THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

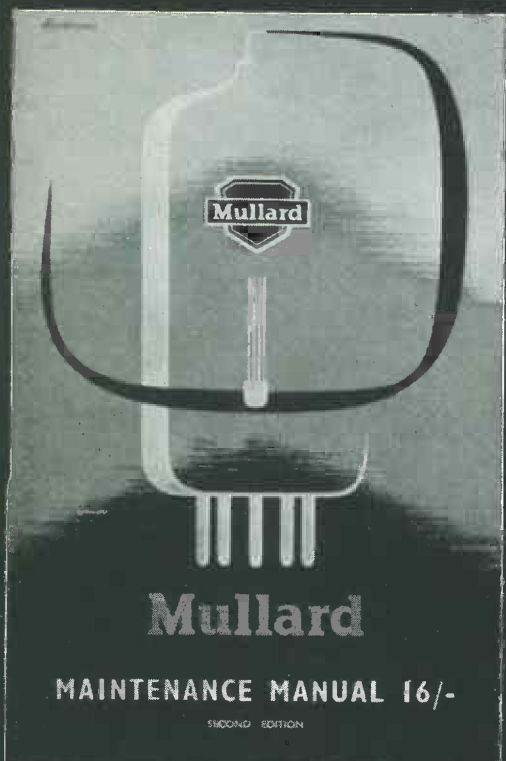
VOLUME 15 NUMBER 9
A DATA PUBLICATION
PRICE TWO SHILLINGS

April 1962

Electronics in Car Servicing

● Telephone Ringing Circuit for Theatrical Use ● Encapsulated Units for the Experimenter ● Easily Constructed Transistor Receiver ● Universal Battery Charger ● The Decibel ● Germanium Tunnelling Devices ● Four Track Conversion for Collaro Tape Decks ● A Linear Scale Resistance-Capacitance Bridge, Part 2 ● Valve Heater Voltages ● Simple Oscilloscope ● Modifying the "Super-3" ● Understanding Radio, Part 8

6 SIX GOOD REASONS WHY YOU NEED THE **NEW EDITION** OF THE Mullard MAINTENANCE MANUAL



1 This is a completely new and up-to-date edition including data on all current replacement valves, semiconductors and cathode ray tubes. It contains valuable new material essential as reference for every Service Engineer.

2 Supplementary data sheets will be issued from time to time to provide data on new types. This service is included in the initial price of 16/-.

3 The binding of this edition is specially designed to allow the supplementary data sheets to be inserted simply and without glueing.

4 The manual contains full data on 178 separate types and the equivalents list of current types provides cross-references to 480 types.

5 All devices are listed in alphabetical order for easy reference.

6 The data on each type has been carefully compiled to supply the information which the Service Engineer is most likely to require, including very clear base diagrams for each type.

Published by Mullard Ltd. U.K. Price 16/-. Get your copy from your radio dealer or order direct from MULLARD LTD., MULLARD HOUSE, TORRINGTON PLACE, LONDON, W.C.1. (Postage and packing 1s. 0d. extra.)

NOTE: A few copies of the previous edition are still available at 10/6d. each (postage and packing 1/- extra).

MVM 4224

Heathkit

DAYSTROM

THE FINEST ELECTRONIC KITS IN THE WORLD

RSW-1

4-WAVEBAND TRANSISTORISED PORTABLE RECEIVER, Model RSW-1. This model possesses Medium, Trawler and two Short-wave bands and is mid-way between the domestic broadcasting and professional general communications receiver. Ideal and inexpensive for those who wish to listen to world broadcasts, shipping and aviation communications. It is not the set to buy if you wish only to enjoy domestic broadcasting. In a handsome leather case, it has retractable whip aerial and socket for car radio use. **£22.10.0**

GL-58

TRANSCRIPTION RECORD PLAYER (STEREO). Manufactured by Goldring-Lenco. This 4-speed unit is fitted with a G60 pick-up arm. Infinitely variable speed adjustment from 33⅓ to 80 r.p.m. Fixed speed of 16 r.p.m. Its balanced turntable (3½ lb) reduces rumble, wow and flutter to very low level. The unique lowering device fitted provides absolutely safe means of placing pick-up on record **£20.12.0**

TA-1M

5" OSCILLOSCOPE. Model O-12U. Has wide-band amplifiers, essential for TV servicing, FM alignment, etc. Vertical frequency response 3 c/s to over 5 Mc/s, without extra switching T/B covers 10 c/s to 500 kc/s in 5 ranges. **£36.10.0**

DECADE CAPACITOR Model DC-1. Capacity values 100μμF to 0.111μF in 100μμF steps. **£6.5.6**

O-12U

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0.1%, 10V sine wave output metered in volts and dB's. **£19.19.6**

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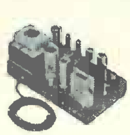

MA-12

MATCHED HI-FI STEREO KIT

We offer as a "packaged deal" the following matched Hi-Fi Stereo Equipment:

4-speed Record Player (RP-1U) ...	£12.16. 4
6W Amplifier (S-33)	£12. 8. 6
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Cost of Units	£46.19.10
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AMATEUR TRANSMITTER, Model DX-100U. The world's most popular, compact and completely self contained Amateur Transmitter covers all amateur bands: 160–10 m. 150w D.C. input. Careful design has achieved the stability and high performance for which the DX–100U is noted and no less than 35 disc ceramic capacitors reduce TVI to a minimum. **£81.10.0**

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SINGLE SIDEBAND ADAPTER. Model SB-10U. May be used with most A.M. transmitters. Less than 3w R.F. input power required for 10w output. Operation on 80, 40, 20, 15 and 10m bands on U.S.B., L.S.B. or D.S.B. **£37.6.0**

HI-FI FM TUNER. This model is available as two units which, for your convenience, are sold separately: the R.F. Tuning Unit, model FMT-4U (£3.5.0 incl. P.T.) with I.F. output of 10.7 Mc/s, and the Amplifier Unit, with power supply, valves, and attractive cabinet, model FMA-4U (£11.11.0) total **£14.16.0**

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TRUVOX TD-1 Mk. 6 TAPE DECK. Mono/stereo tape deck of semi-professional standard. Two tracks, side by side. Limited quantity available at the greatly reduced price of **£29.15.0**

THE BEST QUALITY

TAPE RECORDING AND REPLAY HI-FI AMPLIFIER
Mono. model TA-1M, Stereo model TA-1S

For use with most tape decks. Thermometer type recording indicators, press-button speed compensation and input selection, 3-position bias level and printed circuit construction

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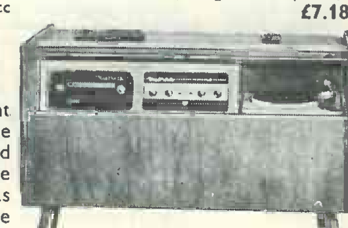
TA-1M and Collaro "STUDIO" ...	£30 10 0
TA-1M and TRUVOX Mk. 6 ...	£46 17 6
TA-1S	£23 6 0
TA-1S and Collaro "STUDIO" ...	£35 14 0
TA-1S and TRUVOX Mk. 6 ...	£52 1 0

HEATHKIT ELECTRONIC WORKSHOP. Model EW-1. This new educational kit will teach and amuse your children, it can make 21 exciting experiments including transistor radios, burglar alarm, radio or TV silencer, intercom., etc **£7.18.0**

HI-FI EQUIPMENT CABINETS



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Our four equipment cabinets meet a wide variety of tastes and requirements: the "CHEPSTOW" was designed for those who have little floor space, the contemporary "MALVERN" for the Tape and Gram. enthusiast, and the "GLOUCESTER" Mk. I and II for those with traditional tastes. All parts are pre-cut and drilled for easy assembly, and left "in the white". Prices from **£11.5.6** to **£17.18.6.**

Available directly from **DAYSTROM Ltd** **Dept. RC4, Gloucester, England**

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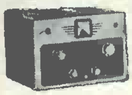
GRID-DIP METER. Model GD-1U. Functions as oscillator or absorption wave meter. With plug-in coils for continuous frequency coverage from 1.8 Mc/s to 250 Mc/s. **£10.9.6**

Three Additional Plug-in Coils Model 34-1U extend coverage down to 350 kc/s. With dial correlation curves. 15/-



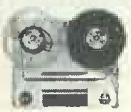
DX-40U

TRANSISTORISED VERSION. Model XGD-1. Similar to GD-1U. Fully transistorised with a frequency range of 1.8 to 45 Mc/s. **£10.8.6**

AMATEUR TRANSMITTER, Model DX-40U. Covers all amateur bands from 80 to 10 metres; crystal controlled. Power input 75W C.W., 60W peak controlled carrier phone. Output 40W to aerial. Provision for V.F.O. Filters minimise TV interference. **£32.10.0**

S-33

6-W STEREO AMPLIFIER. Model S-33. 3 watts per channel, 0.3% distortion at 2.5 w/chnl., 20dB N.F.B. Inputs for Radio (or Tape) and Gram., Stereo or Monaural, ganged controls. Sensitivity 100mV. **£12.8.6**



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

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MONEY-SAVING "PACKAGED DEALS"

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GL-58 Transcription Unit	£20.12.0	TA-1M	£18. 2.6
S-33 Stereo Amp.	£12. 8.6	Collaro "STUDIO"	£17.10.0
Twin SSU-1 Speakers		USC-1	£18.18.6
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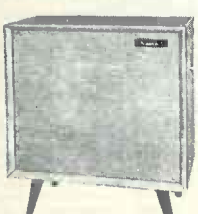

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THE "COTSWOLD". This is an acoustically designed enclosure 26" x 23" x 15½" housing a 12" bass speaker with 2" speech coil, elliptical middle speaker together with a pressure unit to cover the full frequency range of 32–20,000 c/s. Capable of doing justice to the finest programme source, its polar distribution makes it ideal for really Hi-Fi Stereo. Delivered complete with speakers, cross-over unit, level control, Tygan grille cloth, etc. All parts pre-cut and drilled for ease of assembly and left "in the white" for finish to personal taste. **£21.19.0**

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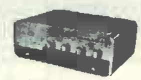

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VALVE VOLTMETER. Model V-7A. 7 voltage ranges d.c. volts to 1,500 a.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.C. input impedance 11mΩ. dB measurement has centre-zero scale. Complete with test prods, lead and standardising battery. **£13.0.0**

TRANSISTOR INTERCOM. Models XI-1U & XIR-1U. The master unit uses a 4-transistor amplifier, constructed on a printed circuit board, and an internal 9V battery. Remote stations use a similar battery for calls only. Up to five remote units can be ordered for each master. XIR-1U (remote) **£4.3.0** XI-1U (master) **£10.15.6**

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CAPACITANCE METER. Model CM-1U. Direct-reading 4½" scale. Full-scale ranges 0–100μμF, 0–1,000μμF, 0–0.01μF and 0–0.1μF. **£14.15.0**

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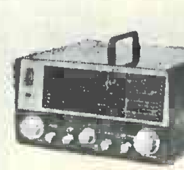
POWER SUPPLY UNIT. Model MGP-1. Input 100/120V 200/250V, 40–60 c/s. Output 6.3V, 2.5A A.C.; 200, 250, 270V, 120mA max. D.C. **£4.16.6**

MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V A.C. and D.C.; 150μA to 15A D.C.; 0.2Ω to 20MΩ. 4½" 50μA meter. **£11.18.6**



GC-1U

THE "MOHICAN" GENERAL COVERAGE RECEIVER. Model GC-1U. With 4 piezo-electric trans-filters, variable tuned B.F.O. and Zener diode stabiliser, this is an excellent fully transistorised portable or fixed station receiver for Amateur and Short wave listeners. Printed circuit boards, telescopic whip antenna, tuning meter and large slide-rule dial, 10 transistors. **£38.15.0**

All prices include free delivery U.K.
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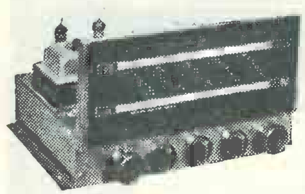
ARMSTRONG AF 208 AM/FM RADIOGRAM CHASSIS



★ Full VHF Band (87–108 Mc/s.) and Medium Band, 187–570M. ★ 7 Valves ★ 5 Watts Output ★ 15dB Negative Feedback ★ Separate wide range Bass and Treble Controls ★ 2 Compensated Pick-up Inputs ★ Frequency Response 30–22,000 c.p.s. ★2dB ★ Tape Record and Playback Facilities ★ Continental Reception of Good Programme Value ★ For 3, 7½ and 15 ohm speakers. Send S.A.E. for leaflet.

Price **22 Guineas** Carr. Free

LATEST "E.M.I." 4 SPEED SINGLE RECORD PLAYER

Acos Hi-Fi Pick-up for LP, and/or 78, 7", 10" and 12" records. Silent motor, heavy turntable, auto stop.
Completely assembled on base plate.
Special offer **£6. 5. 0** post free
Or with Stereo/Monaural Pick-up £6.19.6

SINGLE PLAYER BARGAIN

Ready built complete with B.S.R. TU9 4-speed Gram Pick-up unit. Handsome portable case. 3-watt amplifier with 2 valves and speaker.

Our Price £8. 19. 6.
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In manufacturer's sealed cartons.

I.F. TRANSFORMERS 7/6 pair
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New boxed VALVES 90-day Guarantee

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2X2	3/6	6Q7G	8/6	EBC33	8/6	HVR2A	6/6
3S4	7/6	6SA7	6/–	EBC41	8/6	MU14	9/–
3V4	7/6	6SJ7M	6/6	EBF80	10/–	P61	3/6
5U4	7/6	6SN7	6/6	ECC84	9/6	PCC84	9/6
5Y3	7/6	6V6G	7/6	ECF80	9/6	PCF80	9/6
5Z4	9/6	6X4	7/6	ECH42	10/6	PCL82	11/6
6AM6	5/–	6X5	6/6	ECL80	10/6	PEN25	6/6
6B8	5/–	12A6	7/6	ECL82	10/6	PL81	12/6
6BE6	7/6	12AT7	8/–	EF39	5/6	PL82	10/6
6BH6	7/6	12AU7	8/–	EF41	9/6	PY80	7/6
6BW6	9/6	12AX7	8/–	EF50	5/6	PY81	9/6
6D6	6/–	12BE6	8/6	EF80	8/–	PY82	7/6
6F6	7/6	12K7	6/6	EF86	12/6	SP61	3/6
6H6	3/6	12Q7	6/6	EF92	5/6	UBC41	9/6
6J5	5/6	35L6	9/6	EL32	5/6	UCH42	9/6
6J6	5/6	35Z4	7/6	EL41	9/6	UF41	9/6
6J7G	6/6	80	9/6	EL84	8/6	UL41	9/6
6K6GT	6/6	807	5/6	EY51	9/6	UY41	8/–
6K7G	5/–	954	1/6	EZ40	7/6	U22	8/–

DK96, DF96, DAF96, DL96, 8/6 each or 30/– set

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1/350v.	2/–	50/350v.	5/6	16/450v.	5/–
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4/450v.	2/3	250/25v.	3/–	100/270v.	5/6
8/450v.	2/3	500/12v.	3/–	2,000/6v.	4/–
16/450v.	3/–	8+8/450v.	3/6	5,000/6v.	5/–
32/450v.	3/9	8+16/450v.	3/9	32+32/350v.	5/–
25/25v.	1/9	16+16/450v.	4/3	32+32/450v.	6/–
50/25v.	2/–	32+32/350v.	4/6	32+32+32/350v.	7/–
50/50v.	2/–			50+50/350v.	7/–
				64+120/350v.	11/6
				100+200/275v.	12/6

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4 Mullard valves, 5" speaker, frame aerial. 4 pre-set stations. 1 long, 3 med. wave.
Superhet Circuit.
Size 9" × 6" × 5½" high. Tested ready for use. 200/250V A.C.–D.C. Mains. **Brand New**

DE LUXE MODEL

As above but with illuminated dial. Fully tunable over medium wave 200–550 M and long wave 1,000–2,000 M.

