit pumping r.f. into the grid of V_2 and you've got a 0.01μF capacitor taking a.f. out of the anode! There isn't the faintest vestige of a diode, or of a grid leak and capacitor, *anywhere*. It's as I said just now—this set just doesn't *have* a detector!"

Smithy chuckled.

"V_2" he explained gently, "is the detector."

"Hey?"

"That's right," confirmed Smithy. "It's an anode-bend detector. If you look at the component values around it you'll see that its cathode has a high value of series resistance, R_7, and that its screen-grid is similarly fed via a high value resistor, R_5. The result is that the valve is very nearly cut off, and there is considerable distortion, at the anode, of the input signal applied to the grid. This input signal is amplitude modulated r.f. and, because of the heavy distortion to which it is subjected, detected a.f. becomes available at the anode. The detected a.f. is then passed to the following valve, which is the 35L6."

Dick slowly digested this information.

"What," he asked suspiciously, "are the advantages of using an anode-bend detector?"

"There are two main advantages," said Smithy, "and the first of these is that you get a considerable degree of amplification in the valve itself. The second advantage is that the grid and cathode offer no more damping on the input tuned circuit than do the grid and cathode of a straightforward r.f. amplifier valve. In consequence, the tuned circuit functions practically at maximum efficiency, and offers a full contribution to the overall selectivity of the receiver."

"Well, I'm dashed," said Dick, impressed. "If the anode-bend detector has all these advantages, why isn't it used more frequently?"

"Mainly," replied Smithy, "because it introduces distortion. You see, you detect by working on a non-linear part of the valve's IaVg curve, and the detected a.f. is subjected to the same degree of non-linearity. Usually, the resultant distortion isn't too bad if you have a large signal input, and the circuit becomes acceptable, therefore, for inexpensive receivers of the type we're considering here."

"One thing I've noticed," commented Dick, "is that there appears to be very little r.f. filtering in the circuit after V_2. I should have thought that you'd get both a.f. *and* r.f. at the anode."

"You do," confirmed Smithy. "In the present instance, however, the circuit employs one or two minor dodges to prevent trouble on this score. The first is the use of the grid-stopper R_9. In conjunction with C_{12} and the input capacitance of the 35L6 this forms a fairly effective r.f. filter." (Fig. 2).

"It doesn't look very effective to me," said Dick critically. "After all, you must have stacks of r.f. at the anode of V_2, and the input capacitance of the 35L6 will only be a few puffs anyway."

"You're right in the first part," said Smithy, "and wrong in the second part! There *is* plenty of r.f. at the anode. On the other hand, the input capacitance of a 35L6 is a lot higher than just a few puffs. In point of fact, it is 13.2pF."

"Which is fairly high, I suppose," agreed Dick, reluctantly. "Even so, the filter doesn't appear to me to be exceptionally efficient."

"It isn't," agreed Smithy. "I would guess that quite a lot of the r.f. finds its way to the anode of the 35L6. It can't do any harm there, however, because it's shunted down to chassis via the 0.01μF tone-correction capacitor, C_{14}, and the reservoir electrolytic, C_{17}. If you remove the tone-correction capacitor in quite a few sets of this type, the resultant r.f. instability causes them to howl like banshees!"

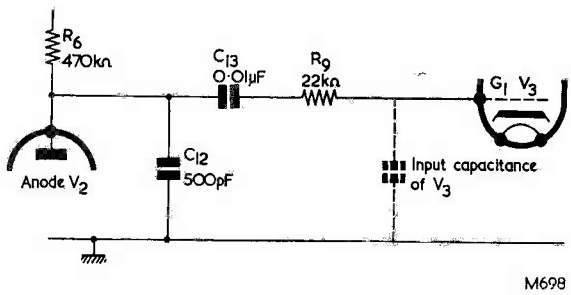

Fig. 2. The r.f. filter given by C_{12}, R_9 and the input capacitance of V_3

The R.F. Circuit

"Well," said Dick, "that seems to clear up my queries concerning the detector. I suppose that the r.f. stage is pretty straightforward."

"It is," confirmed Smithy. "V_1 is a common or garden variable-mu r.f. pentode, and its gain is adjusted by R_4. R_4 then functions as the volume control for the receiver."

"Why," asked Dick, "does the top end of R_4 connect to h.t. positive via R_2?"

"In order to give you a minimum volume position," explained Smithy. "If R_4 were merely a variable resistor in series with the cathode you'd never be able to get V_1 entirely cut off, and it would be impossible to reduce volume to a sufficiently low level when receiving powerful signals. By applying a positive potential to the top end of R_4, it is possible to cut V_1 off completely. There is, incidentally, an alternative method of achieving minimum volume with sets of this nature which you may encounter occasionally."

Smithy scribbed a circuit in the margin of the service manual. (Fig. 3).

"With this alternative arrangement," he continued, "the volume control pot is still in series with the cathode of the pentode. However, as you decrease volume you also apply a continually decreasing resistance across the primary of the aerial coil. When you're at minimum volume, that primary is shorted out, and no signal can get through at all!"

"Blimey," said Dick, looking at Smithy's circuit in disgust.

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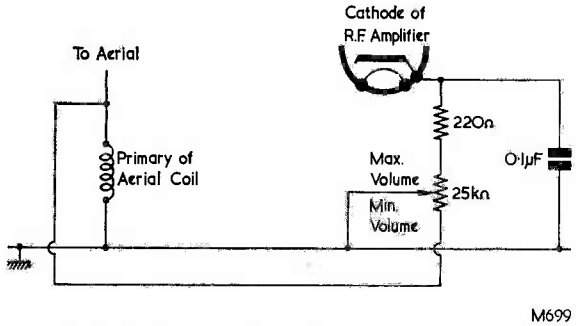

Fig. 3 An alternative form of volume control

"What a ghastly way of setting about things!"

"Shocking, isn't it?" agreed Smithy cheerfully. "Still, it saves a resistor!"

"There's something else I've noticed," said Dick. "The on-off switch is only inserted in one side of the mains, and that's the chassis side."

"True enough," said Smithy, "and there's a reason for that, too. This is that, when the set is switched on, the mains lead going to the switch assumes chassis potential and so it can't radiate any hum. The on-off switch will be ganged with R_4, and the mains lead can follow any route to the switch because, so far as the chassis is concerned, it carries no mains voltage."

Faulty Component

Smithy glanced at his watch and started.

"There I go again," he grumbled, "gassing away as usual when I should be working! Anyway, let's have a quick stab at this set, and see if we can clear it up."

Smithy sat down at Dick's bench and picked up his assistant's prods. He switched on the chassis and waited for the valves to warm up.

"Ah, here we are," he remarked after a moment. "I'm now checking the screen-grid potential for V_2, and I'm getting a reading of about 30 volts. Which seems fair enough to me."

"Isn't it a bit low?" queried Dick.

"Not at all," said Smithy. "Our superior Workshop testmeters have a resistance of 10,000 ohms per volt, and I'm using this one on the 100 volt range. Which means that there's 1MΩ between the test prods. The screen grid series resistor is 2.2MΩ, so I can expect to read about a third of the available h,t, voltage. O.K.?"

"Yes, of course," replied Dick. "I'd forgotten that the screen-grid resistor had such a high value."

"We now," continued Smithy "check the anode voltage. Whereupon we find a sum total of sweet Fanny Adams!"

"Perhaps," volunteered Dick, "the 470kΩ resistor has gone open."

"Quite probably," agreed Smithy, switching off the receiver. "Nevertheless, a quick resistance check between anode and chassis would seem to be called for. It's quite possible that C_{12} has gone short-circuit instead."

Smithy's test soon revealed that no short-circuit existed, and it was a matter of moments only to fit a new 470kΩ resistor in the R_6 position.

"I must say," said Smithy contentedly, as he placed Dick's soldering iron back on its rest, "that it's a real pleasure to get away from printed circuit receivers and on to some of these older sets for a change. It does the spirit good to be able to fit a replacement resistor between two strong and solid tags!"

Smithy switched on the receiver and waited for it to warm up. After a short while the speaker suddenly gave voice to a loud whistle. Smithy adjusted the tuning capacitor to discover that the whistle was a heterodyne with the local station. He turned the dial further, to find that several other stations could also be received, each accompanied by its own violent heterodyne. Between heterodynes, the set produced a loud and fierce hiss. Smithy turned back the volume control whereupon, at a half-setting, the heterodynes and hiss disappeared. Experimentally, Smithy readjusted the tuning capacitor and was able to tune in the local medium wave transmitter. By advancing the volume control to a level just short of oscillation point, the transmission became audible at quite adequate strength.

"That doesn't sound too bad," commented Dick.

"It should be quite a lot better than this," replied Smithy. "Some sets of this type *do* go into oscillation very near the maximum volume position, but in this case I'm getting oscillation with the control only half advanced. Hand me a 0.1μF capacitor, Dick."

Dick picked up a capacitor and handed it over to Smithy.

"What I'm going to do now," said Smithy, "is to advance the volume control until the set's oscillating again, and bridge any decoupling capacitors which could possibly have gone faulty. The first one I'll tackle is C_5 in the screen grid circuit of V_1. No luck! C_{10} in the screen grid circuit of V_2 comes next. Still no luck! Let's try popping my capacitor across the h.t. supply. This should tell us if the smoothing electrolytic is working satisfactorily as an r.f. bypass as well."

An expression of annoyance crept over Smithy's face as the instability still continued when the 0.1μF capacitor was bridged across the smoothing capacitor.

"Why not pop it across the reservoir capacitor?" suggested Dick.

"As you like," said Smithy. "I'd forgotten about that one for the moment."

The Serviceman applied the 0.1μF capacitor across the reservoir capacitor, whereupon the oscillations ceased completely.

"How about that, then?" said Dick proudly.

"Very good," admitted Smithy. "Just for the sake of interest, what made you think of the reservoir capacitor?"

"Because of what you said earlier," replied Dick. "You said that there was an r.f. bypass circuit from the anode of the 35L6 to chassis which was given by the tone-correction capacitor in series with the reservoir capacitor."

"Very good," repeated Smithy, "and I'm glad that you absorbed what I said on the subject. Anyway, the thing to do now is to fit a new reservoir capacitor. The old one is probably still doing its job fairly well so far as rectifier ripple is concerned, but it doesn't seem to be so hot at r.f. decoupling. Since I've seen this job through so far, I think I'll hang on now to the bitter end and see how the set finally ackles."

Short Aerial

Smithy rose and allowed Dick to carry on with the task of fitting a new electrolytic capacitor. After the replacement component had been wired in, Dick switched on and

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listened expectantly. The set now reproduced a number of stations at more than adequate volume and with surprisingly good selectivity. There was, also, no trace of instability, even at the full volume setting.

"That's not bad at all," remarked Smithy judicially. "You'll notice that the set is nearly on the point of oscillation at full volume without actually going over the top. The result is that you get a reaction effect which sharpens up the selectivity very considerably."

Dick turned to the circuit diagram and frowned.

"I can't *see* any feedback circuit," he said, "so how do you get the reaction effect?"

"Through random couplings," replied Smithy. "There are enough random couplings in the layout to bring you just up to the point of oscillation at full volume setting. With some sets using this circuit you may find that you go *into* oscillation at maximum volume, but this should only occur over the last few degrees of volume control rotation if the set's been laid out properly."

Dick nodded his understanding, and continued to experiment with the tuning dial.

"One thing I notice," he remarked after a moment, "is that this set appears to be a little insensitive at the low frequency end of the band."

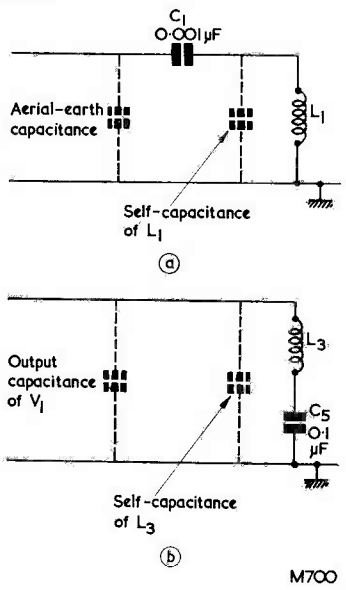

Fig. 4 (a). The capacitance tuning primary winding L_1 (b). The capacitance appearing across L_3

"I'm glad you mentioned that," replied Smithy, "because it has reminded me to tell you to fit a longer aerial."

"A longer aerial?"

"That's right," agreed Smithy cheerfully. "These sets need about ten to twelve feet of throw-out aerial to tune the primary winding of the first tuned circuit. It looks as though the aerial on this particular set has been cut down at some time in its life."

Dick's face took on an expression indicative of total incomprehension.

"I'm now," he announced, "*completely* lost! How on earth can a longer aerial tune up the primary winding?"

Smithy grinned.

"It's quite easy, really," he chuckled. "You must remember that it's common practice in any broadcast band receiver to give the primary of the aerial coil a large number of turns of fine wire in order that it may resonate, with the aerial-earth capacitance, at a point somewhat lower than the lowest frequency in the band covered. (Fig. 4(*a*)). This resonance then gives a boost to signal strength at the low frequency end, and counteracts the falling off given by the reduced L/C ratio in the secondary tuned circuit. With a receiver of this type, you normally get the desired aerial-earth capacitance with about ten to twelve feet of throw-out aerial wire. Too low an aerial-earth capacitance may cause the primary winding to resonate in the band itself, and you may not then get the boost where you want it."

"If you've got a primary tuned circuit in the aerial stage," asked Dick, "isn't it going to upset the secondary tuned circuit?"

"Not to any great extent," replied Smithy. "The tuned circuit given by the aerial-earth capacitance and the primary winding is purposely given a very low Q by employing thin wire for the winding. Now, a particularly knobby point about the class of receiver we're discussing here is that the same technique for boosting the response at the low frequency end is used for the inter-stage coil, L_3L_4, as well. (Fig. 4(*b*)). In this instance, the external tuning capacitance is the output capacitance of V_1, which is very much smaller than the aerial-earth capacitance. Because of this, L_3 is wound with many more turns of fine wire than L_1, whereupon it resonates partly with the output capacitance of V_1 and partly with its own self-capacitance. I should add that L_1 is also, of course, partly tuned by its own self-capacitance. But that self-capacitance will be largely swamped by the aerial-earth capacitance, which will be of the order of 100pF."

"You live and learn," said Dick philosophically. "What are the two low value capacitors C_2 and C_7 for?"

"To boost performance at the high frequency end!"

"Come off it, Smithy," protested Dick. "You're pulling my leg now!"

"No I'm not," laughed Smithy. "By using primary windings which resonate just beyond the low frequency end of the range, the latter is boosted so much that a drop becomes apparent at the high frequency end. The low value capacitors then increase the coupling at this end."

"Blimey," said Dick, supremely impressed, "there are certainly some hidden gubbinses in this receiver! We have, for instance, coils which allow maximum coupling all over the band at the cost of just a little extra wire and a couple of capacitors. Also, we have a regeneration circuit which uses no components at all, because it employs random couplings. We next have a detector which offers stacks of gain with negligible damping on its input tuned coil and whose only snag is that it introduces a small level of distortion. And finally we have the absolute bare minimum of r.f. filtering after the detector, because one of the filter capacitors doubles up for tone-compensation and the other is provided free with each output valve!"

"I told you it was an ingenious circuit," chuckled Smithy. "Indeed, I think that it represents one of the most successful cost-cutting designs which have ever been employed in commercial radios for domestic use."

Back To TV

Satisfied that all was now well, Smithy left his assistant to complete his work on the receiver. Dick replaced the throw-out aerial with a new lead of more acceptable length, after which he returned the chassis of the little set to its cabinet.

Satisfied with its performance, he carried the set over to the "Repaired" rack, after which he glanced over the receivers which were still awaiting attention.

"Looking for another radio?" called out Smithy.

"No fear," replied Dick. "I've had enough of radio for one day. I'm going to pick out a television set—they're less complicated!"

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HIGH IMPEDANCE TRANSISTOR VOLTMETER

By J. B. DANCE, M.Sc.

WHEN AN ORDINARY TEST METER IS SWITCHED to a voltage range and connected to two points in a circuit being tested, the meter will take a certain amount of current from the circuit. The current taken by a good voltmeter is small, but if the circuit has a very high internal impedance (or resistance) between the two points being tested a large drop in voltage will occur at the moment the test meter is connected. Thus the true voltage between the points can only be measured whilst the test meter is actually connected, since the voltage rises again when the meter is removed.

When the circuit being tested has an internal impedance which is much lower than that of the test meter being used, the drop in voltage during the measurement is small. A normal test meter is therefore quite satisfactory for measuring h.t. supply voltages, as the impedance of such supplies is usually comparatively low. If, however, the test meter has an impedance which is less than the internal impedance of the circuit under test, the measured voltage will be less than half the value it had before the meter was connected. The solution to this problem lies in the use of a high impedance voltmeter.

Available Methods

There is a large variety of high impedance voltage measuring devices. If an electrostatic voltmeter can be used, the difficulty will be eliminated, as these meters have almost an infinite resistance. Such meters can, however, be used only for voltage measurements in excess of about one hundred volts.

Gas filled cold cathode circuits can be used to measure voltages; they have a high impedance, but are very tedious to use as the operator normally has to determine the rate of flashing of a neon bulb. Potentiometer methods can be excellent, but they are often fairly complicated.

Valve voltmeters and cathode ray oscilloscopes are excellent instruments for use as high impedance voltmeters, impedances of more than 20 MΩ being quite common.

Transistor Voltmeter

If a simple, portable, direct-reading voltmeter of reasonably high impedance is required, the constructor will find that a transistor voltmeter is very convenient. Although the internal impedance of such an instrument is not as high as that of most valve voltmeters, it has the advantages that the power supplies are self-contained and that the instrument is much cheaper, simple and light in weight.

Two versions of the instrument are described.* Version "A", using a 0-1 milliammeter, has an impedance of 22kΩ per volt, whilst the better version "B", using a more expensive 0-100 micro-ammeter, has an impedance of 150kΩ per volt.

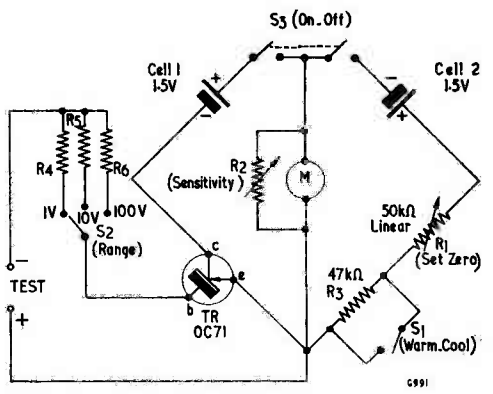

Fig. 1. Circuit of the High Impedance Transistor Voltmeter. The values of the unmarked components differ in versions "A" and "B". (See Components List)

* The instrument described in this article is based on a design published by the Mullard Educational Service.

Components List

	Version "A"	Version "B"
R_2	25kΩ linear pot	10kΩ linear pot
R_4	22kΩ 5% ¼ watt	150kΩ 1% ¼ watt
R_5	220kΩ 5% ¼ watt	1.5MΩ 1% ¼ watt
R_6	2.2MΩ 5% ¼ watt	15MΩ 1% ¼ watt

Common to both "A" and "B"

R_1	50kΩ linear pot
R_3	47kΩ 20% $\frac{1}{10}$ watt
S_1	1-pole, 2-way toggle
S_2	1-pole, 3-way rotary
S_3	2-pole, 2-way toggle
TR	OC71 (Mullard)

Miscellaneous

Red insulated terminals (2)
Black insulated terminals (2)
Control knobs (3)
Small 1.5V cells (2)
Tagstrip (see text)

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The current taken from the circuit being tested does not exceed 50μA for version "A" or 7μA for version "B". The circuit is the same for both versions, but some of the component values differ.

Principle of Operation

The circuit of the instrument is shown in Fig. 1. Let us first consider the case when the test terminals are not connected to any circuit. The transistor base current will then be zero and the leakage current will flow from Cell 1 through the transistor collector-emitter circuit. In order to obtain a meter reading of zero at zero input voltage, it is therefore necessary to balance this leakage current by an opposite current from Cell 2. The potentiometer R_1 is adjusted until the current through it just balances the transistor leakage current; that is, until a zero reading is obtained when the input voltage to the test terminals is zero.

The circuit can be considered as a bridge which is balanced when no current flows to the transistor base. When the test terminals are connected to the voltage to be measured, a small current will flow in the transistor base circuit causing a change in the collector to emitter impedance which unbalances the bridge. The amount of unbalance depends on the base current and hence on the applied test voltage.

If the component values are as stated for version "B" of the circuit and the instrument is switched to the 1 volt range, an input of 1 volt will cause a current of approximately $\frac{V}{R_4} = \frac{1}{150{,}000} = 6.7\mu A$ to flow in the base-emitter circuit of the transistor (assuming the base-emitter impedance to be negligible compared with R_4).

As the transistor is in the common emitter circuit, it acts as a current amplifier. If the current gain (α) of the particular transistor employed is 50, the collector current will be $50 \times 6.7 = 335\mu A$ approximately. This is in addition to the leakage current which has been balanced out by the current drawn from Cell 2. The sensitivity control is then adjusted until the current flowing through the meter is exactly 100μA so that a full scale deflection is obtained.

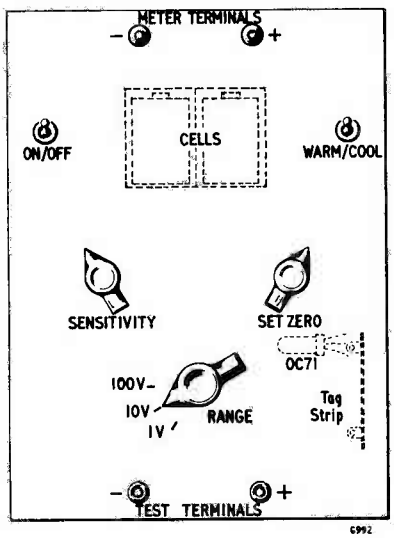

Fig. 2. The positions of the main components. Those shown dotted are secured below the chassis

Front view of the completed instrument

Ranges

S_2 is the range switch and is used to select one of the resistors R_4, R_5 or R_6. These resistors should be of a tolerance which is not wider than ±5% for version "A". Better linearity can be obtained from version "B" and it is therefore worth while using 1% tolerance resistors for R_4, R_5 and R_6 when this version is constructed.

Warm/Cool Switch

The leakage current of the transistor varies considerably with temperature. It is therefore necessary to include a switch (S_1) which can short-circuit resistor R_3 if the temperature should be high. This enables the current passing through Cell 2 to be made exactly equal to the leakage current over a wide range of temperature.

Construction

The instrument can be constructed in many different ways, as the layout is not important. The meter is not included on the chassis of the instrument itself in the method of construction described here, and this has the advantage that a useful micro- or milliammeter is not permanently

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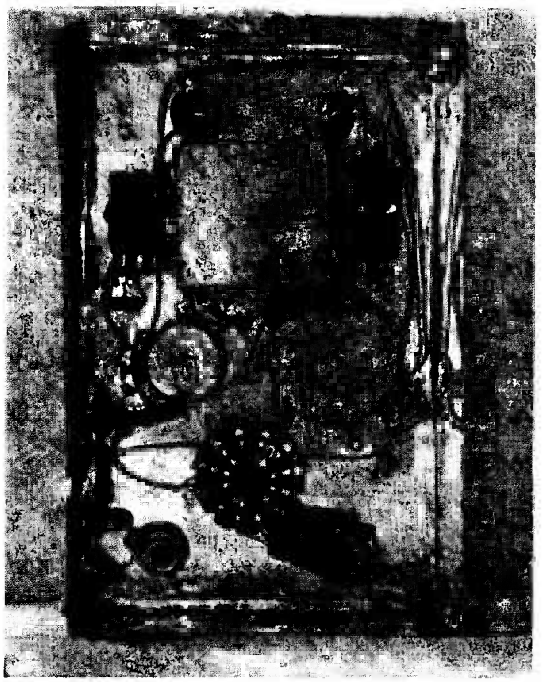

Rear view of the prototype constructed by the author

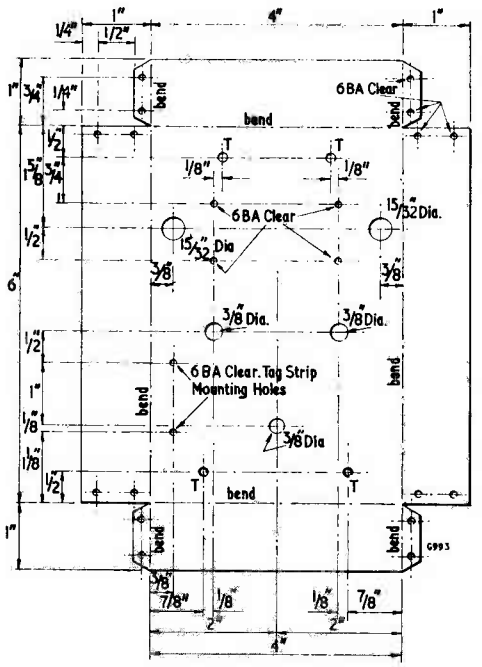

Fig. 3. Chassis drilling diagram (bottom view). The diameter of the holes marked "T" should be suitable for the terminals used

tied to the apparatus and that it can be used for other purposes when the voltmeter is not in use. The meter is connected to the two terminals on the chassis of the instrument when the voltmeter is being used.

The Chassis

The positions of the main components of the instrument are shown in Fig. 2. The size of the prototype chassis was 6in long by 4in wide by 1in deep, but a smaller instrument could have been made if miniature components had been in stock.

A detailed chassis drilling diagram is shown in Fig. 3. The chassis was cut from a sheet of tinplate 8in long and 6in wide. After bending, the corners were secured with 6 BA nuts and bolts. Some constructors may prefer to solder the corners.

A rotary switch was used for S_2 and toggle switches for S_3 (on/off) and S_1 (warm/cool).

The Transistor

The OC71 transistor was mounted on a tagstrip; three insulated contacts are required. The strip used by the writer was a small section clipped from a 28-way tagstrip in which each third tag is connected to chassis by the mounting bracket. If another type of tagstrip is used, the drilling diagram (Fig. 3) should be modified.

The usual precautions should be taken to avoid overheating the transistor when it is soldered into the circuit.

Mounting the Cells

Wires were soldered to the two 1.5 volt cells, care being taken not to overheat any part of the cells during this operation.

The two cells were insulated from each other and from the chassis by cardboard. They were held in position by a tinplate bracket (Fig. 4) and a piece of foam rubber which was compressed by the bracket. The bracket consisted of a rectangular piece of of tinplate of size $3\frac{3}{4} \times 1\frac{1}{2}$in. Four holes (6BA clearance) were drilled as shown in Fig. 4 and the bracket was then bent as illustrated so that it could be mounted to the chassis.

The cells used in the prototype were ordinary dry cells of $1\frac{1}{4}$in length and $\frac{3}{4}$in diameter. If another size of cell is used, the chassis drilling diagram (Fig. 3) and the bracket (Fig. 4) should be modified appropriately.

The current drain from each cell is very small and their life should therefore be virtually the same as their "shelf" life.

Terminals

Four insulated terminals are required, two red and two black. They fit into the holes marked "T" in Fig. 3 and these should be drilled to the size required for the particular terminals used.

Preliminary Adjustments

The following adjustments should be made each time immediately before the instrument is used.

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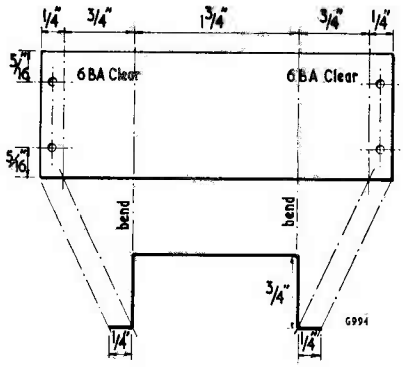

Fig. 4. Bracket used for mounting the two 1.5V cells

(1) After switching on, short-circuit the test terminals and adjust the "set zero" control for zero reading on the meter.
(2) If a zero reading cannot be obtained, switch over the warm/cool switch and adjust the "set zero" control for a zero meter reading.
(3) The sensitivity of the instrument must now be adjusted. After switching to an appropriate range, connect a source of known voltage (e.g. a small cell or power pack) to the test terminals and adjust the sensitivity control until the meter reading is correct for the voltage used. If the sensitivity is adjusted in this way at one point on one range, all ranges should be correct if R_4, R_5 and R_6 have been chosen correctly.

The meter is now ready for use, but the zero should be checked occasionally, as a temperature change may require the preliminary adjustments to be repeated.

Performance

Version "B" has a linear scale and a very high input impedance; it is a very useful instrument.

Version "A" had a somewhat lower input impedance, but is still much higher than that of all but the more expensive test meters. The scale of the version "A" prototype was not quite linear (see Fig. 5) and for accurate work a calibration graph should be plotted. One graph suffices for all ranges.

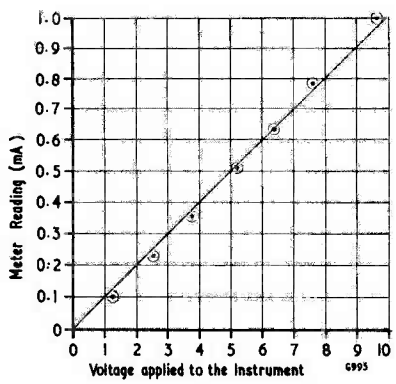

Fig. 5. Graph showing slight departure of version "A" from linearity

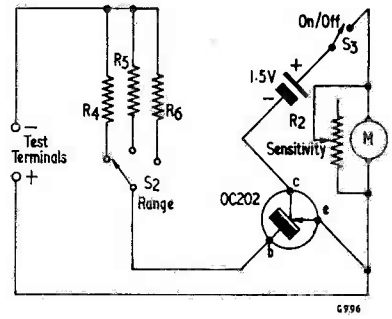

Fig. 6. A more simple circuit which requires a silicon transistor

Possible Modifications

The circuit which has been described can be modified in many ways. The following are a few of the many possible suggestions.

(1) A range to measure up to 1,000 volts could be added. An extra position on the switch S_2 would be required and an extra resistor connected to the switch contact. The value of this resistor is 22MΩ, 5% for the version "A" or 150MΩ, 1% for version "B". Other intermediate ranges could be added if desired.

(2) If an OC44, OC170 or OC171 transistor is used, the current gain is approximately doubled. A meter which is half as sensitive as those suggested could then be used or alternatively the values of R_4, R_5 and R_6 could be doubled. This would double the impedance of the instrument.

(3) An OC202 high gain silicon transistor (current gain = 70) could be used in the simpler type of circuit shown in Fig. 6. Silicon transistors have a negligible value of leakage resistance and therefore the part of the Fig. 1 bridge circuit which is used to balance out the leakage current of the transistor can be omitted. The modified circuit of Fig. 6 is easier to use, as no zero setting control is employed. Unfortunately high gain silicon transistors are still more expensive than equivalent germanium types.

(4) A semi-conductor diode may be included in the input circuit so that measurements of alternating voltages may be made. The scale will require some modification by the inclusion of an extra resistor for alternating voltage measurements.

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Cover Feature

A 6–TRANSISTOR PRINTED CIRCUIT •••SUPERHET•••

BY WALLACE STUDLEY

This receiver is constructed around a standard printed board and, although the modifications detailed are fairly easy to carry out, beginners are advised not to be over-ambitious in tackling this receiver, especially if they are unaccustomed to printed circuit and transistor superhet techniques. Access to a signal generator or modulated alignment aid is essential. No stress is laid on transistor soldering precautions as these are assumed to be already well known.

DESPITE SOME DISADVANTAGES, APPARATUS USING the printed circuit technique is generally neater in appearance and more compact than conventionally wired equipment. The technique is particularly well suited to transistorised units, but is not generally practical from a constructor's point of view unless he invests in a kit.

There is, however, a suitable printed circuit board available in a standardised form to home constructors, this being the "Weyrad" type PCA1. Upon this board it is possible to construct a complete 6-transistor superhet receiver that will cover both medium and long wavebands. Because the board measures 8¼ x 2¾in, the finalised receiver is physically larger than a pocket model, but this can be considered a desirable feature, since a speaker of relatively generous size can be fitted and better audio quality obtained thereby. A suitable cabinet size is 10 x 6 x 4in, and this will enable a PP9 type battery to be included if a modern elliptical speaker is employed.