Bargain Price **£5.19.6**

MAINS TRANSFORMERS
200/250 AC Post 2/- each

STANDARD 250–0–250, 80 mA., 6.3 v. tapped 4 v. 4 a., Rectifier 6.3 v. 1 a. tapped 5 v. 2 a. and 4 v. 2 a. 22/6
Ditto 350–0–350 ... ... 29/6
MINIATURE, 200 v. 20 mA., 6.3 v. 1 a. 10/6
MIDGET, 220 v. 45 mA., 6.3 v. 2 a. ... 15/6
SMALL, 220–0–220 v. 50 mA., 6.3 v. 2 a. 17/6
STANDARD, 250–0–250 65 mA., 6.3 v. 3.5 a. 17/6
HEATER TRANS., 6.3 v. 1½ a. ... 7/6
Ditto 6.3 v. 3 a. 10/6
Ditto 1.4, 2, 3, 4, 5, 6.3 v. 1½ a. 8/6
MULLARD "510" OSRAM "912", 300–0–300, 120 mA, 6.3 v. 4 a. c.t., 6.3 v. 2 a. tapped 5 v. 38/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 22/6
AUTO. TRANS. 150 w., 0, 10, 120, 200, 230, 250 v. 22/6
AUTO. TRANS. 500 w., 0, 115, 200, 230, 250 v. 82/6

O.P. TRANSFORMERS. Heavy duty 50 mA, 4/6. Miniature 3V4, etc., 4/6. Small, pentode, 4/6. Multi-ratio push-pull, 7/6. Multi-ratio push-pull 10 w., 15/6. Goodmans heavy duty 10/20 w. 6K push-pull, 30/–.
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CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1½ a., 15/6; 2 a., 17/6; 4 a., 22/6.
4 AMP. CAR BATTERY CHARGER with amp. meter Leads, Fuse Case, etc., for 6 v. or 12 v., 69/6.

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Precision engineered. Size only 1½" dia. × ⅛"
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12" Baker 15W Stalwart 3 or 15Ω, 45–13,000 c.p.s. 90/–
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12" Baker Ultra Twelve, 20 c.p.s. to 25 kc/s **£17.10.0**
15" Auditorium, Bass Mk II 35W 20 c.p.s. to 12 kc/s. **£18**

LOUDSPEAKERS P.M. 3 OHM. 2½in. 3in. 4in.-19/6; 5in. Rola, 17/6; 7in. × 4in., 18/6; 4in. Hi-Fi Tweeter, 25/–; 8in. Plessey, 19/6; 6½in. Goodmans, 18/6; 10in. R.A., 30/–; 12in. Plessey, 30/–; 10in. × 6in. E.M.I. 27/6; E.M.I. 13½" × 8" 45/–; Stentorian HF1012 10in., 95/–; HF1016, £8. 12 in. R.A. 15Ω45 -.
CRYSTAL DIODES. G.E.C., 2/–; GEX34, 4/–; OA81, 3/–.
40 CIRCUITS FOR GERMANIUM DIODES, 3/–.
H.R. HEADPHONES, 4,000 ohms, brand new, 15/– pair. Low resistance phones, BA5, 7/6 pair, **SWITCH CLEANER FLUID**, squirt spout. 4/6 tin.

C.R.T. BOOSTER TRANSFORMERS

For Cathode Ray Tubes having heater cathode short circuit and for C.R. Tubes with falling emission, full instructions supplied.

TYPE A. LOW LEAKAGE WINDINGS. OPTIONAL 25% and 50% BOOST ON SECONDARY: 2 V. OR 4 V. OR 6.3 V. OR 10.3 V. OR 13.3 V. WITH MAINS PRIMARIES. 12/6.

TWIN GANG CONDENSERS. Miniature transistor gang 208 and 176 pF, 10/6 each; 365 pF, miniature, 1⅞in. × 1⅛in. × 1⅞in., 10/–; 500 pF standard with trimmers, 9/–; midget, 7/6; midget with trimmers, 9/–.
SHORT WAVE. Single 25pF, 50 pF, 75 pF, 100 pF, 160 pF, 5/6 each.
TUNING AND REACTION CONDENSERS. 100 pF, 300 pF, 500 pF, 3/6 each, solid dielectric.
CONDENSERS. 0.001 mfd. 7kV T.C.C., 5/6; ditto 20 kV., 9/6; 0.1 mfd. 7 kV., 9/6; 100 pF to 500 pF Micas, 6d.; Tubular 500 v. 0.001 to 0.05, 9d.; 0.1, 1/–; 0.25, 1/6; 0.1/350 v., 9d.; 0.5/500 v., 1/9; 0.01/2,000 v., 1/9; 0.1/2,000 v., 3/6.
CERAMIC CONDENSERS. 500 v. 0.3 pF to 0.01 mfd., 9d. 0.1/30v., 1/3.
SILVER MICA. 10% 5 pF to 500 pF, 1/–; 600 pF to 3,000 pF, 1/3; close tolerance (plus or minus 1 pF), 1.5 pF to 47 pF, 1/6; ditto 1% 50 pF to 815 pF, 1/9; 1,000 pF to 5,000 pF, 2/–.

465 Kc/s. SIGNAL GENERATOR. Total cost 15/–. Uses B.F.O. Unit ZA 30038 ready made. **POCKET SIZE** 2½in. × 4½in. × 1in. Slight modifications required, full instructions supplied. Battery 7/6 extra 69 v. + 1½ v. Details S.A.E.

WAVECHANGE SWITCHES
2 p. 2-way, 3 p. 2-way, short spindle 2/6
8 p. 4-way 2 wafer, long spindle 6/6
2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle 3/6
3 p. 4-way, 1 p. 2-way, long spindle 3/6
Wavechange **"MAKITS"**. Wafers available: 1 p. 12 wafer, 2 p. 6 wafer, 3 p. 4 wafer, 4 p. 3 wafer, 6 p. 2 wafer. 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer, 16/–. Additional wafers up to 14, 3/6 each extra.
TOGGLE SWITCHES, s.p., 2/–; d.p., 3/6; d.p.d.t., 4/–.
JACKS. English open-circuit 2/6, closed-circuit 4/6, Grundig-type 3-pin 1/3
JACK-PLUGS. English 3/-, Screened 4/–, Grundig 3-pin 3/6.

JASON F.M. TUNER COIL SET, 29/–. H.F. coil, aerial coil, oscillator coil, two i.f. transformers 10.7 Mc/s., detector transformer and heater choke. Circuit and component book using four 6AM6, 2/6. Complete Jason FMT1 kit, Jason chassis with calibrated dial, components and 4 valves, £6.5.0.

VALVEHOLDERS. Pax. int. oct., 4d. EA50, 6d. B12A, CRT, 1/3. Eng. and Amer. 4, 5, 6, and 7 pin, 1/–. **MOULDED MAZDA** and int. Oct., 6d.; B7G, B8A, B8G, B9A, 9d. B7G with can, 1/6. B9A with can, 1/9. Ceramic, EF50, B7G, B9A, Int. Oct., 1/–. B7G, B9A cans, 1/– each.

RADIO COMPONENT

Our written guarantee with every purchase. Buses 133 or 68 pass door. S.R. Stn. Selhurst.

VOLUME CONTROLS

Long spindles. Midget 5K ohms to 2 Meg.

No. sw. 3/- D.P. Sw 4/6

Linear or Log Tracks.

80 ohm CABLE Coax

Semi-air spaced ¼in. Stranded core, 6d. yd. 40 yds. 17/6; 60 yds. 25/-

Fringe Quality, Air Spaced 1/- yd.

EXTENSION SPKR. CONTROL 10 Ohm 3/-.

TELESCOPIC CHROME AERIALS 13in. extending to 43in. 8/6 each. Coax adaptor plug — 1/6 extra.

RESISTORS. Preferred values. 10 ohms to 10 meg. ¼ w., 4d.; ½ w., 4d.; 1 w. 6d.; 1½ w. 8d.; 2 w. 1/-.

HIGH STABILITY. ½ w. 1%, 2/-. Preferred values. 10 ohms to 10 meg. Ditto 5%, 100 ohms to 5 meg. 9d.

WIRE-WOUND RESISTORS 25 ohms- 10,000 ohms

5 watt 1/3
10 watt 1/6
15 watt 2/-
12.5K to 50K 10 w 3/-

WIRE-WOUND Pots. 3 WATT. Pre-set Min. TV Type. All values 10 ohms to 25K, 3/- ea.; 30K, 50K, 4/-. Carbon 30K to 2 meg., 3/-

WIRE-WOUND 4 WATT POTS. Long Spindle, Values, 50 ohms to 50K, 6/6; 100K, 7/6.

TRIPLEXERS, Bands I, II, III, ... 12/6

COAXIAL PLUGS, 1/-. **PANEL SOCKETS,** 1/-

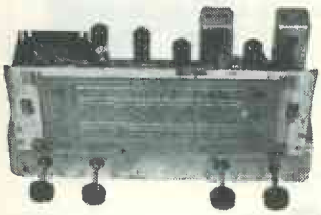
LEAD SOCKET, 2/-. **OUTLET BOXES,** 4/6

BALANCED TWIN FEEDER, 6d. yd., 80 or 300 ohms

TWIN SCREENED FEEDER, 1/6 yd. 80 ohms.

TRIMMERS. Ceramic 30, 50, 70 pF. 9d.; 100 pF. 150 pF. 1/3; 250 pF. 1/6; 600 pF. 750 pF. 1/9; Philips, 30 pF. 1/- each.

1962 RADIOGRAM CHASSIS



Three Wavebands — S.W. 16 m.–50 m. M.W. 200 m.–500 m. L.W. 800 m.–2,000 m.

Five Valves — Latest Mullard ECH81, EF89, EBC81, EL84, EZ80

12-month Guarantee. A.C. 200-250V, 4-way switch. Short-Medium-Long-Gram. A.C.C. and Negative Feedback, 4.2 watts. Chassis 13½" x 5½" x 2¼". Glass dial size 10" x 4½", horizontal or vertical. Two Pilot Lamps. Four Knobs, Walnut or Ivory. Aligned and calibrated. Chassis isolated from mains.

BRAND NEW £9.10.0 Carr. 4/6

Matched Speakers 8" 17/6; 10" 25/-; 12" 30/-

BLACK CRACKLE PAINT. Air drying. 3/- tin.
NEON MAINS TESTER SCREWDRIVER, 5/-
SOLDER RADIOGRADE, 4d. yd., ½ lb. 5/-.

HIGH GAIN TV PRE-AMPLIFIERS
BAND I B.B.C.
Tuneable channels 1 to 5. Gain 18 dB. ECC84 valve. Kit price 29/6 or 49/6 with power pack. Details 6d. (PCC84 valves if preferred.)
BAND III I.T.A.—Same prices
Tuneable channels 8 to 13. Gain 17 dB.

PAXOLIN PANELS, $\frac{1}{16}$in. x 10in. x 8in., 2/-.

MINIATURE CONTACT COOLED RECTIFIERS. 250 v. 50 mA. 7/6; 250 v. 60 mA. 8/6; 250 v. 85 mA. 9/6. 200 mA. 21/-; 300 mA. 27/6.

SELENIUM RECT. 300 v. 85 mA. 7/6.

COILS. Wearite "P" type, 3/- each. Osmor Midget "Q" type, adj. dust core from 4/- each. All ranges.

TELETRON D.W.R. L. & Med. T.R.F. with reaction, 3/6.

FERRITE ROD AERIALS. M.W., 8/9; M. & L., 12/6.

FERRITE ROD AERIALS. L & M. for transistor circuits, 10/- each.

FERRITE RODS 8in. x ⅜in., 2/6. 8in. x $\frac{5}{16}$in. 2/6

ALUMINIUM CHASSIS. 18 s.w.g. Plain, undrilled. 4 sides, riveted corners, lattice fixing holes, 2½in. sides. 7in. x 4in., 4/6; 9in. x 7in., 5/9; 11in. x 7in., 6/9; 13in. x 9in., 8/6; 14in. x 11in., 10/6; 15in. x 14in., 12/6; 18in. x 16in. x 3in., 16/6.

ALUMINIUM PANELS. 18 s.w.g., 12in. 12in. 4/6; 14in. x 9in., 4/-; 12in. x 8in., 3/-; 10in. x 7in., 2/3. 8in. x 6in. 2/-.

H.F. CHOKES, 2/6. Osmor QC1 6/9.

T.R.F. COILS A/HF, 7/- pair; HAX, 3/-, DRR2, 4/-.

ALADDIN FORMERS and cores. ¼in. 8d., ⅜in. 10d.

0.3in. FORMERS 5937 or 8 and cans TV1 or 2, ⅜in. sq. x 2½in. or ⅜in. sq. x 1¾in., 2/- with cores.

SLOW MOTION DRIVES. Epicyclic ratio 6-1, 2/3.

SOLON IRON, 25 w., 200 v. or 230 v. 24/-.

PRECISION Sub-miniature Iron. 200 or 240 v, 29/6:

MAINS DROPPERS. 3in. x 1½in. With adj. sliders, 0.3A, 1,000 ohms, 4/3; 0.2A 1,000 ohms, 4/3.

LINE CORD. 0.3 A 60 ohms per foot, 0.2 A 100 ohms per foot, 2-way, 1/- per foot; 3-way 1/- per foot.

MIKE TRANS. 50:1, 3/9; 100:1 potted, 10/6.

P.V.C. CONN. WIRE, 8 colours, single or stranded, 2d. yd.

SLEEVING, 1 or 2 mm, 2d.; 4 mm, 3d.; 6 mm, 5d. yd.

AMERICAN "BRAND FIVE" PLASTIC RECORDING TAPE

			Spare Plastic Reels	
Double Play	7" reel, 2,400 ft.	60/-		
	5" reel, 1,200 ft.	37/6		
Long Play	7" reel, 1,800 ft.	35/-		
	5¾" reel, 1,200 ft.	23/6	3"	1/6
	5" reel, 900 ft.	18/6	4"	2/-
			5"	2/-
Standard	7" reel, 1,200 ft.	25/-	5¾"	2/-
	5" reel, 600 ft.	16/-	7"	2/6

"Instant" Bulk Tape Eraser and Head Defluxer, 200/250V A.C. 27/6. Leaflet S.A.E.

QMAX CHASSIS CUTTER

The cutter consists of three parts: a die, a punch and an Allen screw.

Sizes	Price	Key	Sizes	Price	Key
½" or ⅝"	12/9	1/-	2"	30/-	2/3
¾" or ⅞"	13/9	1/-	2$\frac{3}{32}$"	33/6	2/3
1" or 1⅛" or 1¼"	16/-	1/6	2½"	38/6	2/3
1⅜" or 1½"	18/-	1/6	1" sq.	29/-	1/6
1¾"	20/6	1/6			

"REGENT" 4 VALVE

"96" RANGE VALVES

Kit Price **£6.6.0**

carr. 4/-

PRINTED CIRCUIT BATTERY PORTABLE KIT

Medium and long wave. Powerful 7 x 4 in. high Flux Speaker. T.C.C. Printed Circuit and condensers. Components of finest quality clearly identified with assembly instructions. Osmor Ferrite Aerial Coils. Rexine covered attache case cabinet. Size 12 in x 8 in. x 4 in. Batteries used B126 (L5512) and AD35 (L5040), 10/- extra. Instructions 9d. (free with kit). Mains Unit **ready made** for above 39/6. Sold separately. Details free.

MONARCH RECORD PLAYER

BUILD IT YOURSELF using 4-SPEED BSR MONARCH AUTOCHANGER READY BUILT 3W AMPLIFIER, HANDSOME PORTABLE CASE. HIGH FLUX LOUDSPEAKER. FULL INSTRUCTIONS SUPPLIED

Total Price **£12.10.0**
Carr. and ins. 5/-

RECORD PLAYER BARGAINS

4 Speed Autochangers: **POST 2/- each**

BSR, U.A.14 .... £7.10.0
BSR. U.A.12 Stereo/Monaural £8.5.0
Garrard Autoslim £8.17.6

4 Speed Single Players:
Garrard TA Mk. II £8.0.0
Garrard 4 HF Transcription £17.19.6

Garrard Stereo Heads £2 extra.
All Sapphire Stylii available from 6/-.

All Crystal Cartridges available from 21/-

AUTOCHANGER ACCESSORIES

Amplifier player cabinets with cut boards, 63/-. 2-valve amplifier and 6½ speaker for above, ready mounted on baffle, 12in. x 7in., 3in. deep, *Wired and tested ready for use.* £4.15.0.

ARDENTE TRANSISTOR TRANSFORMERS

Type D3035, 7.3 CT:1 Push Pull to 3 ohms for OC72, etc., 1in. x ¾in. x ¾in., 9/6.
Type 3034, 1.75:1 CT. Push Pull Driver for OC72, etc., 1in. x ¾in. x ¾in., 9/6.
Type D3058, 11.5:1 Output to 3 ohms for OC72, etc., 1in. x ¾in. x ¾in., 9/6.
Type D167, 18.2:1 Output to 3 ohms for OC72 etc., ¾in. x ½in. x ½in., 12/-.
Type D239, 4.5:1 Driver Transformer, ¾in. x ½in. x ½in., 10/-.
Type D240, 8.5:1 Driver Transformer, ¾in. x ½in. x ½in., 10/-

ARDENTE TRANSISTOR VOLUME CONTROLS. Type VC1545, 5K with switch, dia. .9in., 8/-. Type VC1760, 5K with switch, dia. .7in., 10/6.

DEAF AID EARPIECE Xtal or magnetic 7/6.

WEYRAD

COILS AND TRANSFORMERS FOR A 2-WAVE TRANSISTOR SUPERHET WITH PRINTED CIRCUIT AND FERRITE ROD AERIAL

Long and Medium Wave Aerial—RA2W. On 6in. rod, $\frac{7}{16}$in. diameter, 208 pF. tuning, 12/6.
Oscillator Coil P50/1AC. Medium wave. For 176 pF. tuning, 5/4.
1st and 2nd I.F. Transformer—P50/2CC. 470 kc/s. $\frac{11}{16}$in. diameter by ¾in. high, 5/7.
3rd I.F. Transformer—P50/3CC, to feed diode detector, 6/-.
Driver Transformer—LFDT2, 1$\frac{3}{16}$in. x ⅞in. x 1⅜in., 9/6.
Printed Circuit—PCA1. Size 2¾in. x 8¼in. Ready drilled and printed with component positions, 9/6.
7in. x 4in., 35 ohm Speaker, 25/-.
Wavechange Switch 3/6.
These components are approved by transistor makers and performance is guaranteed.
Constructor's Booklet with full details, 2/-.

NEW MULLARD TRANSISTORS

Audio	OC71 ... 6/-	R.F.	OC44 ...	10/6
	OC72 ... 7/6		OC45 ...	9/6

Sub-miniature Electrolytics (15 V). 1 mfd. 2 mfd., 4 mfd., 5 mfd., 8 mfd., 25 mfd., 100 mfd., 2/6. Diodes OA71, OA81, 3/-; GEX 34 4/-.

B.B.C. Pocket 2 Transistor. M.W. and L.W. Radio Kit, 22/6. Phones 7/6 or deaf aid earpiece, 7/6.

"P.W." Pocket 6. Transistor kit. All parts, printed circuit and cabinet. Osmor Designed Kit, £8.15.0. Mk. II all the latest modifications.

SPECIALISTS

337 WHITEHORSE ROAD WEST CROYDON Telephone THO 1665

P. & P. charge 1/-, over £3 post free. C.O.D. 2/-. (Export welcome. Send remittance and extra postage).

CHECK with these BARGAINS

1 **3-TRANSISTOR POCKET RADIO** with miniature **SPEAKER FERRITE ROD, and 2 GERMANIUM DIODES.** Build it in 1 evening! Tunable over M/L waves. Complete with easy-to-follow instructions and all components (less batteries obtainable anywhere 1/3). **27 6.** P. & P. 2/6. (All parts available separately.)

2 **SUPER 5-TRANSISTOR POCKET RADIO** incorporating printed circuit and miniature earpiece. Size 4¾" × 3¼" × 1½". Output 200 m/W. Five first quality transistors. Push-pull output. Fitted 2" high-flux moving coil speaker. Medium and long wave. Internal high gain ferrox aerial. Twin coloured case in red and black. All parts available separately. Circuit-diagram 1/6. Free with parts. No aerial or earth required. **59/6.** P. & P. 3/6.

3 **OSCILLOSCOPE for D.C. and A.C. APPLICATIONS.** A high gain, extremely stable differential Y-amplifier (30 mV/CM.). Provides ample sensitivity with A.C. or D.C. inputs. Especially suitable for measurements of transistor operating conditions where maintenance of D.C. levels is of paramount importance. Push-pull X amplifier; Fly-back suppression; Internal Time-base Scan Waveform available for external use; pulse output available for checking TV line O/P Transformers, etc. Provision for external—I/P and CRT Brightness Modulation. AC. mains 200/250V **£15.15.0,** P. & P. 8/- or **30/-** deposit, plus P. & P. 8/- and 12 monthly payments of **26/6** FULL 12 MONTHS' GUARANTEE INCLUDING VALVES AND TUBE

4 **A.C./D.C. POCKET MULTI-METER KIT.** 2" moving coil meter, scale calibrated in A.C./D.C. volts, ohms, and milliamps. Voltage range A.C./D.C. 0-50, 0-100, 0-250, 0-500. Milliamps 0-10, 0-100. Ohms range 0-10,000. Front panel, range switch, wirewound pot (for ohms zero setting), toggle switch, resistor and rectifier. **19/6.** P. & P. 2/-. Wiring diagram 1/- free with parts.

5 **CHANNEL TUNER** Will tune to all Band I and Band III stations. Complete with P.C.C.84 and P.C.F.80 valves (in series) I.F. 16-19 or 33-38. Can be modified as an aerial converter (instructions supplied). **32/6,** plus 4/- P. & P. **HEATER TRANSFORMER** to suit above, 200-250V, 6/-, plus 4/- P. & P.

6 **MAINS TRANSFORMERS.** All with tapped primaries. 250-250V 70mA, 6.3V 2A, 10/6. P. & P. 3/6. 280-0-280 70mA, 6.3V 2A, 6.3V 1A, **10/6.** P. & P. 3/6. 280-0-280 120mA, 6.3V 2A, 6.3V 3A, 17/6. P. & P. 3/6.

7 **WOLSEY 3-ELEMENT FOLDED DIPOLE.** I.T.V. Aerial less mounting bracket for external use, complete with 12 yards coaxial cable, 15/-, P. & P. 4/-.

9 **SIGNAL GENERATORS.** Cash £6.19.6. or 25/- deposit and 6 monthly payments of 21/6. P. & P. 5/6. Coverage 100 kc/s to 100 M/cs on fundamentals and 100 Mc/s to 200 Mc/s on harmonics. Case 10" × 6½" × 5½". Three miniature valves and Metal Rectifier. A.C. mains 200/250V. Internal modulation of 400 c.p.s. to a depth of 30 per cent; Modulated or unmodulated R.F. output continuously variable 100 millivolts. CW. and mod. switch, variable A.F. output. Magic eye as output indicator. Accuracy ± 2%.

10 **SIGNAL GENERATORS.** Cash **£4.19.6.** P. & P. 5/6. Coverage 120 kc/s to 84 Mc/s. Case 10" × 6¼" × 4½". Size of scale 6½" × 3½", 2 valves and rectifier. A.C. mains 230-250V. Internal modulation of 400 c.p.s. to a depth of 30 per cent modulated or unmodulated R.F. output continuously variable 100 millivolts. C.W. and mod. switch variable A.F. output and moving coil output meter. Accuracy ±2%.

11 **BATTERY RECORD PLAYER AND AMPLIFIER.** 45 r.p.m. "Star" motor "Acos" crystal pick-up, 3 transistor, push-pull amplifier complete with transistors. Output 500 milliwatts, **49/6.** P. & P. 4/-.

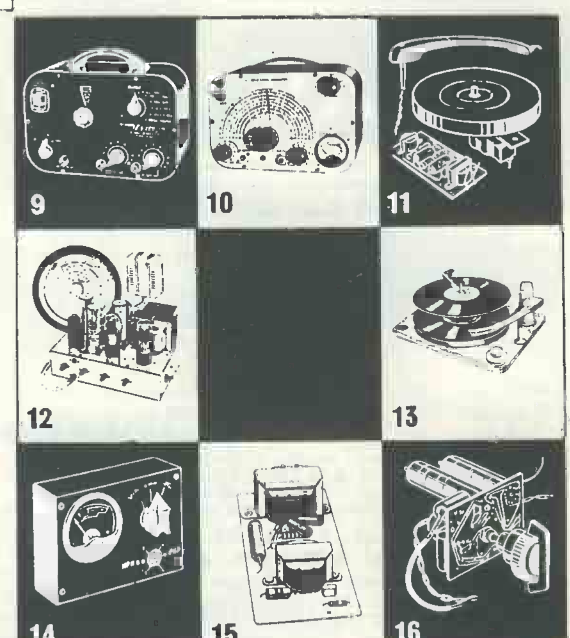
12 **8-watt PUSH-PULL 5 VALVE AMPLIFIER.** A.C. mains 200-250V Size 10½" × 6¼" × 2½". 5 valves. For use with all makes and type of pick-up and mike. Negative feedback. Two inputs, mike and gram. and controls for same. Separate controls for Bass and Treble lift. Response flat from 40 cycles to 15 kc/s. ± 2dB; 4db down to 20 kc/s. Output 8 watts at 5 per cent total distortion. Noise level 40 db down all hum. Output transformer tapped for 3 and 15 ohms speech coils. For use with Std. or LP. records, musical instruments such as guitars, etc. Suitable for small halls, **£3.19.6,** P. & P. 7/-. Crystal mike to suit 15/-. P. & P. 2/-. 8" P.M. Speaker to suit, **12/6.** P. & P. 2/-.

13 **B.S.R. MONARCH UA8 WITH FUL-FI HEAD.** 4-speed, plays 10 records, 12", 10" or 7" at 16, 33, 45 or 78 r.p.m. Intermixes 7", 10" and 12" records of the same speed. Has manual play position: colour brown. Dimensions: 12½" × 10¾". Space required above baseboard 4¾" below baseboard 2¾", Fitted with Ful-Fi turnover crystal head, **£6.19.6,** P. & P. 5/-. **With Stereo Head £7.19.6.** P. & P. 5/6.

14 **TRANSISTOR TESTER.** For both P.N.P. and N.P.N. transistors incorporating moving coil meter. In metal case size 4½" × 3¾" × 1¼". Scale marked in gain and leakage, **19/6,** P. & P. 3/-.

15 **PUSH-PULL OUTPUT STAGE** inclusive of transistors with input and output transformers to match 3 ohms speech coil, suitable for use with the POCKET RADIO. Kit of parts, including transistors, **19/6.** P. & P. 2/- Wiring diagram 1/6, free with parts.

16 **PORTABLE AMPLIFIER.** On printed circuit for A.C. Mains 200/250V. Size 4" × 3" with tone and volume control. Complete with valves: ECL82 and EZ80. Output 2 watts. **39/6,** P. & P. 3/-.



RADIO & T.V. COMPONENTS (Acton) LTD.

23d HIGH STREET, ACTON, LONDON, W.3.

ALL ENQUIRIES S.A.E.
GOODS NOT DISPATCHED OUTSIDE U.K.