When purchased, the PCA1 board has all com-

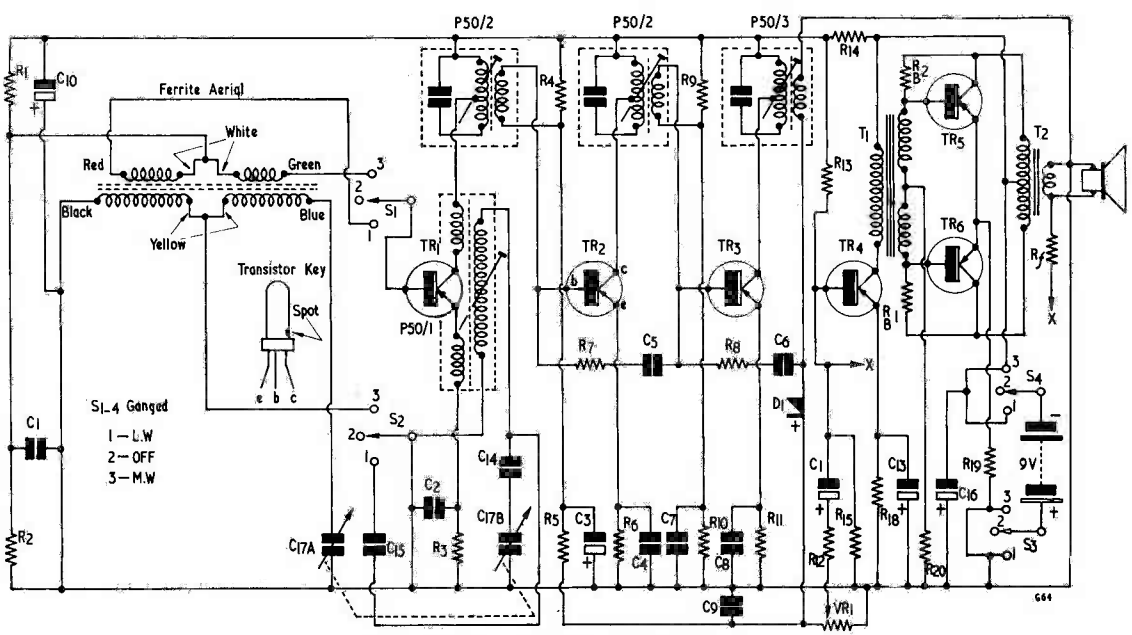

Fig. 1. The theoretical Circuit of the Receiver

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ponent legends plainly printed in yellow ink at the appropriate points on its plain side, and there is little chance of going wrong since one has only to take the appropriate component, slip its lead-out wires through the holes provided, and solder in position on the copper side. Provided that the correct item is selected each time as the work proceeds, foolproof circuitry is obtained and a receiver can be completed in a surprisingly short time.

The Reason for the Modification

The board was originally designed to accommodate a receiver having a single-ended (transformerless) output stage operating in Class B push-pull with two OC72 transistors or their equivalents, and providing some 250mW of audio power. Although single-ended Class B output stages are still *à la mode* transistor types which afford higher output powers have now largely superseded the OC72's, and a pair of OC81 matched transistors will provide some 500mW if suitably driven, and more if heat sinks are fitted. This output pair may be preceded by a OC81 driver transistor but the frequency changer and intermediate amplifier stages can remain as originally conceived.

From a constructor's viewpoint some benefit is derived from using an output transformer instead of the single-ended circuit, since the transformer is considerably less expensive than the relatively high impedance speaker otherwise required; often a suitable 3Ω type will already be to hand.

Circuit amendments cannot be put into practice,

Components List
(Fig. 1)

Resistors (All 10% unless otherwise stated)

R_1	56kΩ
R_2	10kΩ
R_3	3.9kΩ
R_4	56kΩ
R_5	6.8kΩ
R_6	1kΩ
R_7	1.2kΩ
R_8	3.9kΩ
R_9	33kΩ
R_{10}	4.7kΩ
R_{11}	1kΩ
R_{12}	470Ω
R_{13}	39kΩ
R_{14}	1kΩ
R_{15}	10kΩ
R_{16}	None
R_{17}	None
R_{18}	680Ω
R_{19}	5.6Ω
R_{20}	68Ω
R_{B1}	8.2kΩ—5%
R_{B2}	8.2kΩ—5%
R_f	100kΩ
VR_1	5kΩ Potentiometer (log.)

Capacitors

C_1	0.1μF, 200V, paper
C_2	0.01μF, 200V, paper
C_3	8μF Elec., 6V
C_4	0.1μF, 200V, paper
C_5	56pF Mica 5%
C_6	18pF Mica 5%
C_7	0.1μF, 200V, paper
C_8	0.1μF, 200V, paper
C_9	0.01μF, 200V, paper
C_{10}	100μF Elec., 12V
C_{11}	8μF Elec., 6V
C_{12}	None
C_{13}	100μF Elec., 6V
C_{14}	215pF 3%
C_{15}	175pF 3% (see text)
C_{16}	100μF Elec., 12V

Transistors (Mullard)

TR_1	OC44
TR_2	OC45
TR_3	OC45
TR_4	OC81D
$TR_{5/6}$	OC81 (matched pair)
Diode	OA70

Inductors

Ferrite Aerial RA2W (Weyrad)
Oscillator Coil P50/1 (Weyrad)
IFT1/2 P50/2 (Weyrad)
IFT3 P50/3 (Weyrad)

T_1	LFDT4 (500mW) (Weyrad)
T_2	OPT1 (500mW) (Weyrad)

Printed Board

Type PCA1 (Weyrad)

Tuning Capacitor

C_{17} Jackson Bros. Type "00" with trimmers (208+176pF)

Tuning Drive

Jackson Bros. Epicyclic

Speaker

8in by 3in or as required

Switch

4-pole, 3-way rotary

Miscellaneous

Battery—PP9 or similar (9V)
Insulator
Spindle coupler
Press stud connectors,
Flexible leads
Solder
Wood oddments
Screws, etc.

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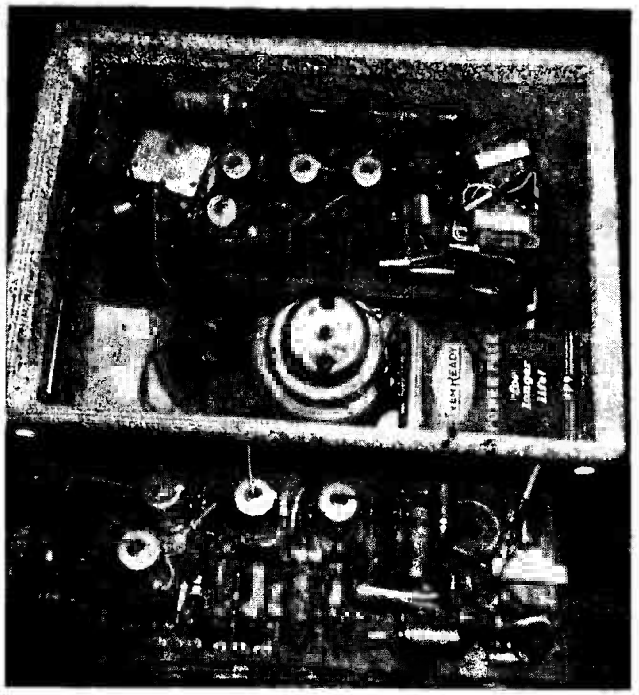

Rear view of the receiver also showing another printed circuit board partly completed

however, without upsetting the pre-arranged layout of the PCA1 board. Fortunately, the work need not become complicated since the alterations only affect the audio stages; it is in fact only necessary to re-route a few components at one end of the board.

The Circuit

The circuit of the receiver is shown in Fig. 1 and this will immediately be familiar in its various sections. TR_1, TR_2 and TR_3 perform the usual duties of mixer/oscillator and intermediate amplifiers, whilst diode D_1 provides the audio signal and a.g.c. bias. Complete stability exists in the i.f. amplifier due to the inclusion of neutralising circuits, and there is really little that can go wrong provided the completed stages are properly set up. No trimmers are depicted for C_{17} as these are fitted to the tuning capacitor when purchased.

Audio is taken from VR_1 as required and injected into the base of TR_4 via R_{12}, C_{11}. The audio signal reappears in amplified form at TR_4 collector and the driver transformer, T_1, provides the correct impedance match into the output pair, TR_5 and TR_6. These operate in Class B push-pull in the interests of output power and battery economy.

A degree of a.c. negative feedback is introduced into the output stage via RB_1 and RB_2 to improve both the response and the stability.

Although some small loss of output occurs due to the use of this circuit, the improved audio quality is more than adequate compensation. It will be appreciated that should the signal at the collectors of TR_5 and TR_6 increase at any given time so does the amount fed back and *vice versa*, and not only does this result in a more level response but, also, the transistors are stabilised; since these are temperature conscious components, any device that will assist in stabilisation is worth while.

In passing, it may be noted that a receiver constructed along the lines depicted in Fig. 1 continued to work well when the battery potential had fallen to 6V and, although output power was then limited, audio quality was not adversely affected. Another receiver in which the a.c. feedback circuit was exchanged for the more usual "bleeder" network to provide the forward bias for the output pair did not perform so well under the same circumstances.

The output transformer, T_2, provides the usual service of matching the output pair to a 3Ω speaker; some 6dB of feedback is taken from the secondary and applied degeneratively to the base of TR_4 via Rf.

All switching can be controlled with a single knob by incorporating S_{1-4} in one wafer, and it can be arranged for the battery to be entirely disconnected at the "Off" position as shown. If this is considered unnecessary only one pole may be switched, S_4 and its wiring being then ignored and its tags left free.

It may be noted that no coil or transformer pin designations appear on the diagram. This is because they are not needed; coils cannot be incorrectly connected if the legends printed on the board are observed. It may be further noted that there are some irregularities and component omissions in the amplifier section—no capacitor C_{12} is shown for example—nor is there an R_{16} or R_{17}. This is due to the modified circuit requirements.

Constructing the Modified Receiver

Initial work consists of fitting the twin gang tuning capacitor C_{17} and making sure that none of the fixing bolt heads accidentally contact the negative supply line along the edge of the board; should this happen the battery will be effectively short-circuited and other damage may be done.

Resistors are next placed in position up to and including R_{15} exactly as designated on the board, each lead-out wire being cut off to allow not less than $\frac{1}{8}$in to be bent over and lie flat on the copper side, thereby enabling a good joint to be made.

Note. No "spot soldering" (i.e. soldering wires where they appear through the board and then snipping off level) should be carried out, or noisy or nil results will be obtained.

Capacitors up to and including C_{10} are next fitted, all "+" signs being ignored regarding these except those referring to C_3 and C_{10}.

The oscillator coil and i.f. transformers can then

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be fitted and soldered, observing the locations given on the board.

At this stage transistors TR_1, TR_2 and TR_3 can be sleeved and fitted, the base lead of TR_1 being left temporarily unsoldered. The transistors cannot be connected incorrectly if the "E" "B" and "C" marks on the board are followed.

The driver transformer, T_1, is now taken and the lower centre spill adjoining the green spot is bent clear. The transformer is then fitted to the board as indicated and the five remaining spills which pass through firmly soldered. Resistors RB_1 and RB_2 (8.2kΩ) are next inserted, one end of each being placed in the holes designated R_{22} on the board and soldered. See Fig. 2. The free ends of these resistors are soldered, one each to the two upper spills of T_1 nearest to the adjacent end of the board, i.e. one on each side of the core stack.

There are three spills in all projecting on either side of the core stack at the top of transformer T_1, and the central one on one side of this stack should be joined to the central one on the other side by

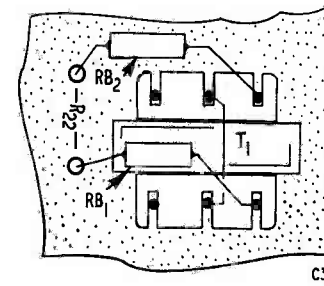

Fig. 2. The Additional Wiring around T_1.

means of a short length of p.v.c. wire. A plain wire is next soldered in place of R_{17}, as marked on the board.

Resistors R_{18}, R_{19} and R_{20} are next inserted as designated, but references to R_{21}, R_{23}, R_{24} are ignored.

Capacitor C_{11} is then fitted *but in the opposite polarity to that indicated on the board;* this point

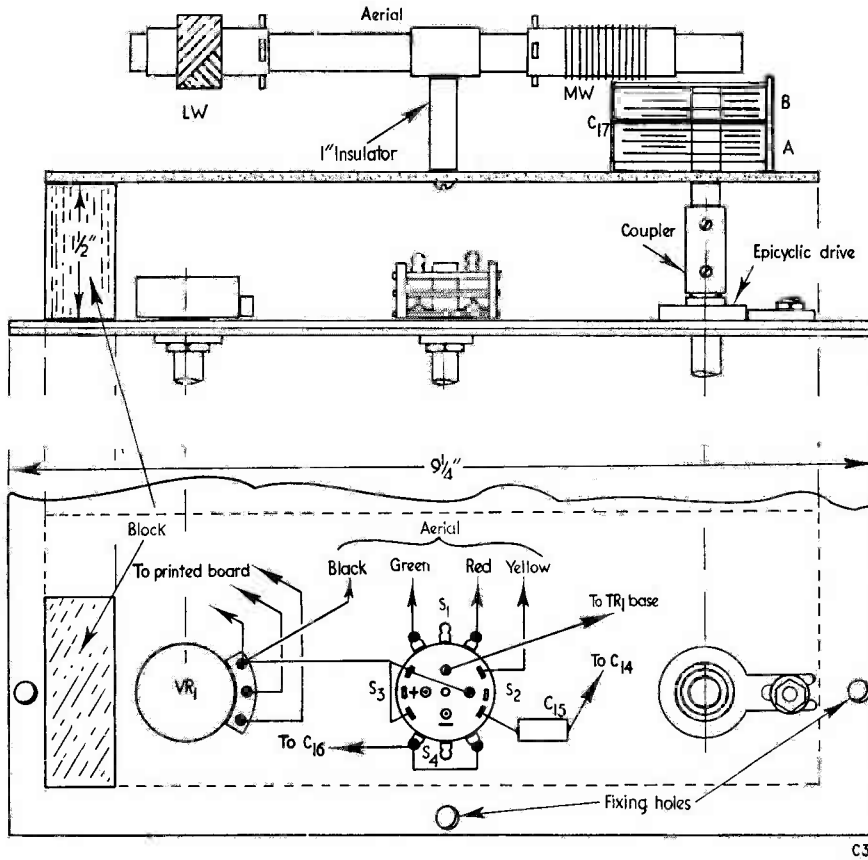

Fig. 3. The two-deck plan suggested in the text

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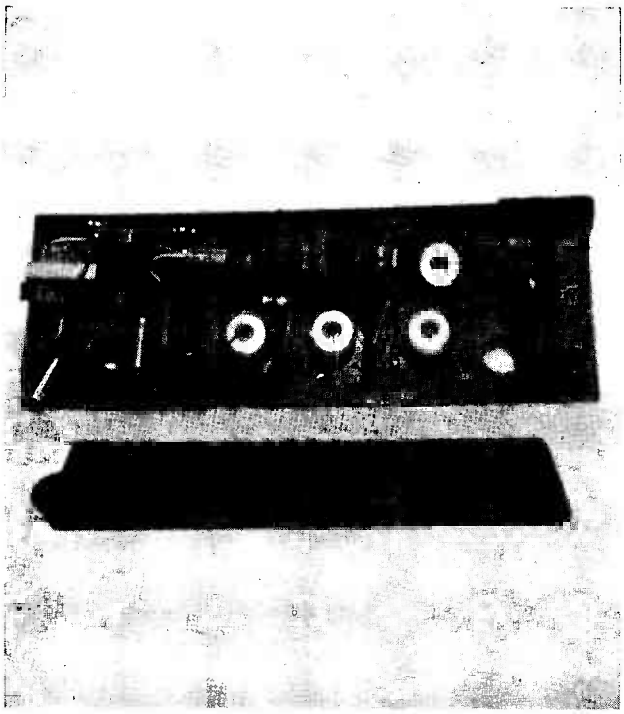

General view of the assembly

will be referred to later under "Further Modifications".

There is no C_{12} but C_{13} is fitted where indicated, also one end of C_{14} (close to the P50/1 can). The free end of C_{14} connects to $C_{17}B$.[1]

C_{16} is not marked on the board but is easily fitted by letting its negative lead-out wire (sleeved) pass around the edge of the board to contact the end of R_{14} which is remote from C_{10}. The positive lead-out wire may be inserted in the hole marked "$C_{12}+$" and continued, on the conductor side, to contact the lower end of the volume control location (this connecting to the positive supply line).