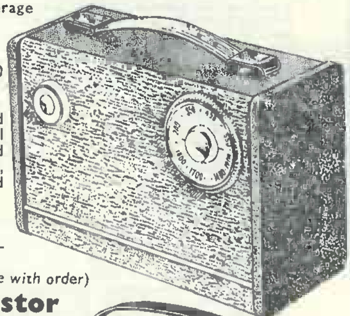
MINISETS LTD Hatherley Mews London E17

6-Stage Portable Transistor Radio

★ All parts including transistors direct from manufacturers
★ Pre-assembled circuit board ensuring ease of construction
★ Full medium-wave coverage
★ **After-sales service**
★ Attractive two-tone case 9" x 6" x 4"
★ Push-pull output, 350 milliwatts
★ 5" high flux speaker
★ Built-in Ferrite Rod aerial. No external aerial or earth required
★ High performance, many stations received on test

Can be built for **£5.4.0** P.P. 3/–
Or with long-wave 8/– extra

Full instructions 1/6 (Free with order)



6-Stage Transistor Pocket Portable

Can be built for **£4.19.6** P.P. 2/6

★ Completely self contained, no aerial or earth required.
★ Push-pull output, 250 milliwatts.
★ 3" high flux speaker
★ Pre-assembled circuit board with simple instructions ensuring easy construction
★ High Q Ferrite Rod Aerial
★ **After-sales service**
Can be supplied with long-wave 6/– extra

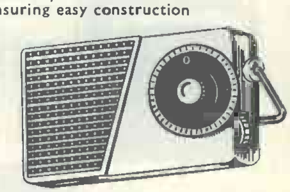
Full instructions, price list 1/6 (Free with order)

3-Transistor Radio (plus 2 diodes)

Total building 70/– P.P. 2/6

★ Pre-assembled circuit board, ensuring easy construction
★ Full medium-wave coverage
★ Attractive case 5$\frac{1}{4}$" x 3" x 1$\frac{3}{4}$"
★ All components including transistors are brand new and direct from manufacturers
★ Ferrite Rod aerial coil, no external aerial or earth required
★ 2$\frac{1}{2}$" high flux speaker direct from manufacturer
★ **After-sales service**

Send 1/6 for instructions, circuit and price list



2-Transistor Radio (plus 2 diodes)

Ideal for personal listening

★ Built-in Ferrite aerial
★ Sensitive earpiece
★ All parts including transistors direct from manufacturers
★ Pre-assembled circuit board and easy-to-follow instructions
★ **After-sales service**
★ Can be built for **50/–** P.P. 2/–

Full instructions, etc., 1/6 (Free with order)

SMITH'S *of Edgware Road*

BLANK CHASSIS

Precision made in our own works from commercial quality half-hard Aluminium. Two, three or four sided.

SAME DAY SERVICE

of over 20 different forms made up to YOUR SIZE. Order EXACT size you require to nearest $\frac{1}{16}$" (maximum length 35", depth 4").

SPECIALS DEALT WITH PROMPTLY

SEND FOR ILLUSTRATED LEAFLET

Or order straight away, working out total area of material required and referring to table below, which is for four-sided chassis in 18 s.w.g. (for 16 s.w.g. add $\frac{1}{8}$th)

48 sq. in.	4/–	176 sq. in.	8/–	304 sq. in.	12/–
80 sq. in.	5/–	208 sq. in.	9/–	336 sq. in.	13/–
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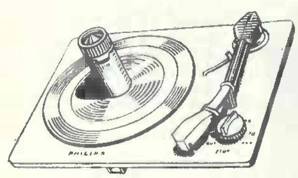

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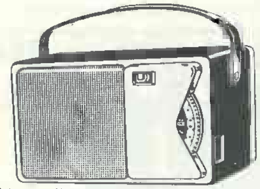

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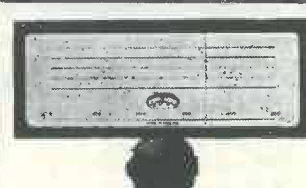

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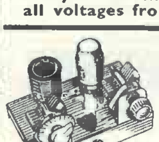

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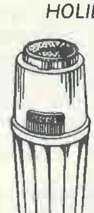

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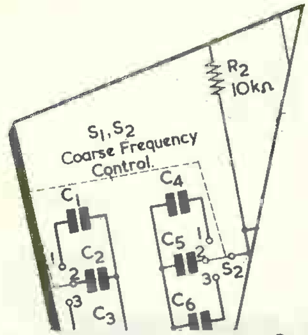

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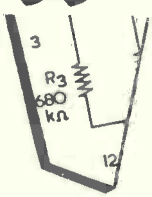


The circuits presented in this series have been designed by G. A. FRENCH, specially for the enthusiast who needs only the circuit and essential data

No. 137 TELEPHONE RINGING CIRCUIT FOR THEATRICAL USE

SINCE THE FIRST SUGGESTED CIRCUIT was published in *The Radio Constructor*, over eleven years ago, the writer has received a number of unusual requests from readers for particular designs. One of the most out-of-the-way requests arrived recently, the reader asking for a simple switching circuit which would cause an electric bell to ring with the same rhythm as a telephone bell. The reader explained that he was connected with an amateur theatrical group and that it seemed impossible to get a stage assistant to provide the familiar "burr-burr . . . burr-burr" ringing cycle when operating a bell from a simple press-button. The ringing of the bell was, of course, necessary in the course of plays and other presentations.

This is rather a challenging project and, since the circuit involved would not be excessively complicated or expensive, the writer decided to include a description of a suitable switching device in this series. The device has immediate applications for readers who are connected with theatrical work, and the principles involved are of general interest.

The writer would like to point out at this juncture that the circuit described in this article should preferably be tackled by the more experienced constructor, as experimental work is involved with regard to some of the component values. Also, an understanding of the functioning of the circuit is needed if it is to be reliably set up after assembly.

The Ringing Waveform

The "burr-burr . . . burr-burr" telephone bell ringing rhythm referred to by the reader who suggested the present device is provided by the larger G.P.O. exchanges, and is readily recognisable by the general public. The time of the switching cycle is accurately controlled by the G.P.O. and the cycle is made up in the following manner: 0.4 second on, 0.2 second off, 0.4 second on, and 2 seconds off. This timing is illustrated in the upper waveform of Fig. 1, this waveform rising to indicate the on condition (bell ringing) and falling to indicate the off condition (bell silent).

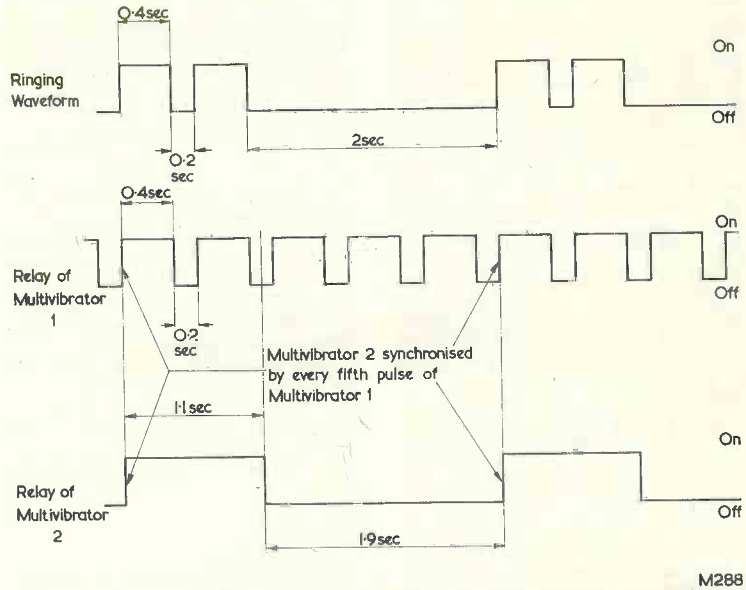
The writer felt that this waveform could be produced artificially by the use of two multivibrators coupled to relays. The waveform given by the first multivibrator relay is shown in the centre of Fig. 1, the on condition corresponding to the relay being energised with its contacts closed. This multivibrator relay provides continuous cycles in which each 0.4 second on period is followed by a 0.2 second off period. It will be noted that the first two on pulses in the centre waveform correspond to the first two on pulses in the ringing waveform shown above it. These first two on pulses are followed by four off periods and three on periods, and it is interesting to note that the total time of these periods (3 x 0.4 second plus 4 x 0.2 second) is exactly equal to the 2 second off period in the ringing waveform. The subsequent two on pulses in the centre waveform correspond, in consequence, to the second pair of on pulses in the ringing waveform.

The second multivibrator relay provides the lower waveform in Fig. 1. In this case, the on period takes up a time of 1.1 seconds and the off period a time of 1.9 seconds. Due to the circuitry employed in the switching device *the second multivibrator is synchronised with the first multivibrator in such a manner that its on period is triggered by the leading edge of every fifth on pulse generated by the first multivibrator.* Because of this, the leading edge of each on pulse of the second multivibrator coincides with the leading edge of each fifth on pulse of the first multivibrator.

If the relay contacts of the two multivibrators are now connected in series, and this series combination is inserted in a bell and battery circuit, the bell will ring in the same manner as if it were actuated by the upper waveform of Fig. 1. It will ring for the first two on pulses of the centre waveform because multivibrator relay 2 is, at this time, on. It will not ring for the following three on pulses in the centre waveform because multivibrator relay 2 is off, and has broken the circuit. Multivibrator relay 2 comes on again for the next two pulses and allows the bell to ring, after which it falls off again. Thus, the ringing waveform of Fig. 1 is provided by the combination of the centre and lower waveforms.

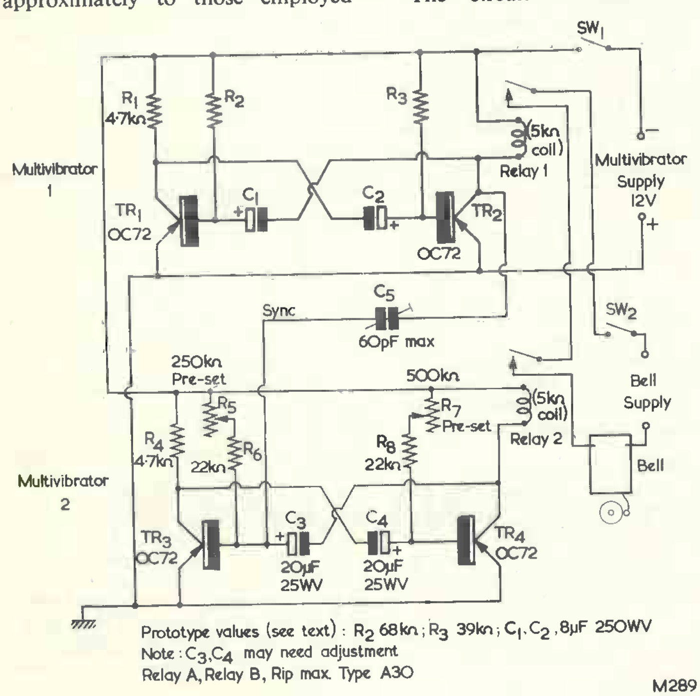
Fig. 1 shows the lower waveform with an on period of 1.1 seconds. This is rather an idealised case because the circuit will function just as well provided that the on period is not shorter than 1 second and does not approach 1.2 seconds. In the first instance the second on period of the composite ringing period would be shortened whilst, in the second instance, part of a third on period could cause the bell to ring momentarily. The fact that there is a tolerance of ± 0.1 second on the on period of 1.1 seconds in the second multivibrator eases circuit requirements and (judging from the writer's experience with the prototype) enables simple circuitry, without frequency compensation, to be employed in the multivibrators. It is only required of the off period in the second multivibrator that it causes the complete cycle to be 3 seconds. This requirement is satisfied because the off period is terminated by a sync pulse.

When the switching device is built in practical form the constructor will only require that the composite waveform ringing times correspond approximately to those employed by the G.P.O., and not exactly, as is illustrated in Fig. 1. The practical approach then consists of having multivibrator 1 offer a constant cycle which is approximately 0.4 second on and 0.2 second off, multivibrator 2 being set up to synchronise with this.



The Circuit

The circuit of the switching device appears in Fig. 2. In this diagram we have two multivibrator circuits, the multivibrators being numbered to correspond with the waveforms of Fig. 1. A relay with a 5kΩ coil forms the collector load of one transistor in each multivibrator, the collector load of the remaining transistor consisting of a 4.7kΩ resistor. The two relays have a set of make contacts, and these are coupled in series with a bell and a bell supply. Both relays have to be energised for the bell to ring.



Multivibrator functioning is quite straightforward in each case, but it is advisable to discuss this in some detail before proceeding further, since certain points have an important bearing on the overall operation of the circuit.

Let us consider multivibrator 1 and assume that it is in the state in which TR_2 is on and TR_1 is off. Because of the previous cycle, capacitor C_1 is now discharging into R_2 (and into other, higher resistance, discharge paths which we shall consider shortly). After a period the base of TR_1 goes sufficiently negative for this transistor to pass current. Its collector at once goes positive, taking with it, via C_2, the base of TR_2. TR_2 collector goes negative in consequence and the cumulative amplifying process given by the multivibrator is set in progress, ending with TR_2 cut off, and TR_1 fully on. Before the changeover, capacitor C_2 was charged nearly to the full supply potential, its right-hand plate being positive. However, TR_1 is now on, and the charge in C_2 causes the base of TR_2 to go positive of its emitter. C_2 discharges through R_3 (and other paths to be considered) and, after a time, the base of TR_2 goes sufficiently negative for this transistor to pass current. Another changeover takes place, resulting in TR_2 being on and TR_1 being off. The next cycle then proceeds.

Two important points arise from this. The first is that the period during which one transistor is on is governed by the discharge time of the capacitor and resistor connected to the base of the other transistor. Thus, TR_2 may be made to stay on for a longer period if either R_2 or C_1 is increased in value. Taking this a stage further, the period during which the relay is energised is governed by R_2 and C_1, and the period during which it is de-energised by R_3 and C_2. This fact has to be borne in mind when setting up the multivibrator.

The second point is that the multivibrator cannot give a true square wave at either collector. To take an example, let us assume that a changeover has taken place which results in TR_1 being cut off. However, the collector of TR_1 cannot rise *immediately* to the potential of the negative supply rail because the right-hand plate of the nearly-discharged capacitor C_2 is held close to the potential of the positive supply rail by the conducting base-emitter diode in TR_2. The collector of TR_1 rises to the negative supply potential relatively slowly, therefore, the speed at which it rises being governed by the charge current in C_2. Thus, negative-going pulses at the collectors are rounded instead of being square. This is an advantage here, because it means that the fall in relay current given when the associated transistor becomes cut off is gradual. The risk of high reverse voltages being generated across the coil, as would occur were there a sudden cessation of energising current, is considerably lessened, and there is no need to connect a protective diode across the coil.

Whilst negative-going pulses at the collectors are rounded, positive-going pulses are square. This is because, when a transistor in the multivibrator conducts, the capacitor coupled to its collector has its other plate connected to the cut-off base-emitter diode of the other transistor. The capacitor does not, therefore, delay the transition to the new potential. For this reason the synchronising pulse for the second multivibrator is taken from the collector of TR_2. This pulse is positive-going (hence sharp) at the instant when the relay energises and so reliable synchronisation is given at the time required. In practice the pulse is sufficiently sharp to enable synchronisation to be effected by the delightfully simple process of fitting the standard r.f. trimmer C_5 between the two multivibrator circuits.

It was stated just now that there are discharge paths for the capacitors in the multivibrator other than the resistor between the appropriate base and the negative supply line. These discharge paths are given by leakage in the cut off transistor and, since electrolytic components are employed, in the capacitors themselves. These leakage paths cannot be predicted and so no firm values can be given for R_2, R_3, C_1 and C_2. The values of these components have to be determined empirically.