The volume control proper and the switch are more conveniently mounted on a separate panel.

Transistors TR_4 to TR_6 are next fitted as marked on the board but *TR_5 collector should not be inserted in the "C" hole*. Instead it is transposed to one of the holes marked "R_{24}" nearby—the one closest to its own emitter "E" marking. Both of the emitters of TR_5 and TR_6 must be externally interconnected (across the other side of the board) by means of a short insulated lead. This completes most of the work on the board.

Mounting the Volume Control and the Switch

A small panel offers the best way of mounting the volume control and switch, and of the various ways in which this can be effected perhaps the simplest is to make use of a "double deck" arrangement as outlined in Fig. 3. Very little weight is involved and the printed board may be held clear of the panel at one end by a simple wood spacer and small screw whilst an epicyclic reduction drive with an adjustable standard spindle coupler provides the same spacing at the other end.

The width of the panel may be as shown but the depth will vary with different models, for it is on this panel that the speaker may be mounted.

The output transformer, T_2, can be located wherever most convenient and either on the board or on the panel, the centre spill of its primary being connected to "C_{16}—" and the other two primary spills to the collectors of TR_5 and TR_6, where it will be found that holes are available. The secondary spills are connected to flexible leads and thence to the speaker, the feedback resistor, R_f being ignored until such time as the receiver has been set up and alignment completed. After this it is only necessary to make the appropriate external connection to the base of TR_4 and the positive line, temporarily at first to check for incorrectly phased feedback. When the phasing is correct the volume level should drop as R_f is connected.

A standard size component can be used for VR_1 and the switch need not be a sub-miniature type. There is no difficulty over wiring the switch even when the panel and board are in position. Switch connections are shown in Fig. 3.

The aerial is most simply held by means of a 1in insulated mounting, this being essential since one end is in connection with the decoupled negative line on the board. Flexible leads should be used for aerial connections and these should be just long enough to permit the coils to be slid along the rod when alignment is carried out.

The battery leads, suitably fitted with stud connectors, are soldered to the arms of S_3 and S_4, care being taken to ensure correct polarity.[2]

There are two connections to make from the switch to the board, viz. C_{15} to C_{14}, and S_1 pole to the base of TR_1 (which may now be soldered). There is also a connection to be made from the two white tags on the aerial to the board at the junction of R_1, C_1, R_2 and a hole is provided for these. The blue aerial tag should be connected to C_{17A} and the black tag to the nearest point on the board carrying the positive line.

This completes the construction and the receiver may be aligned after checking in the usual way, the intermediate frequency being 470 kc/s. No problems should arise over the medium waveband but on the long waveband slight changes to the value of C_{15} might be beneficial in obtaining optimum results.

[1] C_{17} is the oscillator section of the two-gang capacitor, and has the lower capacitance.—*Editor.*

[2] The copper sections on the board carrying the positive and negative supplies may be readily identified. The positive supply line is that to which the coil cans are earthed. The negative supply lines appear on either side of R_{14}, the negative terminal of the battery being applied (after the switch) to the same section that C_{16} connects. —*Editor.*

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If quick results are required fit a trimmer instead, and when the required working is secured replace this with a fixed value component after making the appropriate measurement.[3]

Current demands are modest and, from a 9V supply, a reading of 8 to 10mA should be obtained under no-signal conditions with a suitable meter connected in series with the output transformer primary centre-tap; this reading should rise to approximately 30mA on application of a signal of suitable strength.

No sub-standard transistor types should be used. Sensitivity and selectivity will be excellent and, if a good speaker is in use, quality will be superior to that of some commercial models. The prototype was capable of separating the Luxembourg signal from that of a local regional transmitter radiating on 1457 kc/s and situated only eight miles distant. No external aerial was used.

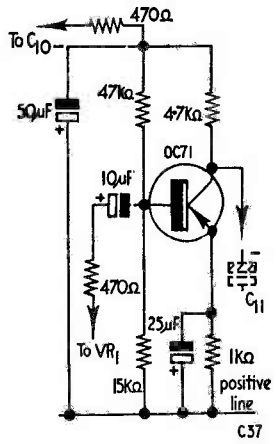

Fig. 4. An additional stage to give increased output

Further Modifications

If an additional transistor stage is inserted between the diode and the driver transistor, TR_4, greater output results. Suitable circuitry for use with a OC71 transistor is shown in Fig. 4. All the components in this diagram can be considered "extras" with the exception of C_{11} which is the original item but which will, in this case, need to be connected in the sense marked on the board; this is the opposite to the previous case. The components may be fitted to a small group board or tagstrip and so form a sub-chassis. R_{12} is omitted from the board and becomes the 470Ω input resistor shown in Fig. 4. The output from the OC71 collector may be fed to one of the now unused R_{12} holes—that adjacent C_{11}—as marked on the board.

Care should be taken, however, when the 7-transistor configuration is adopted in case the output stage becomes overrun; the use of heat sinks for the output transistors is recommended.

A car aerial coupling coil can also be fitted if desired and wired to a suitable input socket.

The dial and general frontal appearance may be chosen to suit individual choice.

[3] The manufacturers of the board and ferrite aerial recommend a 150pF capacitor across the yellow and black terminals, this capacitor coming into circuit on the long waveband only. If needed, it could be fitted at the switch tags.—*Editor.*

Tape Recorders to Help Silence Vehicle Exhaust Systems

Society is becoming increasingly noise-conscious, but most people cannot remember a particular noise for very long. So noise-abatement experiments are relying more and more on tape recordings made during comparative tests.

Development engineers at Morris Motors Ltd.'s Radiator Branch, at Oxford, use two tape recorders supplied by E.M.I. Electronics Ltd. for measuring the acoustic performance of vehicles' exhaust systems under light engine load. One of the tape recorders is also used for recording transient noise conditions and for the cold testing of exhaust systems in the laboratory.

When vehicle exhaust noise is to be analysed, the car or van is parked on hard standing in an open place. The ambient noise level should not normally exceed 65 dbC. Two microphones are placed one at each side of the tail pipe in such a manner that they are not in direct contact with the exhaust gas. One microphone is connected to an RE321 portable tape recorder and the other to a noise level meter. Tape recordings and decibel readings are taken for engine speeds of 2,000, 3,000, 4,000 and 5,000 r.p.m.

Back in the laboratory, the recordings obtained are individually transcribed on to a closed loop of tape fitted to a TR52 tape recorder. Analysing equipment is used to obtain 1/3 octave spectograms and the overall noise level is set to correspond with the particular engine speed being measured. The spectrograms so obtained enable a comparison to be made between different exhaust systems fitted to a particular vehicle.

Tape recordings are also made of transient noise conditions and a closed loop made of each complete noise cycle. Signal loss due to the gap between the erase and record head on the TR52 tape recorder is utilised to switch the filters in the 1/3 octave spectrometer. This is done by rectifying the signal from the extension loudspeaker output and using the resulting d.c. to operate a relay which, in turn, switches the 1/3 octave filter mechanism. The 600 ohm line output from the tape recorder is used to supply the signal to the filter input.

It is thus possible to obtain automatically a pen recording of loudness against time for each 1/3 octave filter setting. This enables a three-dimensional graph to be constructed of loudness versus frequency versus time.

During cold testing of exhaust systems in the laboratory, the TR52 tape recorder plays back a recorded tape of "white noise"—constant amplitude noise at all frequencies audible to the human ear. A re-entrant loudspeaker unit is used to drive noise into the inlet end of the exhaust system. Noise emitted from the tail pipe is then picked up by a microphone and analysed in the usual way.

Attenuation of the silencer can be found by replacing the silencer with a section of exhaust pipe and repeating the experiment. The difference between the two spectrograms obtained is equal to the attenuation.

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Multi-point Soldering Bit for Printed Circuits

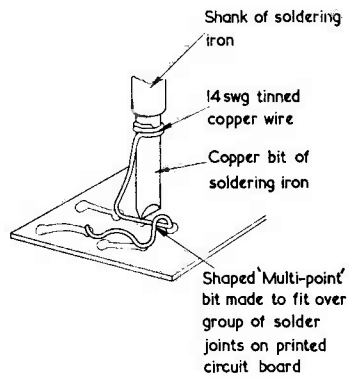
By B. B. Rafter

IF THE CONSTRUCTOR MAKES OR REPAIRS PRINTED-circuit sets, he will be faced sooner or later with having to unsolder simultaneously anything from three to six joints holding a component to the board. This process is always tricky and can be disastrous unless a technique is worked out and the right tools used.

The urgency of finding a simple method was recently brought home to the writer by a traumatic experience in a school radio club. One young enthusiast, who had put together a transistor portable kit using a printed circuit board had soldered in both the i.f. transformers the wrong way round. Each was fixed by five joints and the only hope was to find a way of unsoldering them all in one move. In this case the solution was to round up five club members, each with a soldering-iron, poise one iron over each joint, shout "now", and push the i.f. transformer off the board as the solder softened. This succeeded, but it was a nasty moment!

This event led to a consideration of what is to be done in such a predicament when one is entirely alone or unable to whip up a soldering-iron rally to assist, and the logical solution seemed to be to produce a single bit capable of melting several joints at a single application. The accompanying diagram shows how this was accomplished when a similar problem occurred later.

A short length of 14 s.w.g. tinned copper wire was, at one end, twisted round the bit of a 50 watt soldering-iron. The other end was led down the side of the bit and formed with long-nosed pliers into a foot of such a shape that, when applied to the group of joints to be unsoldered, it made contact with each simultaneously. The tip of the copper bit rested on one side of the foot and was eventually soldered to it for better heat transfer. With the iron well heated, the foot was gently and quickly applied to the group of joints, whilst the component was gently prised off the circuit board. Replacement was then a comparatively simple matter.



M652

It cannot be too strongly emphasised that speed and deftness are really vital, but properly applied the instrument cannot fail to give the desired result. Obviously, also, the shape shown will not serve for every job of this type, but it is a simple matter to form one specially for each separate repair.

B.B.C.'s NEW WELSH REGIONAL HEADQUARTERS

Work is about to start on the first stage in the construction of new B.B.C. premises on a 10-acre site at Baynton House, Llandaff, Cardiff, following the award of a building contract to Sir Robert McAlpine (South Wales) Ltd. The new building will become the headquarters of the B.B.C. in Wales.

Six new sound studios, one an orchestral studio of 3,500 square feet, are to be built to replace the existing studios in Park Place and Charles Street. There will also be a television news and interview studio (television studios at Broadway are already in operation), administrative and technical offices and a new sound outside broadcasts base with garage and maintenance accommodation for the outside broadcasts vehicles. Provision will be made in the grounds for the parking of private cars.

The architects for the new headquarters are Sir Percy Thomas & Son, in association with the B.B.C.'s Head of Building Department, Mr. R. H. S. Howell, O.B.E.

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VARIABLE SHUNT METER

By QUTAIBA BASSIM EL-DHUWAIB

Employing a transistor as a non-linear device in order to extend meter range

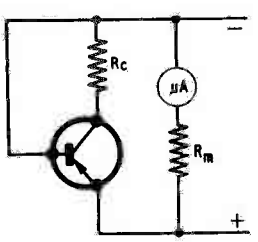
WE AFTEN USE PERMANENTLY connected d.c. meters to measure the voltage given by a power supply. Whilst a linear moving-coil meter works satisfactorily with a constant voltage power supply, it is not always as helpful with variable voltage supplies. This is due to the difficulty of reading the instrument accurately when low output voltages cause the needle to be near the zero end of its scale.

To overcome this difficulty it is possible to employ a multi-range voltmeter incorporating a range switch and a number of series resistors, but this increases costs. Also, it is necessary to have to continually adjust the range switch so that the effective full-scale deflection is always higher than that offered by the supply.

An alternative solution consists of using a meter which is very sensitive near zero and much less sensitive at f.s.d. This may be achieved by connecting a device which exhibits non-linear resistance across the terminals of the meter. The device acts as a shunt and, when the voltage across it is low, exhibits high resistance. When the applied voltage is high, its resistance may drop to about one tenth of its previous value.

A Transistor Shunt

One method of obtaining a non-linear shunt is by using a transistor.



E255

TABLE I

Meter Reading (% of f.s.d.)	Actual Current (μA)
0	0
10	23
20	53
30	92
40	146
50	205
60	304
70	410
80	564
90	760
100	1,000

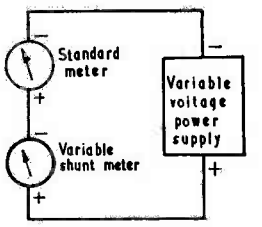
The negative terminal of the meter is connected to the base and may be regarded as the "ground", whilst the positive terminal is connected to the emitter. (A p.n.p. transistor is assumed here.) Current is then allowed to pass. The emitter-base junction acts as a diode in shunt with the meter; it becomes forward biased and a small current passes through it. Now, if we connect the collector to the base, the current carriers injected into the collector junction reach the "ground" and the shunt increases. The transistor could be said to be in the grounded-base configuration with the collector having no supply.

To adjust the f.s.d. of the meter, resistor R_c is added between the collector and the "ground" as shown in Fig. 1.

In a practical experiment carried out by the writer, a 0–100μA meter was shunted by a transistor such that f.s.d. became 1mA. The total meter resistance R_m (see Fig. 1) was 1kΩ, the resistor R_c was 100Ω, and the transistor was an OC71. Other a.f. transistors would also be satisfactory but might require changes in both R_m and R_c. Table I shows the actual current which flowed through the meter and transistor combination, together with the meter reading obtained. The results were obtained by using the circuit shown in Fig. 2, the actual current being indicated by the standard milliameter.

Use as a Voltmeter

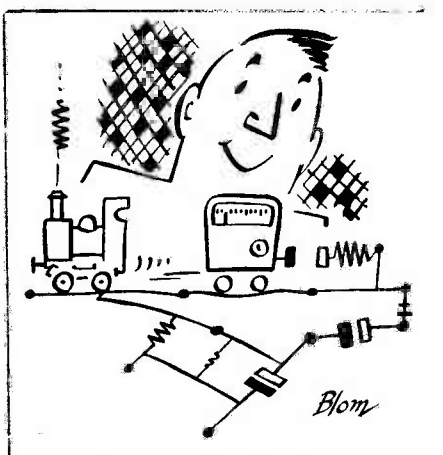
The disadvantage of the variable-shunt meter using the transistor is that it does not have a constant value of internal resistance. This changes, with change of current, from between about 1.1kΩ to about 0.2kΩ. The combination could be converted into



E256

a 0–10 voltmeter by connecting a 9.8kΩ resistor in series, but the correlation between voltage and current readings would be somewhat less than 10%. If we were to increase the series resistor to give 100 volts f.s.d., the correlation figure improves to less than 1%, whilst for 300 volts f.s.d. it is less than ⅓%, and so on.

Table II gives voltage, meter reading, and effective f.s.d. for the 0–300 voltmeter instance. It is clear



Variable Shunt Meter

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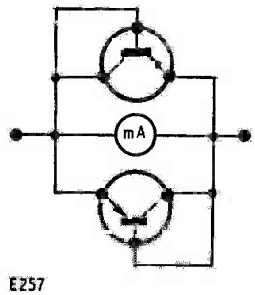
TABLE II

Meter Reading (% of f.s.d.)	Actual Voltage	Effective f.s.d.
0	0	—
10	6.9	69.0
20	15.9	79.5
30	27.6	92.0
40	43.8	109.5
50	61.5	123.0
60	91.2	152.0
70	123.0	175.7
80	169.2	211.5
90	228.0	253.3
100	300.0	300.0

from this table that low voltages can be read almost as easily as high voltages.

Temperature Effects

The most important effect of temperature is change in I_{co} which, in the grounded emitter configuration, is multiplied by α'. However, the transistor is acting here in grounded base. Moreover, I_{co} does not pass because the collector junction is not reverse biased. As a result of these points, the temperature effect on the combination of meter and transistor becomes negligible.



E257

Alternative Values

Table III shows the results given with $R_c=0$ and $R_m=1.8k\Omega$, using the circuit of Fig. 1. The shunt current increases with decrease of R_c and increase of R_m. The maximum current that can be passed depends on the transistor; thus, an OC71 can pass 10mA and an OC72 120mA.[1]

Another use for the transistor shunt is shown in Fig. 3. In this instance two transistors are employed with a centre-zero meter. Reverse voltage applied to either transistor merely causes its base-emitter junction to be reverse-biased, and the transistor does not suffer damage thereby.