Up to now we have mainly considered multivibrator 1. Multivibrator 2 functions in exactly the same manner with the exception that the discharge resistors are made variable. Also, multivibrator 2 is synchronised via the trimmer C_5. The synchronising pulse is positive-going and it is applied to the base of TR_3 when it is in the conducting state. In consequence, a negative pulse appears at the collector of TR_3, this being applied to the base of the cut off transistor TR_4 and initiating, thereby, the multivibrator changeover earlier than would otherwise occur. TR_4 then becomes conductive and energises the relay. Thus, the requirement shown in the centre and lower waveforms of Fig. 1 is met: when multivibrator relay 1 comes on, multivibrator relay 2 is triggered on as well. As is evident from Fig. 1, multivibrator 2 is synchronised by every fifth on pulse from multivibrator 1. In practice this means that the synchronising circuit must select the fifth pulse from the second pulse onwards (the first pulse cannot initiate changeover in multivibrator 2 because TR_3 is then cut off). Such selection is achieved by the requisite adjustment in C_5.

Construction and Setting Up

The procedure followed by the writer in building and setting up the prototype consisted of first putting multivator 2 in working order, carrying on to multivibrator 1, and then coupling the two together by C_5. This approach will now be described.

After multivibrator 2 has been assembled, the 12 volt supply should be connected and the circuit tried out. Initially, the sliders of R_5 and R_7 should be at the centres of their tracks. If all components are in good order the circuit should operate immediately the power is applied. The range of control offered by R_5 and R_7 should next be checked, it being remembered that R_5 (and C_3) control the period during which the relay is energised and that R_7 (and C_4) control the period during which it is de-energised. Timing checks may be conveniently carried out by temporarily coupling the bell and bell supply to the contacts of the relay, and timing the periods when this is on and off with the aid of a watch with a second hand. It is desirable that the relay on period be capable of variation between some 0.9 and 1.3 seconds, and this range should occupy a relatively small portion of the track of R_5. R_7 needs to offer a wider range for the de-energised period: from some 1.7 to 4 seconds. If this range cannot be realised, the value of C_4 may require adjustment, it being remembered that a larger capacitance causes a longer time period.

(It may be found that, because it is necessary for R_7 to insert a considerable amount of resistance to achieve the desired range, relay energising becomes unreliable for the longer time periods. If this is the case, C_4 will have to be increased in value to reduce the resistance inserted by R_7. The writer experienced no difficulty in this respect with the prototype, but mentions the point as a possible cause of trouble.)

After multivibrator 2 has been checked, and is in the condition in which it gives satisfactory time ranges, its ability to synchronise may be tested. It should be possible to trigger the relay on during the off period by applying a 9 volt positive potential to the base of TR_3 via a 0.01μF capacitor, the capacitor being discharged between each application.

Multivibrator 1 next needs to be set up. This is required to give a 2:1 on-off ratio, each cycle occupying 0.6 second. The easiest method of checking the on-off ratio consists of temporarily connecting the bell and bell supply to the relay contacts. It is then quite easy to judge the on-off ratio given by mentally comparing the time when the bell rings and the time when it is silent. The length of the cycle may be judged by counting the number of times the bell rings. There should be approximately 20 ringing cycles in 12 seconds.

The setting up of multivibrator 1 consists of finding the requisite values for R_2, R_3, C_1 and C_2. It will in most cases be found easiest to use fixed capacitances and to vary the values of the resistors. The 8μF components used in the prototype for C_1 and C_2 were employed because they happened to be on hand. Capacitors with lower working voltages would be cheaper. The prototype values for these two capacitors and for R_2 and R_3 given in Fig. 2 were, of course, found empirically, but they should form an adequate starting point for experiment. Each timing period is, of course, roughly proportional to the product of the capacitance and resistance. Thus, if C_1 were doubled, R_2 would need to be halved to give the same relay on period. Values below 22kΩ in either R_2 or R_3 should be avoided.

When multivibrator 1 has been put into satisfactory order, the two multivibrators should be connected together, C_5 fitted, and the series bell wiring coupled up, as shown in Fig. 2. The bell will now only sound when both relays are on.

With C_5 at minimum capacitance both multivibrators will run independently. The capacitance of C_5 should now be increased, whereupon it will be found that an on pulse from multivibrator 1 will trigger an on pulse in multivibrator 2. When this occurs, R_5 should be adjusted such that the on pulse in multivibrator 2 is equivalent to two on pulses in multivibrator 1. The device will now be causing the bell to ring with the familiar "burr-burr . . . burr-burr" rhythm, but spacing between each pair of ringing pulses will very probably be incorrect. The trimmer C_5 should now be set to minimum capacitance again so that the multivibrators run independently once more. Observing the action of multivibrator relay 1, R_7 should next be adjusted such that some five or six operations of this relay occur between successive ringings of the bell (or, in other words, that relay 2 is off for some five or six operations of relay 1). The capacitance of C_5 is now increased until synchronisation occurs, whereupon the bell will once more operate from pairs of ringing pulses. Correct spacing between pairs of ringing pulses is given when relay 1 energises three times between pairs. (This is evident from the centre and lower waveforms of Fig. 1.) It should be found that, according to its setting, C_5 allows spacing between ringing pulse pairs to consist of four operations in relay 1, three operations, or two operations. The correct setting in C_5 is midway between the points where three operations give way to four or two operations. A final adjustment is now required in R_5, this being set midway between the points where the second ringing pulse in a pair is shortened and the point where the start of a third ringing pulse becomes evident. The unit is then set up.

Components

The relays employed in the prototype were Rip Max high speed relays type A30*. They should be set up before use such that they are capable of energising reliably when a 9-volt battery is connected to the coil. The armature should not touch the core when the relay is energised, or de-energising will be unreliable. The Rip Max relay has changeover contacts but only the make pair are used here. The moving contact of the Rip Max relay is common to the frame, so that insulated mountings may be required. The writer has not checked the operation of other relays in this circuit.

OC72's were used in the prototype as they were on hand. It seems probable that any other transistor capable of working at the supply voltages used here could be employed instead.

The electrolytic capacitors employed in the C_1, C_2, C_3 and C_4 positions should be reliable modern components with high leakage resistances. C_5 is a conventional single-leaf r.f. trimmer.

Power Supplies

The power supply may be either a battery or a mains unit. The former is attractive in the present instance, because it ensures portability and because current consumption is low. The battery used should have a low internal resistance if unwanted pulses on the supply rails are to be avoided. (Four 3-volt cycle lamp batteries in series were used with the prototype.) For similar reasons, the output of a mains unit should be well-smoothed, with a large-value capacitor appearing across its output terminals.

The bell supply may be a battery or bell transformer. A common supply for both the multivibrator circuits and the bell is best avoided.

The Prototype

In operation, the prototype gave completely reliable results and was run for several hours without any fall-off in performance. Provided C_5 was set up with reasonable accuracy, there was no tendency for multivibrator 2 to synchronise on the fourth or sixth pulses from multivibrator 1 instead of the fifth pulse. The requisite setting in C_5 for this condition was not critical.

The results given were entirely realistic, but it was found advisable to switch on the multivibrator circuits a second or two before the bell circuit. This was because both relays closed momentarily on switching on, after which the multivibrators settled down to correct operation.

The current consumption of the multivibrator circuits in the prototype varied between 5 and 7mA during the three second cycle.

* These relays are available from Home Radio (Mitcham) Ltd., under Cat. No. Z70.

Marconi TV Cameras for Egypt

The United Arab Republic Broadcasting and Television Service has placed an order with Marconi's Wireless Telegraph Company Limited for the supply of five Mark IV camera channels and associated equipment. English Electric Valve Company Limited 4½in image orthicon camera pick-up tubes will be incorporated.

The cameras, to be installed in the latest of a series of new television studios in Cairo, will be used in the production of plays and theatrical shows and, in general, for any programme which involves audience participation. The studio covers an area of 9,720 square feet (900 square metres), including a theatrical stage.

The Marconi Mark IV camera is now in use in many parts of the world; last year this British equipment gained a premier American award for its design and performance.

ENCAPSULATED UNITS *for the* EXPERIMENTER

By J. ANDERSON

In this article our contributor describes his experiences when encapsulating components and complete circuits in epoxy resin. The resin employed is Araldite, this being available to home-constructors from hardware stores and the like. When using Araldite it is important to ensure that the manufacturer's instructions are followed carefully.—Editor.

MANY CONSTRUCTORS AND EXPERIMENTERS MUST occasionally have been annoyed at the delay involved in testing a particular device because a common unit such as an a.f. amplifier has had to be "knocked up" to complete the circuit. At the same time, if such units are made up beforehand and kept ready for use they tend to be hard to store and to collect dirt and dust, as well as often being heavy and awkwardly shaped owing to the use of conventional chassis.

The author, having frequently met this trouble, decided to make up and keep ready to hand several small units, these including an a.f./r.f. injector for tracing faults, a versatile a.f. amplifier, an r.f. amplifier, and a small pocket receiver. All these units were encapsulated in Araldite epoxy resin.

Making The Circuit

Basically, the principle of this somewhat novel method of construction is to initially make the device wanted in "classical" circuit form (that is, laid out in a rectangular framework on one or at the most two planes, the components being supported by the rigidity of the connecting wiring. The whole is then embedded in a block of material from which connecting pins emerge. The block is finally sanded smooth, painted or varnished, and the internal details either engraved or painted on it in the form of a circuit or a code.

The essential requirements of the embedding material are that it has a high resistance to water, heat, and corrosive chemicals, that it sets without shrinking (which might deform the internal wiring and result in short circuits), and that it has a high electrical resistance. All these requirements are met by Araldite, an epoxy resin which does not "dry" but which hardens chemically, leaving a very tough mass with excellent mechanical and electrical properties.

The circuit to be made up is first converted, on paper, from a circuit diagram to a rectangular plan. See Fig. 1. It is then assembled in this way, care being taken to see that there is no interaction between components carrying alternating currents. If needed a metal screen can be placed in the design at various points. When the circuit framework has been made, it must be tested for faults and adjustments before embedding, as it will be very hard to remove after the Araldite has set. It should be noted that Araldite adheres to all materials in common use provided the instructions are followed carefully.

Now a mould must be made. It will probably be found worth the extra trouble involved to make the mould out of thin sheet metal such as that employed for food tins. Whatever material is used for the mould it must be lined with a thin layer of Vaseline or heavy oil, as the only thing to which the embedding material will not adhere is an oily surface. A small tray, about 1in deep and 1in by 2½in, should accommodate a well-designed average unit, but variations are of course endless. The outside edges of the circuit framework should be covered by at least ¼in of the embedding material and the first step is to pour a layer of material of this thickness in the mould and let it settle. Next, suspend the checked circuit framework in the mould by its connections, and pour in Araldite to cover it entirely. In order to pour it, and to ensure penetration of the framework without bubbles (which will cause mechanical weakness) the material will probably need warming.

If the components are of such a nature that it is felt they might be worth recovering if the unit is ever discarded, then the circuit framework should be dipped in, or painted with, thin insulating paint or shellac (but not oil, which will dissolve the varnish on chokes, etc.), and embedded whilst this coating is *still wet*. This will prevent the adhesive adhering to the components themselves, so that tapping with a hammer at a later date will crack the block and allow the framework to be scraped clean.

The block can be freed from the mould after six to ten hours, but setting is not considered complete for twelve hours. Indeed, the embedding material does not reach its ultimate state, approaching the consistency of wrought iron, for three days.

Setting may be hastened by warming the block, as explained fully by the makers on the carton, but discretion is needed here for the safety of the internal components. After freeing the block, it can be rasped or sanded down to a smooth finish. Fixing holes may be made by drilling slowly with a fine drill, using thin oil as a lubricant. The circuit can either be stamped into the block after setting has started, or painted on; the author used a code with the aid of Panel-Signs transfers.

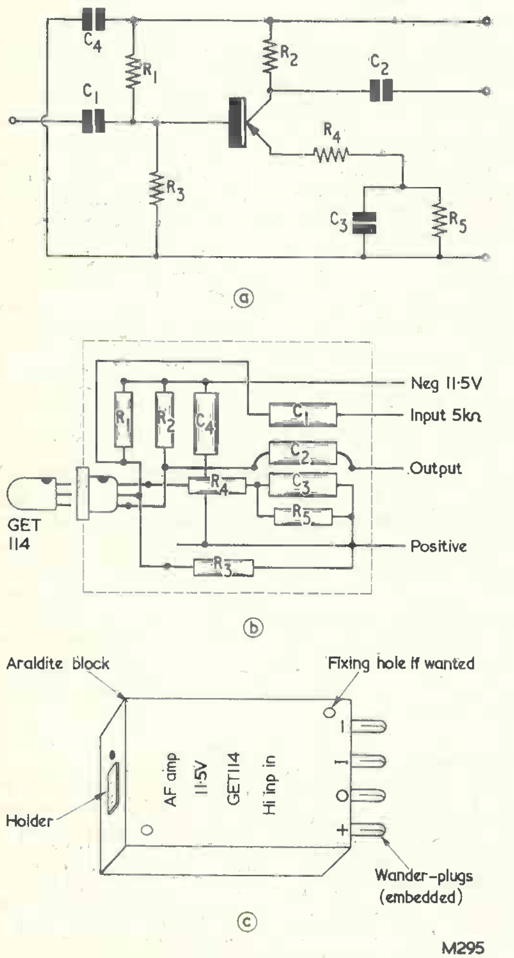


Fig. 1. Showing the three separate stages in the making of an encapsulated transistor a.f. pre-amplifier

Transistors

Transistors themselves may be embedded, but it is probably more economical and safer to embed transistor-holders in one end of the block; the small holders currently available lend themselves to this process well, both mechanically and chemically. When the unit is not in use the holders can be covered with a small strip of adhesive tape to hinder the entry of dust, and prevent contact corrosion. A small spot of paint can be put on the block at one end of the holder to coincide with the spot on the transistor.

It is, of course, possible to recess the holders in the side of the block and, also, to make a larger recess containing two strips of brass into which a cell can be clipped to "switch on" the internal unit. The r.f. injector mentioned above was actually made as a cylinder which fitted into the hand, with a probe at one end and a recess in the barrel into which a battery clipped. The transistors employed were in fact embedded into this unit, which is of a permanent nature.

Plug-in Coils

Plug-in coils for grid-dip meters, and for an all-wave standby receiver, have also been made and embedded in Araldite, the connections in these cases being through octal or miniature valve bases (Araldite will adhere well to clean glass). It is possible to make coil formers from the material, the space for the dust-core being occupied during moulding by a hardened casting made from the inside of an existing former, and the mould consisting of cylinders of stiff paper bound with fine wire.

Other uses found recently for Araldite include the making of internal screens consisting of two sheets of thin "tin" with a thin layer of adhesive between them for rigidity; the fixing down of components which cannot be drilled easily, such

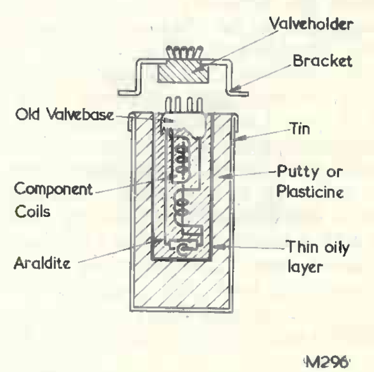


Fig. 2. Method of encapsulating grid-dip, absorption wavemeter or t.r.f. plug-in coils

as miniature transformers; the attaching of panels of a light nature; and even the designing and moulding (in putty moulds) of highly individual knobs. These last were subsequently enamelled black and had the grub screw (greased) cast in them. Two rebuilt i.f. transformers have had the component parts coated with a thin layer of Araldite, giving them a rigidity which has allowed the removal of the customary internal supports, and a subsequent saving in weight (albeit small) in a receiver.

Easily Constructed

TRANSISTOR RECEIVER

By K. BERRY

THE RECEIVER DESCRIBED IN THIS ARTICLE WAS made as the result of a requirement for a receiver that was simple to operate, but which was nevertheless reasonably sensitive. A normal crystal set utilising a simple tuned circuit and semiconductor diode was rejected on the grounds of lack of sensitivity. Also considered, but immediately rejected, was any type of receiver employing manually controlled positive feedback (reaction). Receivers of this type are normally somewhat difficult to operate and, furthermore, if they are used carelessly or mischievously they are a source of nuisance to other listeners in the vicinity. Having disposed of the aforementioned types of receiver, the first circuit tried was one comprising a common base amplifier (OC44) followed by a germanium diode detector. This worked, but gave insufficient audio output, so the next step was to replace the diode with a transistor detector. This functioned quite well, but it was noted that an r.f. transistor (OC44) had been employed as detector. When this was changed for an a.f. transistor (OC71) the output fell considerably. Since, therefore, it appeared than an r.f. transistor was necessary as a detector if optimum performance was to be obtained it was decided to try another arrangement. This consisted of using a germanium diode (which is efficient over the whole range) as a detector, and obtaining extra gain by following it with a single a.f. amplifier stage. The new arrangement was found to be very satisfactory and, indeed, gave more output than when the r.f. transistor was used as a detector. Before finalising the circuit it was decided to check the performance obtained with a common emitter r.f. stage in place of the common base connection then in use. When the r.f. stage had been rearranged, measurements were made which showed that there was a considerable increase in gain with the transistor so connected.

Circuit

The complete circuit is shown in Fig. 1. TR_1 is an untuned common emitter r.f. stage. This is followed by D_1, a germanium diode detector, and the audio output is amplified by TR_2, a common emitter a.f. stage.

There are a few points regarding this circuit which require explanation. The common emitter r.f. stage was chosen, because, as explained in the introduction above, it was found to give more gain than the common base configuration. Now the transistor specified is an OC44, and the cut-off frequency, $f\alpha$, is quoted by the manufacturers as being typically 15Mc/s with limits of 7.5Mc/s minimum and 30Mc/s maximum. As a matter of interest the OC44 used in the r.f. stage was tested and found to have an $f\alpha$ of 23Mc/s with a common emitter current gain, α', of 170. This particular transistor is thus a "good" specimen. If a "poor" specimen with an $f\alpha$ of say 8Mc/s and an α' of 50 had been used, then the receiver would probably have given a considerably inferior performance. When buying transistors, one has no indication of the exact parameters of the specimen one obtains—it may be good or, equally, it may be poor. With this in mind, the r.f. stage is shown again in Fig. 2, only this time the transistor is in the common base mode. Since no extra components are needed, it is very easy to make this change if it is felt that poor gain is being obtained with the particular r.f. transistor in use whilst using the common emitter circuit.

The detector is arranged so that the diode is tapped down the coil, thus preventing excessive damping of the tuned circuit.

Whilst the r.f. stage is fully d.c. stabilised, no such stabilisation has been provided for the a.f. stage. This has been omitted since with high resistance (4,000Ω) phones no damage to the transistor can result—there is furthermore a reduction in the number of components required. Should it be desired to use low impedance phones, then some form of d.c. stabilisation would be desirable. It may be found that the 250Ω rheostat inserted in the emitter lead of TR_1 as a volume control is unnecessary in some areas and it may be omitted if so desired.

Performance

The completed receiver was first tested on an aerial some 12 to 15 feet long, about 3 feet above the ground, an "earth" being obtained from a central heating radiator. This gave reception of the Home Service (M.W.) and Light Programme (L.W.) at a level sufficient for a quiet room. When the receiver was connected to a longer aerial and a proper earth, ample volume was readily obtained.

The measured electrical performance is given below:

(1) *Frequency Coverage*
 Long waveband 160–740 kc/s
 Medium waveband 520–2,400 kc/s

(2) *Power Consumption*
 1.6mA at 4.5 volts

(3) *Sensitivity*
 The input required to produce 100 millivolts across 4,000Ω phones was measured. The r.f. carrier was 30% modulated at 1 kc/s

(a) L.W.

$f(kc/s)$	Input (μV)
160	650
200	480
500	310
700	650

(b) M.W.

$f(kc/s)$	Input (μV)
600	250
1,000	260
1,500	440
2,400	700

The only further comment is that this receiver, having only one tuned circuit, cannot be expected to offer great selectivity, and in localities where there are strong local transmitters, trouble from breakthrough may be expected. This can however be overcome by putting a wavetrap or rejector circuit (à parallel tuned circuit tuned to the frequency of the undesired station) in series with the aerial connection.

Components and Construction

Little need be said about the components. The Mullard transistors and diode specified may be replaced by other makes having similar characteristics, though the use of a reputable make of transistor for TR_1 is strongly recommended. The performance figures quoted are for a receiver using a 500pF single gang air-spaced capacitor. The use of a small solid dielectric variable capacitor will certainly result in reduced sensitivity. To obtain some idea of the losses involved, a Wright and Weaire PHF2 coil was resonated with an air-spaced capacitor of 500kc/s. The "Q" factor of the tuned circuit so formed was 100. The air-spaced capacitor was then replaced with a solid dielectric variable capacitor, whereupon the "Q" of the tuned circuit fell to 40. The actual position in the receiver will not be as bad as these figures would suggest because the tuned circuit is damped by the input circuit (TR_1) and the detector (D_1). Compared with these losses, the effect of the solid dielectric capacitor may be negligible. However, if increased size is no objection, the use of an air-spaced capacitor will ensure maximum efficiency.

The prototype receiver was mounted in an Eddystone die-cast box approximately $4\frac{5}{8}$ x $2\frac{3}{16}$ x $3\frac{5}{8}$in in size. Aerial and earth leads were brought out to terminals and phone leads to an Igranic jack socket. Four small rubber feet were fitted to the underside of the box to prevent scratching polished surfaces, though two strips of the self-adhesive plastic foam would do just as well.

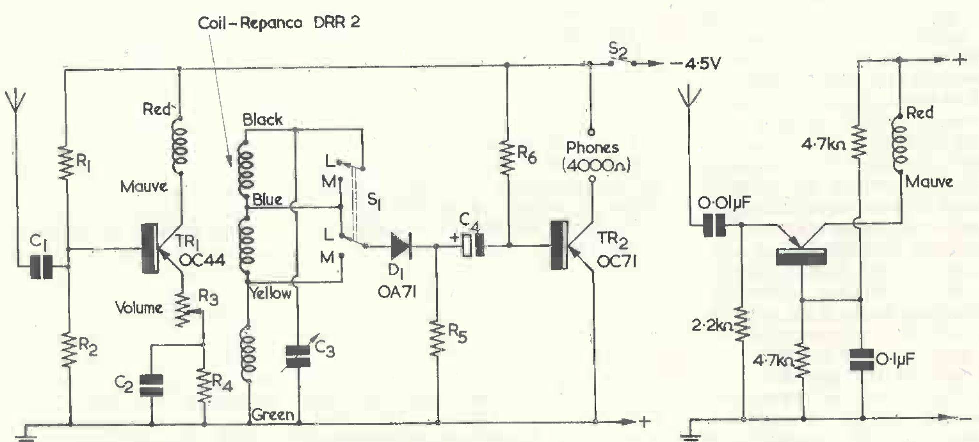


Fig. 1. Circuit of the transistor receiver

Fig. 2 (right). An alternative r.f. stage. This may give more gain with some transistors M294

Components List (Fig. 1)

Resistors

R_1	4.7kΩ ¼ watt
R_2	4.7kΩ ¼ watt
R_3	250Ω potentiometer
R_4	2.2kΩ ¼ watt
R_5	8.2kΩ ,,
R_6	1MΩ ,,

Semiconductors

TR_1	OC44 Mullard
TR_2	OC71 Mullard
D_1	OA71 Mullard

Coil

Repanco Dual Range type DRR2

Capacitors

C_1	0.01μF 150 w.v.
C_2	0.1μF 150 w.v.
C_3	500pF variable (see text)
C_4	8μF electrolytic 6 w.v.

Phones

4,000Ω (with jack plug and socket)

Switches

S_1	Wavechange d.p.d.t.
S_2	On/off s.p.s.t.

Universal BATTERY CHARGER
FOR WET AND DRY CELLS

by M. J. PITCHER B.Sc.

THIS IS A BATTERY CHARGER WITH a difference. It can be used to recharge accumulators and to revive dry cells. The section for dry cells is based on a circuit published some years ago in *Wireless World*.[1] A similar circuit has also appeared in *Short Wave Magazine*.[2]

Accumulator charging

The circuit for accumulator charging is quite conventional. A full-wave bridge rectifier is used to supply current from a standard transformer. The size of the maximum charging current depends on the depth of the constructor's pocket; in the writer's case a current of 2 amps was chosen. It is generally considered that the best charging current is one tenth of the ampere-hour rate of the accumulator, whereupon a car battery needs between six and eight amps according to its size. Lower currents will also charge the battery, but with less efficiency. Trickle-charging at half an amp or less should be accompanied by regular charging at the full rate.

The length of charging time depends on the size of the battery and the state of its charge. Consider a car battery of 60 ampere-hour capacity which has become discharged in normal use. Charging at 2 amps for 30 hours will bring it up to somewhere near full charge, and this is not an unduly long time. Normally, charging is carried out at regular intervals so that the battery is not allowed to become entirely exhausted; the charging time is proportionately shorter and the life of the battery is extended.

The state of charge of an accumulator should *not* be arrived at by guesswork. The best method is to use a reliable hydrometer. Remember that, as with other electrical equipment, a "cheap" article is likely to prove very expensive in the long run.

The low charging current of 2 amps has the advantage that it will not cause violent "gassing" as the cells reach full charge, nor is it likely to result in overheating the electrolyte.

A Low-cost Ammeter

The ammeter shown in the circuit diagram is essential. It enables the current to be regulated so that it remains within the rating of the rectifier.

To avoid purchasing a relatively expensive new meter, the writer obtained a surplus r.f. thermo-couple ammeter, which is a high grade moving-coil meter, for six shillings. These instruments generally have a full-scale deflection of 5mA when the thermo-couple is removed. The scale is not linear but for battery charging non-linearity is of no account.

It is a simple matter to bypass, or entirely remove, the thermo-couple. It should be pointed out here, that is is a wise precaution to spread a large newspaper over the workbench or table before removing the case of any meter. This prevents the loss of small and irreplaceable screws, and stops iron filings from attaching themselves to the magnet. The greatest caution is needed when the case is removed, since the working parts of a moving-coil meter are extremely delicate.

When the meter has been re-wired so that the terminals connect directly to the coil a shunt can be fitted to provide its new range. In the writer's case the shunt was made from a length of cotton covered 20 s.w.g. copper wire, a length of this wire being connected in series with the charging unit and a reliable meter. The converted thermo-ammeter was then connected to a short length of the copper wire by pushing a pointed prod through the insulation. In this way the correct length of wire needed to produce about three-quarter scale deflection was found quickly and safely. A similar method could be employed by constructors.

The existing scale readings can be removed by gently scraping them with a sharp penknife. The dust formed by the scraping should be blown away from the working parts. After this, new figures can be marked in with Indian ink and an ordinary pen nib, whilst temporary marking can be carried out with a pencil.

It is not, of course, essential to employ a converted thermo-ammeter of this type in the charger, and a conventional instrument could be used in its place. However, the writer has described the method of making up the meter fitted in his own unit because of the significant saving in cost which resulted.

Dry Cell Reviver

The circuit for dry cell reviving is unusual. It is meant to be used for 4.5 volt batteries. These cannot be recharged in quite the same way as an accumulator, and the process is best thought of in terms of reactivating, or reviving.

The circuit diagram shows that half-wave rectification is produced by W_2. This component is bypassed by a 200Ω 2 watt resistor so that the current flowing through the cell consists of both a.c. and d.c. The flashlamp bulb L_2, rated at 3v 0.2A, serves to regulate the current.

The battery, after being revived, has a higher e.m.f. than usual. This falls to its normal value after the cell has been in use for a little while. The abnormal e.m.f. does not matter for most uses but care is obviously necessary if the battery is to be used for operating transistor circuits.

The dry cell reviver was originally used by the writer to reactivate a battery that provided power for a parking light on his car. It was found that an EverReady battery type 126 would light a 6 volt bulb for about ten hours each night for 5 to 6 nights without reactivation. *By connecting the battery to the reactivator all day, and using it to power the lamp at night, the same battery had a useful life of 19 to 20 nights.*

The reviving process has been found to be most effective if periods of use alternate with reactivation. It is, nevertheless, possible to put new life into batteries that have had prolonged use in torches, door-bells, and model trains.

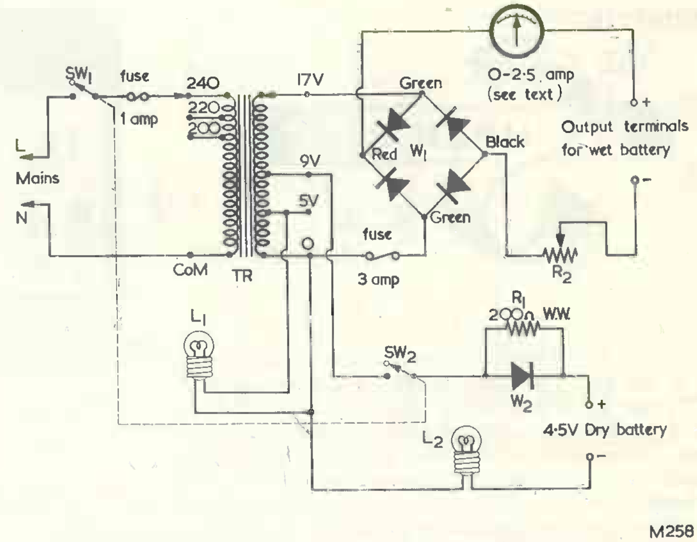
[1] "Dry Cell Reactivator", R. W. Hallows, *Wireless World*, October 1955.