TABLE III

Meter Reading (% of f.s.d.)	Actual Current (μA)
0	0
10	35
20	90
30	185
40	340
50	595
60	1,035
70	1,650
80	2,550
90	3,750
100	5,300

[1] These figures apply, approximately, to the maximum rated collector currents for these two transistors, whilst maximum base currents are 2 and 20mA respectively. Unless base current in the variable shunt can be ascertained, it might be safer to work to base current limits rather than collector current limits.—*Editor.*

LIGHT-BEAM TRANSMITTER-RECEIVER

by J. EMMETT

Speech and music may be transmitted over a beam of light without interconnecting wire or a radio frequency link. In this article, our contributor describes a particularly successful light-beam transmitter-receiver which he has designed and built himself.

TRANSMISSION OF AUDIO FREQUENCIES VIA A BEAM of light has been, for some time, the subject of experiments by the writer. With the advent of the phototransistor suitable transmitters and receivers become a feasible proposition, and the writer has had his greatest success with the transmitter-receiver described in this article. The good results obtained have been partially due to the fact that both the transmitting bulb and the receiving phototransistor are fitted into a lens system which provides a closely aligned beam. Despite the fact that a bulb rated only at 5.5 volts and 0.3 amps is employed, reliable communication has been obtained at distances in excess of 400 yards.

The transmitter-receiver incorporates a standard transistor amplifier which operates both whilst transmitting and receiving. When transmitting, a microphone is coupled to the input terminals of this amplifier. The a.f. output of the amplifier then modulates the light from the bulb, the output being superimposed on an adjustable direct current which flows through its filament. When receiving, a phototransistor feeds a transistor pre-amplifier, the output of which is fed to the main amplifier. The latter then drives the loudspeaker.

The Circuit

The circuit of the transmitter-receiver is given in Fig. 1. In this diagram, switches S_2 to S_5 are ganged, providing "Transmit" on Position 1, and "Receive" on Position 2.

When S_{2-5} is set to Position 1, the phototransistor and pre-amplifier are switched out of circuit and the microphone is coupled to the volume control

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R_{10}, the slider of which connects to the input of the main amplifier. This latter employs the line-up, OC71, OC81D and two OC81's, and offers an output of 500mW or more. It was obtained as a kit from Henry's Radio Ltd.

The output of the main amplifier is passed, via S_4, to the 1 : 3 transformer T_1, the secondary of this transformer being connected in series with the transmitting bulb. The direct current flowing through the bulb is controlled by R_{12}. The amplified microphone signal modulates the bulb current and, in consequence, its illumination.

On "Receive" (S_{2-5} in Position 2) the power supply is passed, via S_2, to transistors TR_1 and TR_2. TR_1 is a phototransistor, and it is biased by means of potentiometer R_2. The choke in the base circuit of TR_1 allows d.c. due to steady light to pass to earth and eradicates frequent readjustments in R_2. These were necessary in earlier versions where the choke was omitted. The collector current in TR_1 varies according to the modulation of the light by which it is illuminated, and this electrode is coupled to TR_2 via C_1. TR_2 amplifies in normal manner, the signal on its collector being fed, via R_9 and the volume control R_{10}, to the main amplifier. The output of the latter connects, via S_4, to the loudspeaker.

C_4 and R_{11} form a tone-adjusting circuit, and are not essential to the operation of the transmitter-receiver. If desired, they may be omitted.

Components

There are a number of important points concerning the components used in the transmitter-receiver, and these will now be dealt with.

An OCP71 phototransistor is recommended for the TR_1 position, although it should be pointed out that the writer has obtained equivalent results with "surplus" phototransistors obtained, at much lower cost, from Henry's Radio Ltd. An OC71 with the protective paint scraped away (see Fig. 2) could be used, but it has been found that the more recent versions of the OC71 are opaque and cannot therefore be employed for this application.

The choke in the base circuit of TR_1, is experimental. It may be necessary to employ a component

Components List

Resistors (all fixed resistors ¼W 10%)
- R_1 150kΩ
- R_2 25kΩ potentiometer, pre-set
- R_3 10kΩ
- R_4 680Ω
- R_5 56kΩ
- R_6 10kΩ
- R_7 6.8kΩ
- R_8 680Ω
- R_9 3.3kΩ
- R_{10} 5kΩ potentiometer (with switch)
- R_{11} 50kΩ potentiometer, pre-set
- R_{12} 50Ω potentiometer, 2W

Capacitors
- C_1 0.5μF
- C_2 50μF 6V wkg electrolytic
- C_3 50μF 6V wkg electrolytic
- C_4 0.04μF
- C_5 100μF 12V wkg electrolytic

Transistors
- TR_1 OCP71 (see text)
- TR_2 GET106, OC200 (see text)

Inductors
- CH_1 Choke, 2 to 20H (see text)
- T_1 Transformer, ratio 1:3 (see text)

Switches
- S_1 On-off. Ganged to R_{10}
- S_{2-5} 4-pole 2-way wafer (see text)

Other Components
- Bulb—pre-focus 5.5V, 0.3A
- Speaker—3Ω
- Microphone—surplus magnetic insert, 2kΩ impedance (Electronic Precision Equipment Ltd.)
- Main amplifier—OC71, OC81D, 2 X OC81, 3Ω output (Kit from Henry's Radio Ltd.)
- Lenses—as required (see text)
- Red celluloid filter

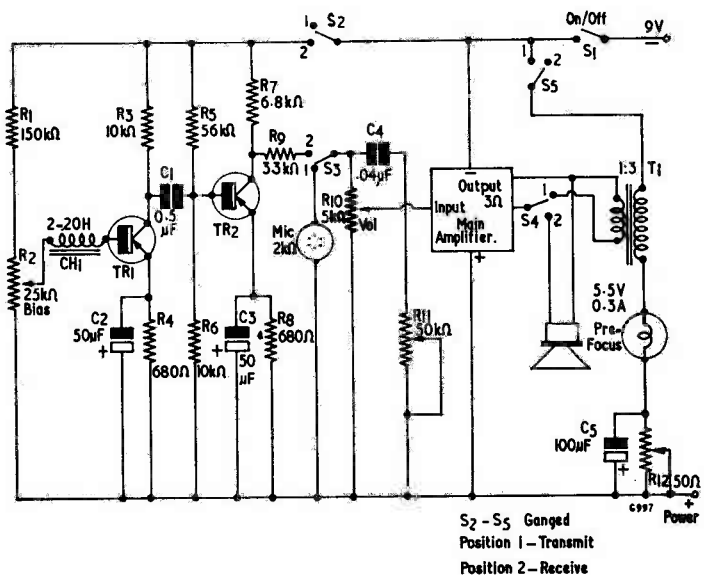

Fig. 1. The circuit of the transmitter-receiver

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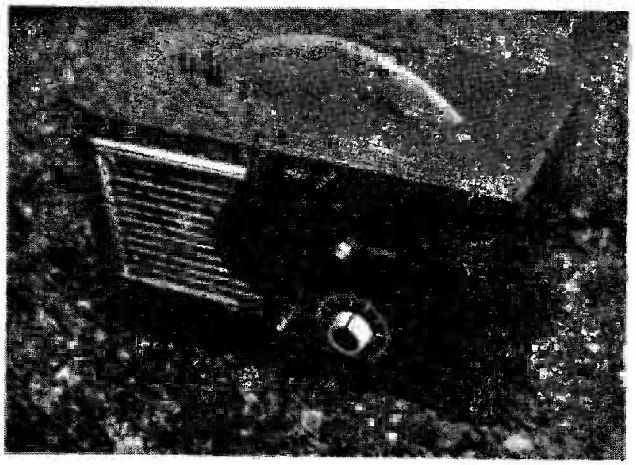

The complete transmitter- receiver in its cabinet

of different inductance when finally setting up.

TR_2 may be a GET106, or a silicon transistor such as the OC200. An OC71 has been tried in this position, but it caused background hiss to be excessive.

The microphone is a magnetic insert of low-medium impedance (2kΩ), and is a surplus type available from Electronic Precision Equipment Ltd.

Transformer T_1 is home-constructed, and is made up in the following manner. Obtain a single-ended speaker transformer capable of handling 5 watts or more and with the 3Ω secondary winding on the inside. Remove its laminations. Next, remove the primary and determine the number of turns on the 3Ω winding. Wind on three times as many turns with 26 s.w.g. enamelled wire and put a layer of tape on top. Replace the laminations. These should previously have been butt-assembled (i.e. all the "E" laminations on one side and all the "I" laminations on the other) and they should now be re-fitted in the same manner. If a spacer consisting of thin card or paper was previously interposed between the two sets of laminations this should also be re-fitted. These precautions ensure that the steady direct current which flows through the new winding on "Transmit" does not saturate the laminations. The previous 3Ω winding now connects to the output of the main amplifier via S_4, and the new winding is inserted in the bulb circuit.

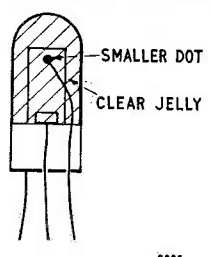

Fig. 2. The light-sensitive section of a non-opaque OC71

If desired, suitable laminations can be bought, in which case winding details are as follows:

Wind a layer of tape on the core.

Wind on 30 turns of 26 s.w.g. enamelled wire.

Add a further layer of tape.

Wind on 90 turns of 26 s.w.g. enamelled wire.

This method of construction is relatively cheap and simple, but it is desirable to employ a core at least as big as that for an 8 watt audio transformer.

The transmitting bulb needs to be a type drawing a low current and having a small filament. If the filament is too heavy, all the higher frequency modulation will be cut off. With bulbs such as are used in cycle head-lamps it is possible to see the filament cooling after switching off, and these are of no use for the present application. The writer found that best results were obtained with a pre-focus torch bulb rated at 5.5 volts 0.3 amps.

Resistor R_{12} regulates the direct current flowing through the bulb. It needs to be rated at 2 watts or more.

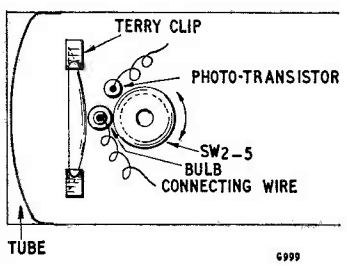

Fig. 3. The lens assembly, showing how the bulb and phototransistor are fitted to an extension of the Transmit-Receive switch

The battery required for the transmitter-receiver has to be capable of providing adequate current for relatively long periods. The PP types are of no use here because of their high internal resistance. Mercury cells or double life pen-cells are cheapest, whilst small nickel-cadmium cells (DEAC units) or accumulators are preferred.*

The Focus Unit

The focus unit comprises a Paxolin or cardboard tube some 3in long, in which are fitted one or a pair of enlarger condenser lenses. Two such lenses are shown in Fig. 3, and it is their function to create as narrow a beam as possible. The smaller lens is closer to the bulb, and the prototype employs a 2in type and a 3½in type with ¾in spacing between them. Optical condenser lenses can be obtained from most photographic dealers and a 2in diameter, 4in focus, lens costs around 11s. 6d. However, *moulded* 2in types are sometimes available much

* DEAC cells are available from G. A. Stanley Palmer and Co. Ltd., Maxwell House, Arundel Street, London, W.C.2.—*Editor.*

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cheaper, at prices around 2s. each. The constructor is advised to check with photographic supply sources in order to obtain suitable lenses at reasonable cost.

A common lens system is employed for both the bulb and the photo-transistor, the latter two components being mounted on an extension of the spindle for S_{2-5}. This arrangement causes the bulb or the phototransistor to be moved to the focal point of the system as applicable, whenever "Transmit" or "Receive" is selected.

A piece of red celluloid (available from most model shops) may be placed over the open end of the tube in order to improve selectivity. This it does by acting as a filter and reducing the light spectrum passed to the phototransistor. The red celluloid clears the buzz given when incident light from mains-operated lamps falls on to the focus tube.

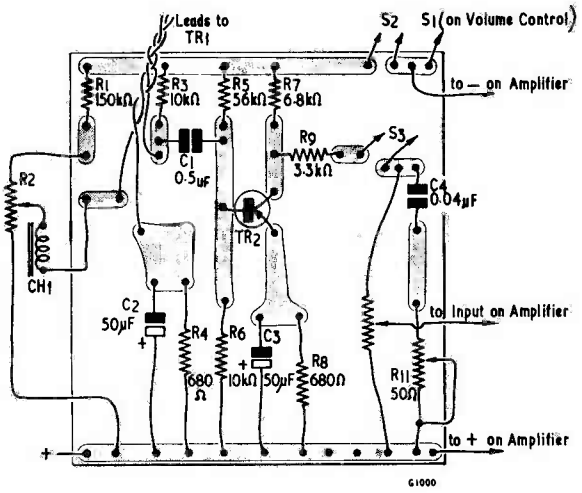

Fig. 4. A suitable printed circuit layout for the phototransistor and pre-amplifier stages

Assembly

The completed transmitter-receiver was fitted in a light-tight cabinet measuring approximately 9 x 4 x 4in. The speaker and microphone should be mounted behind a grille. The volume control and on-off switch, the Transmit-Receive switch, and the power control (R_{12}) should be fitted on the side of the cabinet. The bias and tone controls, R_2 and R_{11}, are pre-set, and may be mounted inside. A larger case, 11 x 4 x 4in would be better, as this would enable large batteries to be carried.

If desired, the components associated with TR_1 and TR_2 may be fitted to a printed circuit board. A suitable design is shown in Fig. 4.

Testing and Setting Up

After the transmitter-receiver has been completed and the wiring carefully checked, it requires to be set up. Before switching on, the controls should be adjusted in the following manner.

Bias (R_2): one-third to one-half from positive end.

Tone (R_{11}): half way.

Power (R_{12}): near positive end.

Select "Receive," switch on and turn up the volume. Face the unit (without the red celluloid filter) towards a mains-operated lamp. If there is no 100 c/s buzz, there may be no light falling on the sensitive area of the phototransistor. Other possibilities are that the inductance of the choke in the base circuit of TR_1 is too low, or that the bias control needs adjusting.

Switch to "Transmit" and turn up the power control until the bulb glows. Keep volume at a low level at this stage. This is because it is possible to burn out the bulb by speaking near the microphone if a high volume level has been selected when the bulb is bright. Aim the set at a wall, preferably in the dark, and adjust the position of one lens (or both, if necessary) until a bright image of the filament is seen. This procedure should then be repeated as far away from the wall as possible. A distance of 15ft is suitable.

A torch should next be positioned so that it shines towards the set and is in the centre of the beam from the transmitting bulb. Switch to "Receive" and position the phototransistor so that its sensitive area is in the focus from the torch beam.

Finally, set the power control to cause approximately 3.7 volts d.c. to appear across the bulb. It is not possible to see the modulation of the light from the transmitting bulb, but it should flicker when the microphone is tapped.

Results with the Prototype

The prototype has been tested up to a distance greater than 400 yards and there has been hardly any loss. However, aiming is critical, as is to be

The extension on the Transmit- Receive switch

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be expected considering the narrow beam width. Different versions will vary but, by careful adjustment of the lens system, it should always be possible to receive if the transmitting light is visible. If the transmitter-receiver is used during the day, when there is no risk of 100 c/s buzz from mains-operated lamps, the red celluloid filter can be removed with a consequent increase in power.

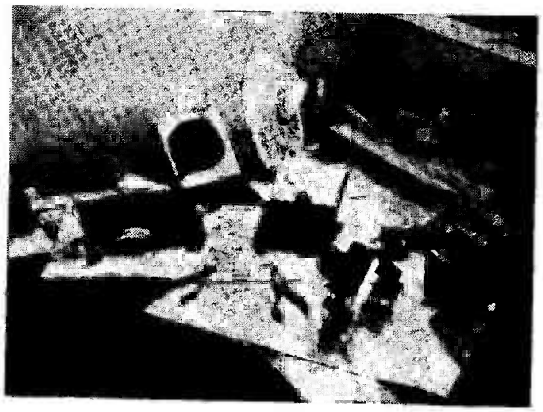
In addition to speech, music has also been transmitted. This has been subject to loss of treble, which has been easily corrected by adjustment of the tone control.

TRADE REVIEW . . .