[2] "Longer Life for Dry Batteries", J. B. Dance, M.SC., *Short Wave Magazine*, April 1960.

Components List

TR	2 amp charging transformer.
W_1	Bridge rectifier to suit the above.
W_2	6V 0.5amp rectifier, half-wave.
R_1	200Ω 2 watt, wirewound.
R_2	Rheostat. See text.
L_1	6V 0.04A pilot bulb.
L_2	3V 0.2A regulating bulb.
	Meter. See text.
$SW_{1, 2}$	D.P.S.T. tumbler switch.

Panel-mounting fuse holders and fuses. (Two sets, 3A and 1A).
Output terminals. (Four required.)
Panel-mounting signal lamp holders. (Two required.)
Voltage selection strips. (Two required.)
Case, hardware, etc.



Construction

There are no special problems concerned with the assembly of the charger and the constructor can choose any layout that appeals to him. To the builder of radio receivers the making of a battery charger is, indeed, like having a restful holiday!

Adequate ventilation should be provided if the unit is to be housed in a very small case. The writer used a shallow metal box measuring 10½in square by 3½in deep which was a piece of ex-Government surplus. The cover was not used, a piece of thick plywood being cut to fit the box with all the components mounted on it. This ply "bread-board" was bolted to some angle-iron which, in turn, was bolted to the box. In this case no special provision was made for ventilation, and the unit was left running for many hours without showing any sign of generating too much heat.

The pilot lamp L_1 and the regulating lamp L_2 were mounted in lamp holders to act as indicators. The fuses, switch, and rheostat R_2 were mounted on the front of the panel to be easily accessible. Voltage adjustment strips were used for both the mains and low-tension side of the transformer, these also being panel mounted.

A double pole, single throw, switch is used to cut the live side of the mains supply and also to disconnect the dry cell section. The writer initially used a changeover switch to permit only one kind of charging at a time, but this was found to be unnecessary as the transformer could supply the extra current when it was required to do so.

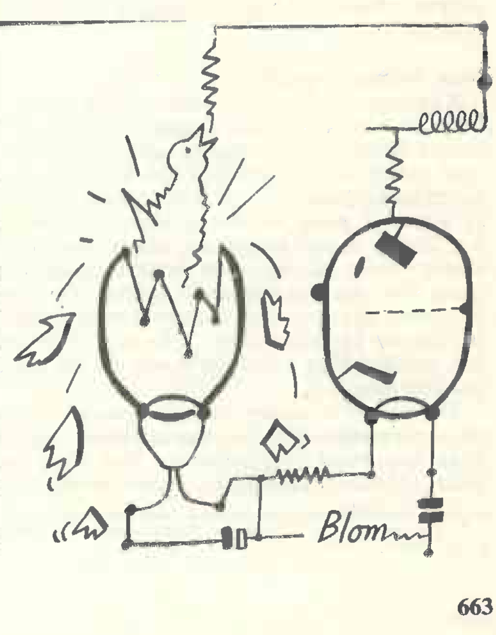
The rheostat R_2 needs to be fairly small physically, and its value should be between 1 and 3Ω. Such an item is not easy to obtain ready-made. The writer modified a 12Ω type by soldering some Eureka wire at intervals along the underside of the resistance coil. The length of wire needed was determined experimentally by touching it on the rheostat before soldering.

Microwave Link Contract for G.P.O. Space Station awarded to Pye Telecommunications Limited

Pye Telecommunications Limited of Cambridge announce that they have been awarded a contract by the British Post Office for a three-hop microwave link between Plymouth and Goonhilly in Cornwall—the United Kingdom terminal for the trans-atlantic satellite communication experiment planned to take place later this year.

The link will take television programmes from the existing G.P.O. network at Plymouth and transmit them over the Pye 7,000 Mc/s equipment to Goonhilly—a distance of 60 miles. From Goonhilly the programmes will be transmitted via satellites "Relay" and "Telstar" to the American Satellite Ground Station at Andover, Maine, and thence into the American television network.

The equipment is similar to that currently being supplied to the B.B.C., I.T.A. programme contractors and many other users. It is suitable for 405, 525 or 625-line transmission.



MODIFYING THE SUPER 3

By

J. C. FLIND

UNTIL THE "SUPER-3" DESIGN WAS FEATURED IN the May 1961 issue of *The Radio Constructor*,* the writer had for a long time been looking for a pocket transistor receiver to meet a special need. What was wanted was a really personal set employing a deaf-aid type earpiece, so that it could be used in bed or in a deck-chair without annoyance to others, and with sufficient sensitivity to ensure a worthwhile signal of good entertainment value on both long and medium wavelengths. Several published t.r.f. circuits had been tried but only with moderate success, usually because of instability or poor sensitivity, while superhets were "out" because of high cost and complexity.

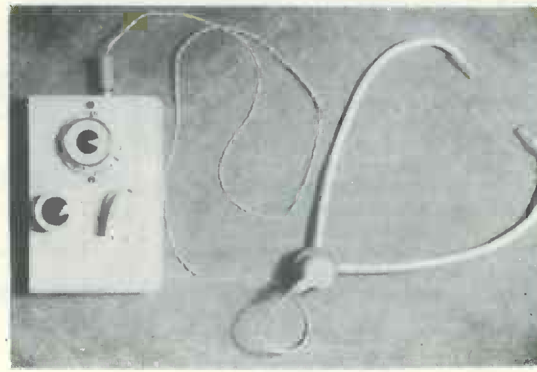
The "Super-3", whose circuit is shown in Fig. 1, looked more hopeful, as it featured two r.f. transistors in a regenerative circuit which seemed to promise adequate pick-up from the internal ferrite aerial. Accordingly the very reasonably priced kit was purchased and assembled. Assembly was an easy proposition, thanks to the printed-circuit chassis, which offered a great help towards neatness and small size. First trials came up to expectations, so the next step was to modify the design to meet the requirements stated above, at the same time taking the opportunity which the use of an earphone output offered to improve certain features of the original kit.

New Tuning Capacitor

Removal of the loudspeaker unit left a space large enough to accommodate a standard Radiospares 500pF solid-dielectric tuning capacitor—this type, while inexpensive and not an ultra-miniature component, occupies only a little over a square inch of area. A piece of thin aluminium sheet cut to 3 x 2in—a useful protection against hand-capacity effects while tuning—was bolted inside the lid, using the two holes already drilled for fixing the discarded speaker, and a central hole drilled in it to take the capacitor bush. The bush itself and the ¼in spindle were trimmed down to the minimum possible length.

The use of a rotary tuning capacitor instead of the compression-type trimmer supplied with the kit, is an important improvement. Not only does the rotary capacitor make for easier handling but it also makes it possible to provide a tuning scale, thus greatly simplifying searching for the desired programme.

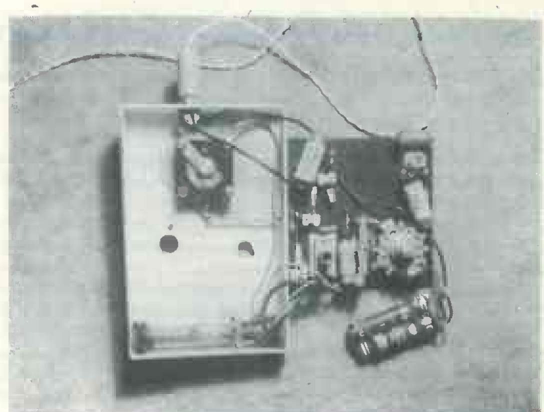
* "The Super-3, A 3-Transistor Pocket Receiver", described by R. A. Langis, *The Radio Constructor*, May 1961.



Front panel view of the modified "Super-3" receiver with headset attached

Experiment now showed that the tuning range had shifted towards the low-frequency end of the scale, so that Luxembourg and the Medium wave Light Programme were no longer tuneable. To put matters right some turns were cautiously removed, a few at a time, from the primary or aerial coil of the ferrite rod—in all about 18 turns has to be taken off, and the coverage then extended from just under 200 metres to around 600 metres. The removal of so many turns affected the ratio between the aerial and the coupling coil, with the gratifying result that signal transfer noticeably improved. A less happy effect was that the B.B.C. Long wave transmitter now lay outside the tuning range. A new value for C_1 had to be found by experiment, and this turned out to be 2,500pF.

It should be noted here that in the Long wave position of the control switch the tuning capacitor operates more as a trimmer than as a true tuner: C_1 and TC_1 are in parallel so that their total capacit-



Rear view of the receiver showing the new tuning capacitor and regeneration control

Components List

Resistors

- R_1 2.2kΩ ⅛ watt
- R_2 4.7kΩ ⅛ watt
- R_3 680Ω ⅛ watt
- R_4 1kΩ ⅛ watt
- R_5 4.7kΩ ⅛ watt
- R_6 10kΩ ⅛ watt
- R_7 2.2kΩ ⅛ watt

Capacitors

- C_1 1,500pF ceramic
- C_2 0.1μF tubular, 150WV
- C_3 16μF, electrolytic, 6WV
- C_4 2μF, electrolytic, 6WV
- C_5 560pF, ceramic
- C_6 0.1μF, tubular, 150WV
- C_7 2μF, electrolytic, 6WV
- TC_1 250pF variable trimmer

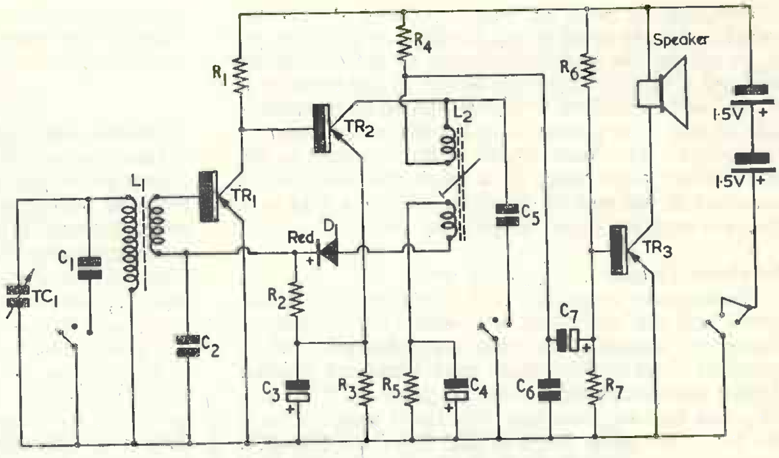


Fig. 1. The original "Super-3" circuit M264

Transistors

- TR_1 Surface barrier r.f. type (R & TV Components Ltd.)
- TR_2 Surface barrier r.f. type (R & TV Components Ltd.)
- TR_3 V10/15 (R & TV Components Ltd.)

Batteries

Ever Ready U16 (2).

Miscellaneous

Case, 3-way 4-pole switch, balanced armature insert, printed circuit board, ferrite rod aerial assembly, coil L_2, germanium diode, knob, nuts and bolts, etc. (R & TV Components Ltd.)

ance can be varied approximately only from 3,000pF to approximately 2,500pF, a ratio of 1.2/1. (In the original design the capacitance range was 1,800pF to 1,500pF.) Accordingly the tuning range is limited to a few kc/s, but as few listeners on this waveband will be interested in anything other than the B.B.C. on 200 kc/s this is not a matter of great importance.

Variable Regeneration

The tuning dealt with, there remained available the vacant space occupied in the original design by TC_1, and it was decided to incorporate a variable regeneration control: the designer's idea of paralleling the leads to the base of TR_1 and the collector of TR_2 proved rather tricky, and the optimum setting was not the same for all frequencies. The most satisfactory method found was to join these leads by the smallest postage-stamp type trimmer that could be purchased (3–30pF) and to mount this in such a way that it could be controlled by a knob outside the case. The trimmer was fixed to a small square of thin plywood, drilled so as to allow the adjusting screw to project downwards, the plywood then being mounted, with contact glue, on to the printed circuit board between TR_1 and C_2 in such a way that the head of the adjusting screw came directly under the small hole already drilled in the case for the original tuner. A short length of ¼in brass rod (or preferably, for greater strength, tube) soldered to the head of the adjusting screw will project through the case ready to accept a suitable knob.

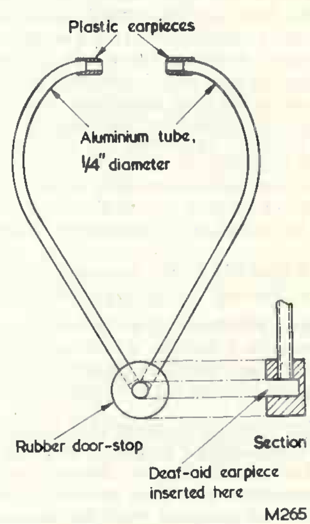


Fig. 2. The "stethoscope" headset

This spindle and the one operating the on-off switch were trimmed down as short as possible, so as to reduce the overall thickness of the completed set, and a tuning scale was added in the form of a disc of white celluloid or ivorine, glued to the underside of the tuning knob and calibrated by hand in indian ink. The leads which originally went to the loudspeaker were taken to a miniature jack socket mounted in the end of the case, so that a lead to a deaf-aid earpiece could be plugged in.

Earphone Output

The earpiece employed had a resistance of about 250Ω, and did not work very well with the output transistor supplied, so this was changed for a standard "red-spot" which gave excellent results. (Other transistors were tried in place of TR_1 and TR_2, but best results came from those supplied with the kit.) In order to facilitate these experiments none of the transistors were soldered directly into the circuit, but transistor holders were used, so that they could be plugged in. Not only does this procedure make experimenting easier, but it protects the transistors from accidental damage by heat.

The set was now operating really well—in the Greater London area all the B.B.C. transmissions could be made loud enough to be uncomfortable to the ear (control of volume is easily obtained by tilting or rotating the whole set so as to reduce aerial pick-up). After dark under good reception conditions and with careful orientation and adjustment of the regeneration control, Luxembourg and other Continental stations came in at good strength.

A Stethoscope Headset

One further improvement seemed worth while—the provision of a "stethoscope" headset for listening over long periods or in noisy surroundings. An inexpensive but highly satisfactory unit was made up using as a basis an ordinary rubber doorstop, obtained for a few pence from Woolworths. With a tubular cork-borer, kept wet during the operation, two radial holes, ¼in diameter and about 75° apart, were bored from the circumference down to the centre, and short lengths of soft aluminium tube plugged in. These were then bent by hand as shown in the illustration, a piece of spring curtain-rod threaded inside preventing the bores from collapsing during bending. The two radial holes and the inner ends of the tubes, of course, connect with the axial hole thoughtfully left by the manufacturers of the doorstop, and the deaf-aid earpiece is plugged into this. The whole outfit weighs just an ounce, and can be taken to pieces in a moment for carrying in the pocket. The improvement in quality of the sound, coupled with the absence of interference from extraneous noise, has to be experienced to be believed. As an additional refinement, plastic earpieces can if desired be shaped and fitted over the ends of the tubes.