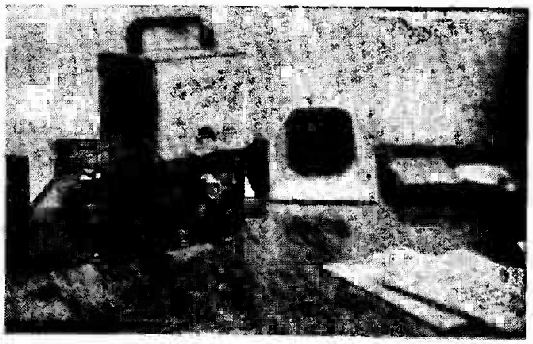
Heathkit Valve Millivoltmeter Model AV-3U

OF THE NUMEROUS KITS WHICH DAYSTROM LTD. now market in this country, those for the construction of laboratory equipment are possibly of even more interest to the radio constructor than the more conventional equipment such as audio amplifiers, amateur radio transmitters, etc. Whilst this latter type of equipment can be assembled from scratch by purchasing the required components, few laboratory instruments can be made up in this manner. It is by making use of the Heathkit range that the "do-it-yourself" constructor of electronic equipment can provide himself with a selection of such test instruments—and at a price within his reach.

An example of this occurred recently. An instrument was required which would measure a.c. voltages over a wide range of frequencies, the particular job in hand being that of assembling some audio filters for a RTTY terminal unit. This type of millivoltmeter is not easily borrowed, and even though it was likely to be put to quite a lot of use during the course of time, the cost of purchasing such an instrument would not have been justified. Fortunately, Daystrom Ltd. have such an instrument available in kit form—the Millivoltmeter Model AV-3U.



. . . once a start was made, rapid progress resulted . . .



The completed Heathkit Valve Millivoltmeter

The writer had already some experience of assembling Heathkit equipment. The detailed sted by step instructions and the foolproof designs have always resulted in the equipment being pleasureable and interesting to build and they have always worked right from the initial switching on. It was with some trepidation however that the construction of this laboratory type instrument commenced.

The kit arrived extremely well packed and a preliminary check revealed that all the components were enclosed and undamaged. A general idea of the principles of the instrument and the sequence of assembly was soon obtained from a perusal of the Instruction Manual and once a start was made, rapid progress resulted—thanks to the well thought out sequence of construction. No snags were met at any time, though some of the assembly stages have to be carried out with due care and attention to ensure that no wrong connections are made, such for instance as the assembly of the range switch.

The instrument was completed in two or three evenings of spare time and needless to say it worked right from the word go! Now the proud possessor of an audio type millivoltmeter, which has already proved its usefulness in more ways than expected, the writer confidently recommends the Heathkit range of kits to fellow readers.

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1-Valve T.R.F. Receiver Using a 12AT7

By I. K. Gurney

The simple receiver described in this article has the advantages of extreme simplicity and low cost. Some of the success with the prototype may be due to the fact that the components and layout employed provide regeneration and, hence, an improvement in sensitivity and selectivity. It must be pointed out that regeneration may not similarly occur in other receivers built to the same circuit and layout.—Editor.

SOME TIME AGO AN APPEAL FOR A small radio set from one of the more aged of the community was met by the author. The receiver which was finally constructed is described here.

Since the author does not have an unlimited supply of money and time it was decided that a t.r.f. set must suffice. As the public are critical of any receiver which does not give a professional performance, it seemed doubtful at first whether a t.r.f. would perform to the necessary standard. Nevertheless, design commenced with the requirement of adequate selectivity being kept well in mind. It was felt that sensitivity was less important in this instance provided, of course, that the local B.B.C. transmitters could be received at good strength. Conventional parts were employed, and the utmost use was made of the spares box.

The Circuit

The circuit of the receiver is given in Fig. 1. Reception is on medium and long waves and the use of separate r.f. transformers, one for each band, results in an enhanced performance. The long waveband was included because of varying reception strength of the medium wave Light Programme transmission. VR_1 adjusts volume, and it functions also as a reaction control. There is no deliberate regeneration circuit in the receiver, and the necessary feedback is provided mainly by random coupling between the speaker transformer and the aerial coils. The presence of this coupling was checked with the prototype by placing an earthed screen between the transformer and the coils, reaction ceasing when the screen was present. Reversing the leads to the speaker transformer primary had no effect on regeneration with the prototype, although this could occur with other receivers employing the same circuit and layout.

A measure of negative feedback for the output triode is given by R_4. C_3 provides top-cut, and causes the output to have an acceptable tone.

The power supply is quite conventional, employing an inexpensive mains transformer having an isolated single-phase h.t. winding. The chassis of the receiver is, in consequence, isolated from the mains supply.

Components List

Resistors (all ½W unless otherwise stated)

R_1	1MΩ
R_2	1MΩ
R_3	22kΩ
R_4	3.3MΩ
R_5	200Ω
R_6	1.5 to 2kΩ 2 watts
VR_1	500kΩ potentiometer, log track

Capacitors

C_1	100pF
C_2	0.001 to 0.01μF
C_3	0.01μF
C_4	50μF, 12 w.v. electrolytic
C_5, C_6	16+16μF, 275 w.v. electrolytic
VC_1	500pF variable, solid dielectric
VC_2	See text

Coils and Transformers

L_1, L_2	See text
T_1	Mains transformer. Secondaries: 220V at 20mA, 6.3V at 0.3A minimum
T_2	Speaker transformer. Ratio approx. 65:1

Valve

$V_{1(a)\ (b)}$ 12AT7, ECC81

Rectifier

MR_1 Metal or contact-cooled, 220V at 20mA

Switches

$S_{1(a)\ (b)}$	d.p.d.t. wavechange
S_2	s.p.s.t. on/off

Speaker

3Ω impedance

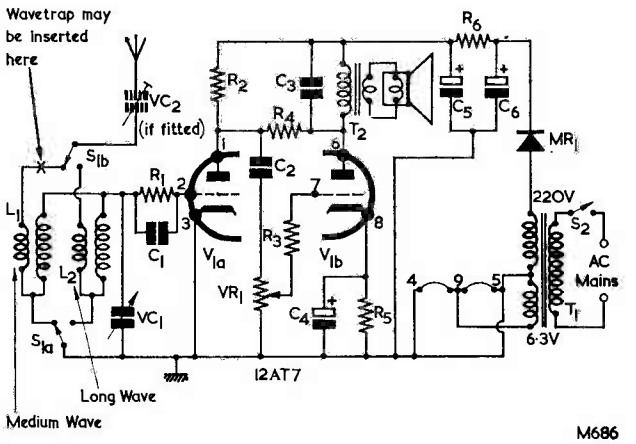

Fig. 1. Circuit of the receiver. VC_2 is required only for long aerials

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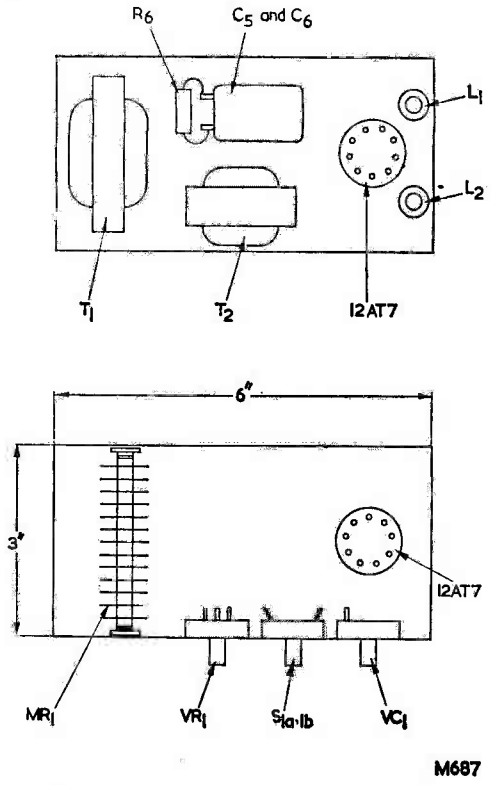

Fig. 2. The positions of the principal components

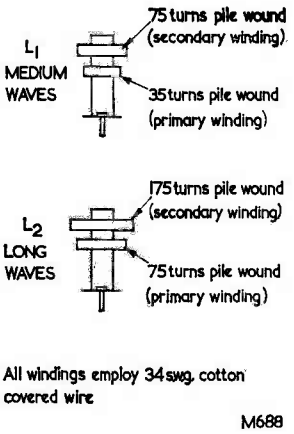

Fig. 3. Coil winding details

Construction

The receiver was constructed on a small aluminium chassis 6in wide by 3in deep. Fig. 2 illustrates the positions of the main components above and below the chassis, wiring between these following normal commonsense practice. The valve projects above the chassis and is not screened. A large metal rectifier is shown in Fig. 2 but this may be replaced by a small contact-cooled component if desired. None of the wiring was found to be critical, but it is necessary that all leads to the grid of $V_{1(a)}$ be kept short. Failure to observe this precaution may result in quite a considerable loss of efficiency.

The coils for the prototype were wound on $\frac{3}{8}$in diameter formers as shown in Fig. 3. If the constructor does not wish to wind his own, the Wearite coils type PHF1 and PHF2 would fulfil the job equally well.

Final Points

After all wiring has been carefully checked the set can be switched on. With the prototype it was found that a whistle was evident when VR_1 was advanced to maximum. Optimum volume was then given when a station was tuned in and VR_1 adjusted just below the oscillation point.* The set should then be tried out, using the aerial with which it will be in permanent use. The best length is around 20 to 30 feet, although good results with a shorter length or with a "bed-springs" aerial can be obtained. If the aerial is longer than 30 feet, a series capacitor should be inserted in the VC_2 position, as shown in Fig. 2. VC_2 should be adjusted for greatest signal strength commensurate with selectivity, and it is unlikely that a value in excess of 200pF will be needed.

If a local station causes interference on medium waves, a wavetrap may be inserted at the point indicated in Fig. 1. A suitable wavetrap consists of a coil paralleled by a trimmer as in Fig. 4. For wavelengths between 300 and 500 metres, the coil can consist of 50 turns of 34 s.w.g. cotton covered wire pile-wound on a $\frac{3}{16}$in dowel, and the trimmer may have a maximum value of some 450pF.

The receiver has been used in the Midlands and in London, and has given a good account of itself in both instances.

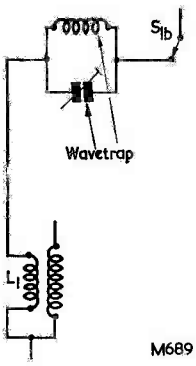

Fig. 4. How a wavetrap may be connected into circuit

* As was pointed out in the introduction, this condition may not be attained in other receivers employing the same circuit and layout.—EDITOR.

THE "CRYSTELLA" FM TUNER—CORRECTION

In the Components List for Fig. 1 (page 519, February issue) the de-emphasis resistor R_{20} was specified as 47Ω. The correct value for this component is 47kΩ.

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Some U.H.F. Amplifier Circuits

AS TIME PASSES, MORE AND MORE CONSTRUCTORS become interested in the ultra high frequency section of the radio spectrum. However, one of the greatest difficulties associated with u.h.f. reception is that of obtaining satisfactory low noise amplification at the frequencies used. Difficulties arise when ordinary grounded cathode pentode circuits are used above about 100 Mc/s, as poor noise factors are obtained. The constructor will usually have to choose between a grounded grid amplifier and a cascode r.f. stage, but u.h.f. transistor circuits are now becoming more common. It is unfortunate that transistors for use above 1,000 Mc/s are still priced at a figure which is greater than most amateur constructors care to pay.

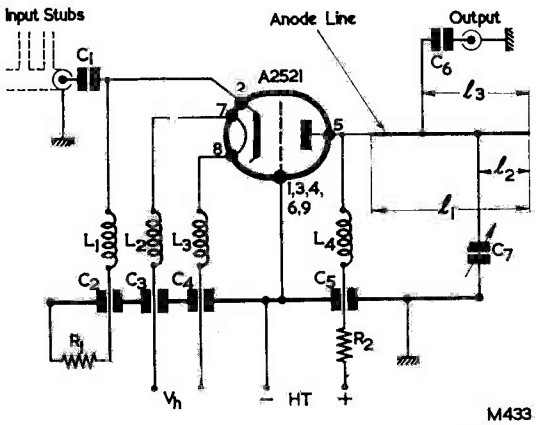


Fig. 1. Circuit of the 400 Mc/s low noise amplifier

Components List
(Fig. 1)

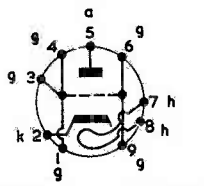
L_{1-4} 15 turns 26 s.w.g. enamelled copper wire $\frac{3}{16}$in i.d. air-cored
R_1 68Ω
R_2 3.3kΩ
C_1, C_6 100pF
C_{2-5} 1,000pF feedthrough
C_7 3–10pF concentric trimmer

Anode Line
l_1 18.3cm
l_2 5.6cm
l_3 10.2cm

Valve Circuits

Valve Used

A number of u.h.f. amplifier circuits are given in Figs. 1 to 6 using the A2521 valve which is manufactured by the M-O Valve Company Ltd. and which has a mutual conductance of about 15mA/volt. The circuits are for use at 400 Mc/s, 900 Mc/s and 1,250 Mc/s, but any intermediate value of operating frequency can be obtained by appropriate scaling of the length of the tuned lines.



The A2521 is intended for use as a grounded grid low noise r.f. amplifier at frequencies up to about 1,250 Mc/s. It has a B9A base and its heater rating is 6.3 volts at 0.3 amp. The CV2453 has similar characteristics to the A2521, but its heater rating is 6.3 volts at 0.37 amp. The pin connections and operating conditions of the A2521 valve are shown in the Table.

The circuits shown use the "trough line" technique which enables the tapping points on the tuned line

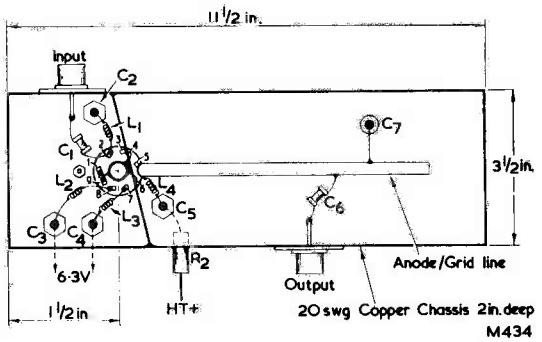


Fig. 2. Layout of the 400 Mc/s low noise amplifier

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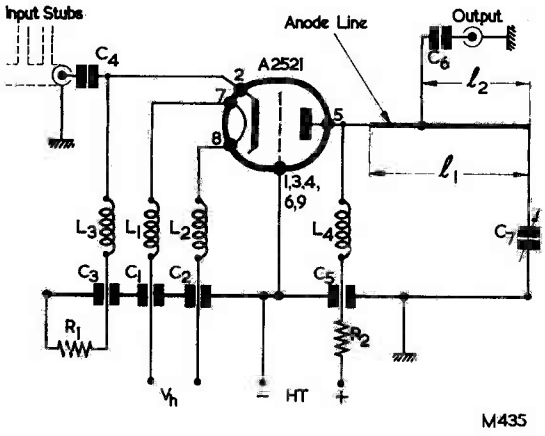

Fig. 3. Circuit of the 900 Mc/s low noise amplifier

Components List
(Fig. 3)

L_{1-4} 15 turns 24 s.w.g. enamelled copper wire $\frac{1}{8}$in i.d. air-cored
R_1 68Ω
R_2 3.3kΩ
$C_{1-3, 5}$ 1,000pF feedthrough
C_4 680pF
C_6 47pF
C_7 3–9pF ceramic trimmer

Anode Line
l_1 5.5cm
l_2 2.8cm

to be easily adjusted. The copper lines are mounted in a trough or chassis of copper or brass about $1\frac{1}{2}$in deep. The size of this chassis depends on the frequency of operation.

The tuned line is made of $\frac{1}{8}$in diameter copper rod mounted $\frac{1}{4}$in above the base of the chassis. One end of the line is soldered directly to the anode pin of the valveholder and the remote end is either short-circuited to the chassis or mounted on a small tuning capacitor depending on whether three-quarter wavelength or half wavelength lines are used.

Fairly similar circuits using coils instead of tuned lines can be constructed for use at frequencies up to at least 300 Mc/s, but above this frequency the small size of the coils required causes difficulties.

Operation of the A2521 as a Class A Grounded Grid Amplifier

Frequency	1,250	900	400	200 Mc/s
H.T. supply	180	180	180	180 volts
Anode current	16	16	16	16mA
Bandwidth (±3dB)	20	50	6	4 Mc/s
Power gain	9	10	17	14.5 dB
Noise factor*	11.1	9.5	6.7	4.6 dB
Noise factor†	—	12.6	8.0	4.6 dB

** Measured with a gas discharge noise source.*
† Measured with a coaxial noise diode source (CV2341) but not applying transit time corrections to the result.
In each case the input circuit was adjusted for minimum noise factor.

Construction

The orientation of the valveholder must be as shown. A transverse metal screen should be placed across the socket and well soldered to the walls of the chassis in order to completely screen the output from the input. All the five grid pins and the centre spigot of the valveholder should be soldered to the centre screen using a wiring jig whilst doing so in order to prevent distortion of the valve pins.

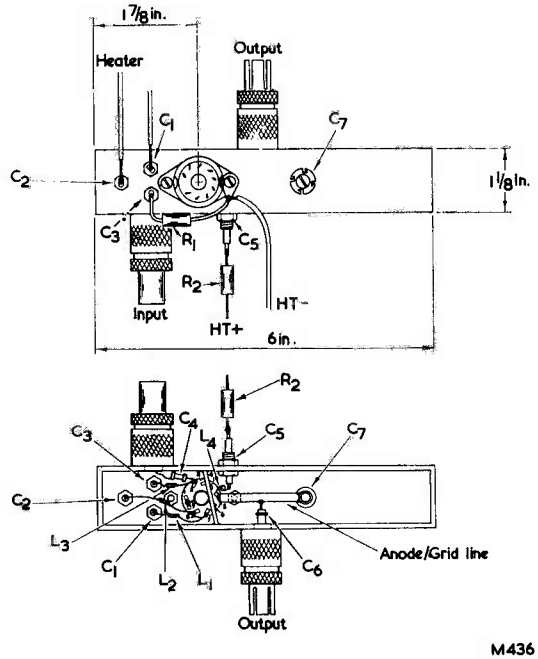

Fig. 4. Layout of the 900 Mc/s low noise amplifier

Coaxial sockets are used for the input and the output connections. All external connections for h.t. heaters and bias are made through chokes and, feedthrough capacitors to the outside of the chassis. A baseplate should be fitted to the chassis to ensure efficient all round screening.

Tap Positions

The input and output impedances can be matched to the required value by varying the positions of the tap along the line. The tap positions shown in the circuits are for output and input impedances of 50Ω and for the bandwidths stated.

400 Mc/s Amplifier

The circuit of a low noise amplifier for use at

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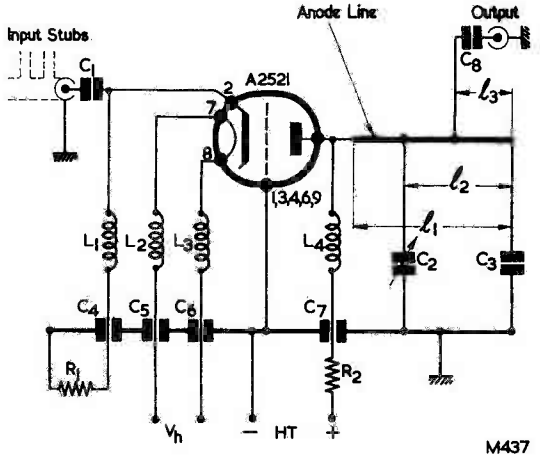

Fig. 5. Circuit of the 1,250 Mc/s low noise amplifier

Components List
(Fig. 5)

L_{1-4} 8cm 26 s.w.g. copper wire on $\frac{1}{8}$in dia. former
R_1 68Ω
R_2 3.3kΩ
C_1, C_8 47pF
C_2 0–5pF ceramic trimmer
C_3 40pF mica spaced capacitor
C_{4-7} 1,000pF feedthrough

Anode Line
l_1 4cm
l_2 2.5cm
l_3 1cm

400 Mc/s is shown in Fig. 1. A half wavelength anode tuned line is used. The h.t. supply required is about 180 volts at 16mA.

The power gain is about 17dB when the input circuit is adjusted for minimum noise factor and the bandwidth is about 6 Mc/s, but both bandwidth and power gain can be adjusted by altering the coupling between the anode circuit and the output line.

A noise factor of 6.7dB was measured with the input circuit adjusted for minimum noise factor when a gas discharge noise source was used. Under the same conditions a noise factor of 8dB was measured using a CV2341 coaxial noise diode source without applying transit time corrections.

The chassis layout diagram is shown in Fig. 2.

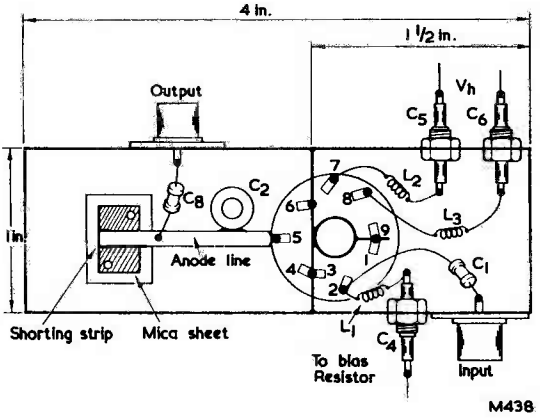

Fig. 6. Layout of the 1,250 Mc/s low noise amplifier

900 Mc/s Amplifier

Fig. 3 shows the circuit of a low noise amplifier for use at about 900 Mc/s. The basic circuit is very similar to that of the 400 Mc/s low noise amplifier, but the chassis can be made much smaller owing to the shorter lengths of resonant lines required. A half wavelength anode line is used. The r.f. output is tapped off the anode line at a point 2.7cms from the anode end and passes through C_6 to the coaxial output socket.

A valveholder employing very low loss insulation such as p.t.f.e. (polytetrafluoroethylene) should be used. The chassis layout diagram is shown in Fig. 4 and it is most important that the transverse screen should fit closely over the valveholder and be soldered in position with tags 4, 5 and 6 in the output compartment. Tags 3 and 4 are soldered directly to the opposite sides of the screen. Tags 1 and 9 are soldered to the socket screening boss and the boss is soldered to the screen as shown in Fig. 4.

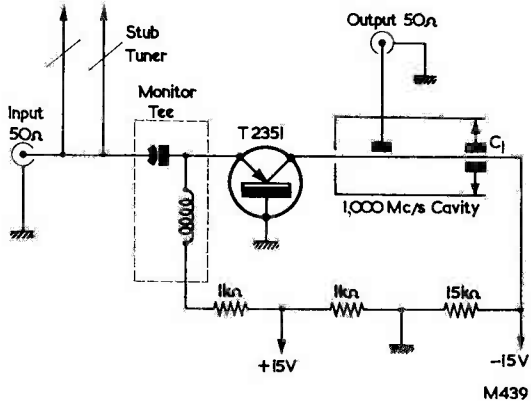

Fig. 7. Circuit of 1,000 Mc/s r.f. amplifier using the Philco T2351 transistor

The power supply is 180 volts h.t. at about 16mA. The bandwidth is about 50 Mc/s and the power gain about 10dB. A noise factor of 9.5dB has been measured using a gas discharge noise source with the input circuit adjusted for minimum noise factor. Under similar conditions a noise factor of 12.6dB was measured using a CV2341 coaxial noise diode without applying corrections for transit time.

1,250 Mc/s Amplifier

The circuit of a 1,250 Mc/s low noise amplifier is shown in Fig. 5. The basic circuit is again very

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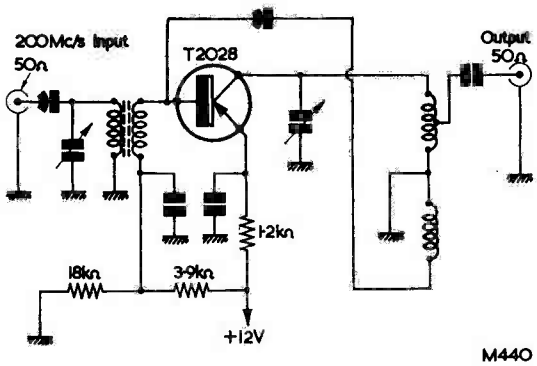

Fig. 8. Circuit of a 200 Mc/s r.f. amplifier employing the Philco T2028 transistor

similar to the two amplifiers already discussed, but a three-quarter wave-length anode tuned line is employed in this circuit. It is connected to the anode pin at one end and is short-circuited to chassis at the other end (as far as r.f. voltages are concerned) by the d.c. isolating capacitor C_3. This capacitor is formed by separating the shorting strip from the chassis with a sheet of 0.005in mica and securing the surfaces with nylon screws. This arrangement gives a capacitance of about 40pF. The chassis layout diagram for the 1,250 Mc/s amplifier is shown in Fig. 6. It can be seen that the chassis used is approximately two-thirds of the size of that used for the 900 Mc/s amplifier described previously.

As in the case of the two amplifiers discussed previously, the anode voltage should be about 180 and the anode current about 16mA. A p.t.f.e. valveholder should be used.

The bandwidth is about 20 Mc/s and the power gain is about 9dB when the input circuit is adjusted for minimum noise factor. The bandwidth and power gain may be adjusted by altering the coupling between the anode circuit and the output line, but a limit is reached when the amplifier becomes unstable.

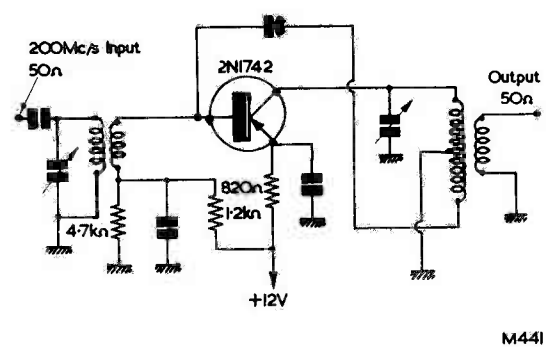

Fig. 9. A 200 Mc/s r.f. amplifier using the Philco 2N1742 transistor

The noise factor was found to be about **11.1dB** when a gas discharge noise source was used and a correction was applied for the noise generated in the second stage of the equipment used.

Amateur Television

Readers may be interested to know that G3KKD/T has received television pictures from G3NOX/T at a distance of about 51 miles and at a frequency of about 430 Mc/s. The r.f. stage employed in the receiver used consisted of a grounded grid A2521 stage similar to that shown in Figs. 1 and 2. A 64-element stack aerial placed 76 feet above the ground was used. This was reported in the *R.S.G.B. Bulletin*, February 1962, page 400.

Transistor Circuits

A 1,000 Mc/s Amplifier

The circuit shown in Fig. 7 is an r.f. amplifier for frequencies of about 1,000 Mc/s using the Philco T2351 coaxial u.h.f. transistor. This is a micro alloy diffused base transistor with a typical maximum operating frequency of about 3,500 Mc/s. The power gain of the circuit shown at 1,000 Mc/s is not less than 8dB and the noise factor is about 8.5dB.

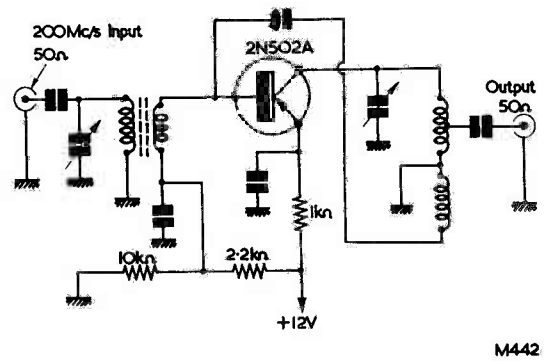

Fig. 10. A 200 Mc/s r.f. amplifier with the Philco 2N502A transistor

200 Mc/s Amplifiers

Three 200 Mc/s r.f. amplifiers are shown in Figs. 8 to 10 inclusive, various Philco transistors being employed in these circuits.

The circuit of Fig. 8 employs a very low noise u.h.f. transistor T2028. The power gain at 200 Mc/s is not less than 16dB and the noise factor is not greater than 4.5dB. This type of circuit is conveniently used with the T2029 transistor as mixer and the T2030 transistor as oscillator at frequencies from 30 to 1,200 Mc/s.

The 200 Mc/s r.f. amplifier shown in Fig. 9 using the 2N1742 transistor provides a power gain of not less than 14dB and a noise factor of 5.5dB. This type of circuit may be combined with the 2N1743 transistor as mixer and the 2N1744 transistor as oscillator for use at frequencies from 30 to 600 Mc/s.

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The circuit of Fig. 10 using the 2N502A transistor provides a power gain of at least 10dB at 200 Mc/s and a noise factor of not more than 7dB. The typical gain of this circuit is 12dB.

All of the transistors used in the 200 Mc/s circuits shown are micro alloy diffused base types.

Acknowledgements

Figs. 1 to 6 inclusive and the accompanying information are taken from A2521 *Application Report*, Issue 1, February 1962, The M-O Valve Co. Ltd., Brook Green, London, W.6.

Figs. 7 to 10 inclusive and the accompanying information are taken from *Philco Semiconductor Short Form Catalog*, January 1962, Philco Corporation, Lansdale Division, Pennsylvania. (Philco International Ltd., 30–32 Gray's Inn Road, London, W.C.1.)

RADIO topics

AT THE TIME OF WRITING THESE notes, this country is looking back somewhat ruefully upon what is generally concluded to have been the worst winter in living memory. Blizzard stories have appeared in almost as great a profusion as blitz stories after the last war. We have also had demonstrated to us, beyond any shadow of doubt, the fact that our present electricity generating system cannot meet the needs of the country when the country needs it most.

The Electric Fire

To a certain effect, one can sympathise with the problems of the Central Electricity Generating Board in this respect, and one would certainly not apportion any blame for the cuts which resulted when, for instance, pylon insulators became encapsulated in great blocks of ice because of freezing fog. Also, so far as generating capacity is concerned, the C.E.G.B. has to continually fight local interests whenever a new power station or a new run of transmission lines has to be added to the system. We must either accept the existence of pylons in the countryside or resign ourselves to a non-expanding system of electricity generation.

The real reason for the widespread power cuts during the bitter weather was, of course, the widespread use of electric fires and other electrical heating equipment. In essence, an electric fire is nothing more than a partial short-circuit connected across the mains supply. The shorting conductor gets red-hot (as it should do when you consider the current which flows through it) and this gives off the heat. Despite this fact, the lay public was not informed in sufficient detail during the crisis that *disproportionately* large currents were being consumed by electric fires. Some actual consumption figures would have helped a great deal here. Many non-technical people were, indeed, under the impression that they were playing their part in saving electricity just as effectively by switching off a 60 watt lamp in the hall as by switching off one bar of an electric fire. They were never told that the electric fire bar consumed as much current as sixteen 60 watt lamps.

In a typical house one might have two rooms in use, each with a 100 watt bulb. Also switched on in one room might be a television receiver (140 watts) and, in the other room, a valve table radio (50 watts). Total consumption then comes to 390 watts. If, however, just one bar of an electric fire (1 kilowatt) is switched on in addition, the consumption jumps to 1,390 watts, which is 3½ times the original figure. Switch on a second bar and consumption hops to 2,390 watts; a figure which is no less than 6½ times the initial consumption.

If the C.E.G.B. cannot meet rising demands for electricity in the future it may be well advised to ease sales pressure on the voracious electric fire. The trouble is that, when the demands of electric fires cause cuts in cold weather, all other electrical services, including domestic and road lighting, railway signalling, and hospital equipment, are left without power as well.

De-Freezing Pipes

An interesting technique which has been developed during the winter has been the thawing out of water pipes by passing an electric current through them. This is, of course, an obvious application, but it needed the Arctic conditions of the early part of this year to provide the necessity which mothers invention.

To thaw out a pipe, connection is made at its two ends and a current is caused to pass. Provided that a metal circuit appears between the two connections, the heating effect of the current then allows a gentle thaw to take place. Pipes fracture at the time of freezing but the breach only becomes apparent when the water thaws, and

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so the electrical technique, in common with any other pipe de-freezing method, does not prevent bursts. On the other hand, it does offer a simple method of thawing out a pipe which is buried below the ground or is situated in a similarly inaccessible place. A suitable low voltage generator or transformer operated from the mains supply would be capable of providing the de-freezing current, and it would seem that this should preferably be alternating in order to reduce the risk of arcs to neighbouring conductors. Obviously, the voltage applied to the pipe must not be connected to earth in any way (apart from the connections to the pipe itself) and, under no circumstances, must there be any direct connection to the electricity mains supply. The electrical de-freezing system cannot be employed if rubber or plastic junctions appear in the pipe circuit.

So far as I can judge from the provincial papers and from what I hear, electrical de-freezing appears to have originated in the West Country and in Wales. The technique is by no means entirely safe and, in this respect, I cannot do better than quote the words of the Chief Fire Officer for Glamorgan, as reported in the *South Wales Evening Post* for 13th February.

"This de-freezing technique has been the cause of two fires in the Glamorgan county area within the last week, and householders are reminded that if this method of de-freezing is misapplied there is a risk of fire and explosion.

"In the de-freezing technique current is passed through a length of frozen water pipe, and heat is generated, causing the pipe to thaw itself out.

"However, in both of the fires in Glamorgan the current followed an unplanned circuit and an arc occurred with nearby gas pipes.

"Escaping gas from the pierced pipes caused fires which could have been far more serious.

"If de-freezing of pipes by electric current is attempted, it should be used only on the underground length of service pipe between the stop tap outside the house and the consumer's stop tap within the premises.

"A.C. equipment, operating at no more than 6 volts and producing 150 amps, is advisable.

"The plumbing and wiring arrangements of the average house are so complex that the best advice for householders who are thinking of trying this technique as an answer to their problems is—leave things in the hands of the experts from the Water Board."

Bursts

With reference to the question of bursts themselves, polythene piping is becoming fairly common for cold water systems these days and, unlike the lead piping it supersedes, is capable of expanding and does not burst. However, I have often felt myself that bursts with lead piping could be completely eradicated by the simple process of changing from a round cross-section to an oval cross-section. If a pipe of round cross-section is sealed (by ice) at its ends, and its contents expand slightly, a fracture must result because the round shape offers the maximum cubic capacity for surface area. If, alternatively, the pipe has an oval cross-section, fracture need not occur. All that then happens is that the expansion causes the oval shape to become slightly rounder.

A Halt In The Desert

Turning, with some relief, to a much warmer climate, the Royal Air Force passes on a tale of the desert in which an unnamed Arab must have suffered far greater discomforture than any pirate television viewer who has been caught out by one of the new G.P.O. detector cars.

During a recent R.A.F. exercise in Libya, a "Sarah" beacon, of the type carried by aircrew, was placed in an isolated spot of the desert. It was then the task of No. 103 Squadron, at El Adem, near Tobruk, to locate the beacon and bring it back.

In the meantime, however, the beacon was spotted by a wandering Arab who must have felt that this interesting little device, which had (like the Desert Lily) apparently popped up from nowhere, could well be the subject of further investigation in the privacy of his tent. In consequence, he bore it home and, doubtless because he had more pressing matters to attend to, concealed it in a flour sack.

Several hours later he was amazed to find a Sycamore helicopter hovering over his tent. The helicopter then landed, and its pilot entered the tent to ask for the beacon back.

Telescopic Masts Displace Aircraft

A news item which also has to do with the Royal Air Force concerns the telescopic masts manufactured by A. N. Clark (Engineers) Ltd. of Ryde, Isle Of Wight. The Clark range of masts is well-known amongst amateur transmitters, and they have the special feature that they are air-operated. They have been used in many parts of the world where it is needed to raise relatively light objects, such as aerials, microphones, television cameras, floodlights and spotlights, quickly and easily to heights up to 80ft above the ground.

This company has now secured an order for fifteen trailer-mounted 70ft masts for the Royal Air Force. These masts will be used for checking aircraft landing beam signal strength and elevation at R.A.F. stations. Up to now, this task has been carried out by the costly use of a test aircraft, in addition to ground personnel.

U.H.F. Transmitters For The B.B.C.

The introduction of 625 line television in Bands IV and V approaches, and the B.B.C. is already ordering the equipment required for the new transmitting stations. A contract valued at approximately £650,000 has, for instance, been placed with Marconi's Wireless Telegraph Company for twelve transmitters of new design, together with the ancillary equipment.

Each of the Marconi transmitters consists of a vision and sound driving unit type BD463 and a vision and sound amplifier type BD378. The outputs of the BD463 at vision and sound radiated frequencies is 100 and 12 watts respectively, and the corresponding outputs from the BD378 are 25 and 5 kilowatts.

In the BD463 driving unit, the vision r.f. signal is derived from a crystal controlled transistorised oscillator which has the crystal and the first oscillator stages mounted in a temperature-controlled oven. Oscillator output is 1 watt in the range 14 to 28 Mc/s, this representing one thirty-second of the radiated vision frequency. The oscillator is followed by a low power multiplier unit which provides one output at a quarter of radiated vision frequency and another, for use by the sound mixer circuits, at one sixteenth. The first of these outputs drives four grounded-grid stages, the first two of which are doublers and the remaining two amplifiers. The resultant signal is 12 watts at radiated vision frequency, and this is passed to a newly-developed diode modulation circuit which is the subject of a patent application.

The modulated r.f., now at 1 watt peak level, is fed to a further amplifier whose output is split,

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by a hybrid circuit, into two equal components with 90° phase difference. These equal components are amplified separately, then re-combined in a second hybrid circuit to provide a 100 watt signal which is fed directly to a klystron amplifier in the BD378. The quadrature arrangement is employed to ensure that varying input impedances in the klystron do not affect the performance of the preceding amplifier. The output of the klystron feeds the aerial.

On the sound side, the output at one sixteenth of radiated vision frequency given by the low power multiplier unit is processed, by a combination of multiplying and mixing with a frequency modulated signal, to give an output of 12 watts on the sound radiated frequency. This is passed to a second klystron in the BD378 unit, which provides a final output to the aerial of 5 kilowatts. As will be noted, the transmitter employs frequency modulated sound, as is required for the 625 line system.

An important feature of these new transmitters is that, after video modulation, the video r.f. signal passes through a correction unit which ensures that it meets the stringent requirements imposed by colour television.

"Packaged" Control for TV Transmitters

The I.T.A. television transmitter which came into operation recently at Strabane in Northern Ireland is operated entirely by remote control using a new "packaged" control system built by Standard Telephones and Cables Limited. This was supplied through Pye TVT Ltd., who built the transmitter.

This S.T.C. remote control system, priced at about £5,500, has also been supplied for the Marconi television transmitter at Stavanger, Norway. It has been built into the I.T.A.'s Foel Drych station in North Wales to control the Brynchain "boost" transmitter which will be commissioned shortly.

The Selkirk I.T.A. transmitter in Scotland, brought into service recently, is controlled from Carlisle using this S.T.C. system.

The equipment consists of a control desk at the control centre and an apparatus cubicle at the distant transmitter. It provides controls and indications for up to 36 circuit breakers or contactors and a further 36 circuit indications, along with safety alarms.

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FOR SALE. Mullard double-beam oscilloscope type L101, with service manual. £25, o.n.o.—239 Collenswood Road, Stevenage, Herts.

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FOR SALE. AR88D with p.v.c. wiring. £28.—Trow, 28 Prospect Hill, Rawtenstall, Rossendale, Lancs.

FOR SALE. 160 metre Table-Top transmitter, 10 watt, phone and c.w., in polished oak cabinet, 15¼ x 8¼in deep x 8in high. Separate power supply, 250V 50 c/s input. Aerial change-over relay included in Tx, as well as power relays in power supply. A very neat Table-Top unit. £20, o.n.o.—Box No. F 171.

WANTED. Q.S.T. for April 1960.—Langford, 20 Eastlake Avenue, Parkstone, Dorset.

FOR SALE. Smart Creed type 3 teleprinter. Completely overhauled, many new parts, including keyboard. A.C. motor, 250V, 50 c/s, suppressed. Black matt silence cover. £10, plus carriage.—Box No. F172.

FOR SALE. R1155B with built-in output stage, £5. Q-fiver Command receiver, £3. Power supply (mains) 250V, 100mA, £2. Goodmans Axiom speaker, £5.—Goodwin, "Aynhoe", Darvil Road, Ropley, Hampshire.

WANTED. Reflectograph Model 400 or Model D or E. Ferrograph or Vortexion considered. Manual for Reflectograph 500 required. Please state model, make and price.—B. K. Kelly, 56 Kingsway, Waterloo, Liverpool 22.

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1L4	3/–	10D2	11/8	DK92	8/6	EM81	9/6	U18/20	8/6	v. at ½ amp.
1LD5	5/–	10F1	10/–	DK96	8/6	EM84	10/6	U19	48/6	No larger
1LN5	5/–	10P13	15/–	DL66	17/6	EM85	16/10	U22	8/–	than a shirt
1N5GT	10/6	10P14	18/9	DL68	15/–	EN31	71/–	U24	29/1	button!
1R5	5/6	12A6	5/–	DL96	7/–	EY51	7/6	U25	15/9	8/– each.
1S4	9/–	12AC6	14/11	DL510	10/6	EY83	16/2	U26	9/–	
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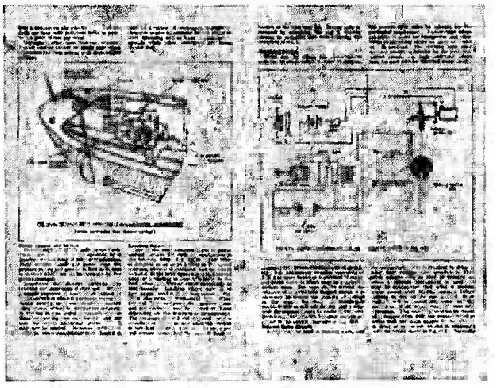

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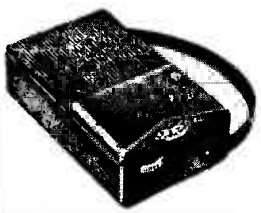

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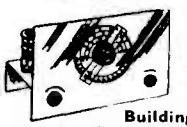

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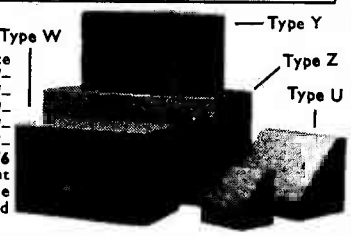

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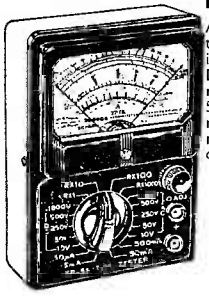

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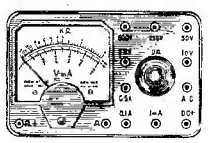

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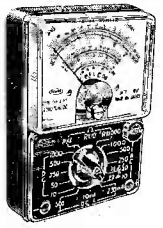

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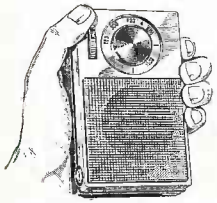

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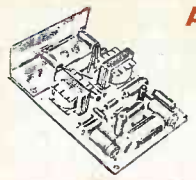
Order Now! New design 7-transistor amplifier and pre-amplifier. Separate treble, volume and bass controls. Small size, excellent quality.

£5.10.0 P.P. 2/–.

¾ Watt 4 Transistor Amplifier



- Improved Version
- 1½ watt peak output.
- ± 3dB 70c/s to 12 kc/s.
- Output to 3 ohm speaker
- 9 volt operated.

Built and Tested	Kit of Parts
59/6 OR	**52/6**
P.P. 1/6	P.P. 1/6

Details on request

RUN YOUR RADIO OR AMPLIFIER FROM MAINS BATTERY ELIMINATORS AND CHARGERS

1. For PP3 or equivalent 9 volt Pocket Radio Battery, **18/6**, P.P. 1/–.
2. For PP4, PP7, PP9, PP10, 9 volt Portable Radio and Equipment Supplies up to 300mA, **49/6**, P.P. 2/–.
3. De Luxe version of No. 1, also charges PP3 type batteries, **29/6**, P.P. 1/–.
4. Rechargeable PP3 battery. Runs as long as 100 batteries. Completed with charger unit, **25/–**. P.P. 1/–.

THE "CONTESSA"

★ **COMBINED PORTABLE AND CAR RADIO** ★

AMAZING SENSITIVITY AND SELECTIVITY ON MEDIUM AND LONG WAVEBANDS

★ The easiest Superhet Radio to build on the market. Features clearly marked printed circuit and packaged components with full illustrated building instructions. Full tuning of medium and long wave bands with unbeatable sensitivity and selectivity. Excellent tone and volume with over 600mW push-pull output.

★ Clearly marked horizontal station dial with slow motion tuning. Two-colour blue or beige cabinets with gold handles, grilles and fittings. Size 10¾" x 7¾" x 3⅜". Include car aerial socket, recording sockets.

★ 6 Mullard Transistors and 2 Diodes.

Guaranteed the Best Obtainable

TOTAL COST

£9.19.6 P.P. 3/6

NO EXTRAS TO BUY

★ **Attractive Appearance—Reliable Design—Quality Performance** ★

UNBEATABLE FOR QUALITY AND VALUE

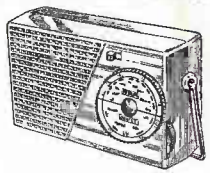
Fully Detailed and Illustrated Leaflet on request

"MINIRANGER"

3-Transistor plus 2 Diodes. Smallest radio to build yourself. Printed circuit, full tuning. **ONLY** 3" x 2" x ¾". Over 20 stations.

TOTAL COST **49/6** P.P. 1/6

"QUINTET" POCKET RADIO



Size 5¼" x 3" x 1¾" 5-Transistor, plus Diode MW/LW to build.

79/6 P.P. 2/–

BOTH MODELS AS PREVIOUSLY ADVERTISED

★ **ALL PARTS SOLD SEPARATELY BOOKLETS FREE ON REQUEST** ★

BATTERY RECORD PLAYERS

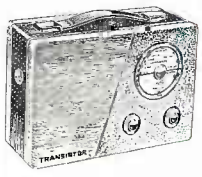
★ 6–7½ volt Garrard turntable with crystal pick-up. Plays 45 r.p.m. Ideal for above amplifier. **55/–** P.P. 1/6

★ Suitable cabinet for amplifier and player, **17/6** P.P. 2/–.

★ G.C. 9 volt 45 r.p.m. and 33 r.p.m. Player, **99/6** P.P. 2/–.

★ B.S.R. 9 volt 4-speed "Hi-Grade" Turntable with turn-over Crystal Pick-up. **£6.5.0** P.P. 2/6.

"TRANSFIVE" PORTABLE RADIO



Total Cost of all Parts

£5.19.6

P.P. 2/6

A 7-stage push-pull output printed circuit portable radio of attractive appearance. Features 5" speaker, clearly marked printed circuit panel, ferrite aerial, carded components and fully detailed and illustrated building instructions. Size 8½" x 6½" x 3½".

★ Plans Free on Request ★

TRANSISTOR ALL WAVE SIGNAL GENERATOR

200 kc/s to 220 Mc/s in 7 switched fully tunable bands. Variable outputs on c.w. Mod. to 2% A.F. output.

£7.10.0 P.P. 2/6

We can supply most of the components specified on circuits published in this and other magazines and books. Let us quote for your circuit. Competitive prices.

REMEMBER—All our transistors and devices are 100% 1st Grade and Fully Guaranteed. We can advise as to the correct type to use. See our new 54-page Catalogue for full lists.

METER BARGAINS

50 Microamp 2" square MC ... **35/–**
1mA 2" square MC **25/–**
1mA 2½" Flush round **30/–**
2⅜" Moving Coil double range Voltmeter centre zero. 30-0-30 and 3-0-3 volts. Ideal for transistor tester or voltage measurements, **12/6**, post free.
0/500 microamp, 2½" flush mounting DC **20/–**
2½-0-2½mA, 2½" flush DC **12/6**
0/40/120mA 2" DC **10/–**
0/15 volt M.I. 2½" FR **8/6**

Miniature Panel Meters

*0/50μA (DC) **39/6** *0/5mA (DC) **27/6**
*0/500μA (DC) **32/6** *0/3004 (DC) **27/6**
*0/1mA (DC) **27/6** Vu Meter **42/6**
"S" Meter **35/–** All Brand New Boxed
* Available Clear Plastic Front or Black Moulded. State which.

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