Book Reviews . . . .

THERMIONIC VALVE CIRCUITS, Fourth Edition. By Emrys Williams, Ph.D., B.Eng., M.I.E.E., M.Brit.I.R.E. 427 pages, 5½in by 8½in. Published by Sir Isaac Pitman & Sons, Ltd. Price 27s. 6d.

"This book is not about valves but about valve-circuits." The very first sentence of the preface to the fourth edition of *Thermionic Valve Circuits* fully informs us of its purpose. Indeed, out of its 427 pages, only 17 are devoted to the thermionic valve. Another 9 give a summary of the a.c. theory and mathematics involved, and all the rest are devoted to valve circuits. Further, the direct approach evident from the first sentence just quoted permeates the whole book.

A prodigious number of different valve circuits are described, the widely diverse list including a.f. phase-splitters, adding circuits, wide band amplifiers, the flip-flop, valve voltmeters, voltage multiplying rectifiers, servo systems, bridge rectifier frequency changers, the cascode amplifier, reactance valves, computer gate circuits, and many more. In each case, performance is described and evaluated mathematically.

The end of the book contains a newly added set of problems with answers (there are over a hundred on amplifiers alone) and, as the author helpfully points out in the preface, some of these are trick questions aimed at the reader who may be tempted to give an answer with insufficient information.

This is an excellent handbook for the engineer. It is equally useful as a text-book for the university student.

USING TRANSISTORS, Second Enlarged Edition. By D. J. W. Sjobbema. 136 pages, 5¾in by 8¼in. Published in the "Popular Series" by Philips Technical Library. Price 15s.

This book, printed in the Netherlands, is another addition to the well-known Philips Technical Library. It deals with transistors in a manner which can be readily appreciated by the home-constructor, and the final chapter provides 14 tested practical transistor circuits, including amplifiers up to 15 watts, three radios, and a d.c. converter. There is no shortage of circuits in the remainder of the book, however, where the text is amply illustrated by the accompanying diagrams.

The book commences with an introduction to transistor theory, carrying on to transistor characteristics and the influence of temperature changes. Practical circuit techniques for a.f. and r.f. amplifiers together with oscillators and mixers appear in one chapter, whilst another (incorporated in the new edition) is devoted to pulse techniques and shows the transistor employed in multivibrators and blocking oscillators. Two remaining chapters deal with transistor measurements and practical hints for mounting and servicing.

The English translation is by P. J. Arthern, and the book is distributed in the U.K. and Eire by Cleaver-Hume Press Ltd.

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

part 8

understanding radio

By W. G. MORLEY

IN LAST MONTH'S CONTRIBUTION TO THIS SERIES WE completed our consideration of resistors and resistance. We also saw that if two plates are mounted parallel to each other they form a capacitor, and are capable of being charged.

Capacitance

As we have seen, two parallel metal plates form a capacitor which is capable of being charged, or of holding a *charge*, if a battery is connected to them and then disconnected again. The charge exhibits itself as a deficit of electrons on one plate and a surplus on the other, the condition being maintained because the surplus electrons are attracted towards the plate having the deficit. The surplus electrons may be considered as congregating on the surface facing the plate having the deficit.

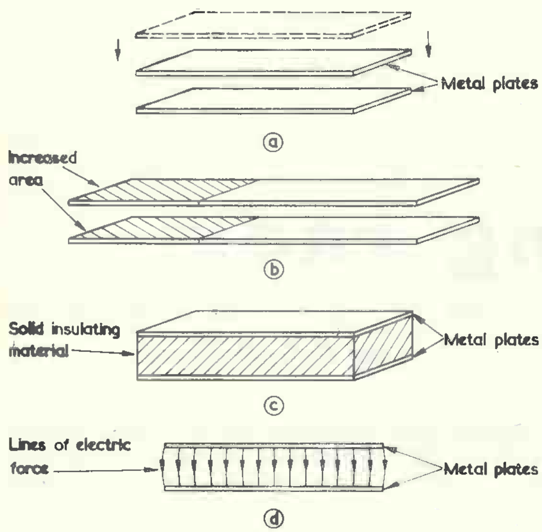
The surplus electrons maintain their position because of the attraction exerted by the other plate. If we were to bring the plates closer together, as in Fig. 35 (*a*), we would find that it would be possible for more surplus electrons to be held in position because the attraction towards the other plate would become greater. In consequence, bringing the plates closer together increases the charge that the capacitor may hold.

If we maintained the same distance between the plates but increased their area, as in Fig. 35 (*b*), we would find that the charge which the capacitor could hold would once again increase. The reason for this is simple enough: there is a larger area over which surplus electrons may be retained in position. It should be remembered that, both in this instance and in that of Fig. 35 (*a*), the increase in electrons is balanced by an equal deficit of electrons on the other plate.

Up to now we have assumed that our two plates are mounted in air, with the result that air is the insulating material between the two. If we were to maintain the two plates at the same distance but were to insert a solid insulating material (such as, say, glass) between them, we would find that the charge they could hold would once more increase. See Fig. 35 (*c*). The reason for this is not so obvious as in the other two instances, and it may be briefly outlined in the following manner. It is assumed that when the capacitor is charged *lines of electric force* appear between the two plates, as illustrated in Fig. 35 (*d*). These imaginary lines are usually given a direction, shown by an arrow which points away from the positive point (in this case, the plate with the deficit of electrons) to the negative point, and they are assumed to have a contracting elastic effect in that they attempt to draw unlike types of electricity together. The lines of force constitute an *electric field*, and the strain they exert is proportional to the *electric flux density* of that field. We need go no further in this context than to state that an increase in electric flux density is proportional to an increase in the attractive force between the unlike types of electricity. It so happens that solid insulators permit higher electric flux densities than does air, so that by replacing the air between our two plates by a solid insulator we enable more surplus electrons to be maintained in position. The capacitor is, therefore, capable of holding a larger charge.

The ability of a capacitor to hold a charge is defined in terms of its *capacitance*, or *capacity*. As the capacitance of a capacitor increases, so does the charge it can hold. Let us now re-examine the instances given in Figs. 35 (*a*), (*b*) and (*c*), and see how they are related to capacitance.

In Fig. 35 (*a*) we brought the plates closer together, whereupon we increased the charge which the capacitor could hold. In other words we increased its capacitance. In practice, the capacitance offered by the plates varies as the reciprocal of the distance between them; that is, it varies as $\frac{1}{d}$, where d is the distance. If d is halved, capacitance is doubled.



M277

Fig. 35. The capacitance between two metal plates may be increased by (a) bringing the plates closer together, (b) increasing their area, or (c) replacing the air between them with a solid insulating material. In (d) lines of electric force appear between the plates (shown edge-on). The upper plate is positive (i.e. it has the deficit of electrons)

In Fig. 35 (*b*) we increased capacitance by increasing the area of the plates. Again a simple relationship holds true, and this time the capacitance varies directly as the area of the plates. If the area is doubled, so also is the capacitance.

In Fig. 35 (*c*) we replaced the air insulation between the plates by a solid insulating material, and once more increased the capacitance. In this case the capacitance is increased by reason of the increased electric flux density between the two plates. The ratio between the electric flux density permitted by an insulating material and that permitted by a vacuum is known as the *dielectric constant*, or *permittivity*,[1] of the material. The dielectric constant of air is 1.006 (which means that flux density in air is 1.006 times that in a vacuum) and this is near enough to 1 for most practical requirements. The dielectric constant of solid insulators is higher than that of air, a typical figure being 6.2 for certain types of glass. As we would now expect, replacing the air between the plates by a solid insulating material causes the capacitance to be multiplied by the dielectric constant of the insulating material. In other words, capacitance varies as the dielectric constant of the material between the plates.

We may now combine the three points we have just observed by stating that capacitance varies as $\frac{KA}{d}$, where K is the dielectric constant of the material between the plates, A is the area of the plates, and d is the distance between them.

The basic unit of capacitance is the *farad*, this being subdivided into the *microfarad* (one millionth part of a farad), and the *micromicrofarad* (one millionth part of a microfarad). The micromicrofarad is normally referred to as a *picafarad*, and this is the term which we shall use in these articles.[2] The abbreviation for farad is F; for microfarad, μF; for micromicrofarad, $\mu\mu$F; and for picafarad, pF. In practice, the farad is too large a unit for radio work, and it is normal to talk of capacitance in terms of microfarads and picafarads.

Capacitance varies, as we have just seen, as $\frac{KA}{d}$. Using measurable units, the relationship may be shown as follows:

$$C = \frac{KA}{4\pi d}.$$

This equation holds true when C is capacitance in picafarads, K is dielectric constant, A is the area of one plate in square centimetres, and d is the distance between the plates in centimetres.

Terminology

It is necessary at this stage to clear up a few minor points of terminology.

We have referred[3] to a *capacitor*, or *condenser*. We have also referred to *capacitance*, or *capacity*. The terms "capacitor" and "condenser" mean exactly the same thing, the use of the former word being that which is nowadays preferred. Similarly, "capacitance" and "capacity" mean exactly the same thing, and it is once again the former word whose use is preferred. We have also referred to the *dielectric constant* of the insulating material between the plates. This insulating material is known as the *dielectric* of the capacitor, the term "dielectric" being applicable for all insulating materials including air or a vacuum.

Recapitulation on several of the points raised up to now is also desirable. When we discussed the charge held by the capacitor we referred to the plates as having either a surplus or a deficit of electrons. Some texts explain the action of a capacitor by referring to the plate with the surplus of electrons as being "negatively charged", and the plate with the deficit of electrons as being "positively charged". The unlike charges on the plates are then

[1] Or, sometimes, "specific inductive capacity".

[2] A picafarad is described, in slang parlance, as a "puff".

[3] In last month's issue.

said to concentrate on the facing surfaces because of their mutual attraction.

Finally, it was stated that the capacitance of the capacitor increases when the dielectric is changed from air to a solid insulator, since the dielectric constant of solid insulators is higher than that of air. It should be pointed out that the capacitance will also increase if the air is replaced by a *liquid* dielectric, since the dielectric constant of liquid insulating materials is similarly higher than that of air. A liquid dielectric could, of course, be used by suspending the plates in it. Table VI shows representative dielectric constant figures for commonly encountered insulating materials, including two liquids.

TABLE VI
Representative Dielectric Constants

Material	*Dielectric Constant*
Air	1.006
Bakelite	4–6
Crown Glass	6.2
Mica	7–7.3
Mineral Oil	2–2.5
Paraffin	2–2.5
Polystyrene	2.4–2.9
Porcelain	6–7
Quartz	4.2
Rubber	2–3

Electricity in a Capacitor

Since a capacitor is capable of holding a charge which consists basically of electrons displaced from their normal positions, it can be said to store a quantity of electricity. We have already seen that quantities of electricity are measured in coulombs[4]. Coulombs are related to capacitance and the e.m.f. applied to a capacitor in the following simple manner:

$$Q=CE$$

where Q is the quantity in coulombs of electricity held by the charged capacitor; C is the capacitance in farads; and E is the applied e.m.f. in volts.

This equation is not required in elementary radio work, but it is introduced here for the sake of completeness and because it shows that the charge held by a capacitor is not only proportional to its capacitance. It is also proportional to the voltage of the applied e.m.f.

Multi-Plate Capacitors

In Fig. 35 (*b*) we saw that increasing the area of the plates of a capacitor causes an increase in capacitance. An alternative method of increasing the effective area of the plates consists of stacking them, as in Fig. 36 (*a*), with alternate plates connected together. A capacitor of this nature can be described as a *multi-plate capacitor*, and it enables high values of capacitance to be obtained in a compact assembly. So far as capacitance is concerned, the total effective area in the multi-plate capacitor is the sum of the facing surface areas of one set of plates. Fig. 36 (*b*) shows this clearly in a five-plate capacitor. Surfaces B, C, D and E form the total effective area of the set connecting to the right hand terminal, because they face the surfaces of the other set of plates. Surfaces A and F offer no useful contribution to capacitance, as they face outwards. At the same time, surfaces W, X, Y and Z of the set of plates connecting to the left hand terminal form the total effective area for this set. Whichever set of plates is considered the total effective area is four times that of the area of a single plate, a figure which is, incidentally, 1 less than the number of plates. This applies for any number of plates, and the capacitance of a multiplate capacitor is expressed by:

$$C=\frac{KA(n-1)}{4\pi d},$$

where C is the capacitance in picafarads, K is dielectric constant, A is the area of one plate in square centimetres, d is the distance between the plates in centimetres, and n is the number of plates.

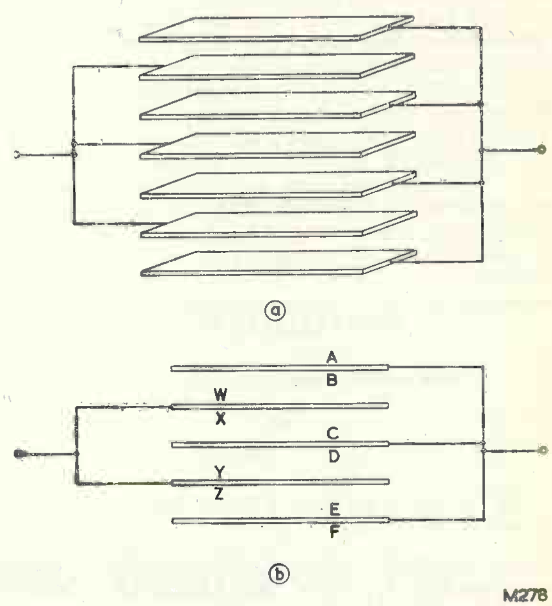


Fig. 36 (a). In a multi-plate capacitor, alternate plates are connected together
(b). Demonstrating the manner in which the capacitance of a multi-plate capacitor is calculated. The letters refer to the surfaces of the plates

If there are two plates (n–1) equals 1, and so the equation applies to a two-plate capacitor as well.

Overlapping Plates

Up to now we have considered capacitors whose plates have the same shape and area, and which are

[4] In "Understanding Radio", part 1, August 1961 issue. A coulomb is equal to 6.29 x 10^{18} electrons.

positioned directly above each other. It is also possible to form a capacitor with plates which overlap only, instead of having their total areas facing each other. A typical example is shown in Fig. 37 (*a*). With a capacitor of this nature the effective area, so far as capacitance is concerned, is the area of overlap. In practice, the actual capacitance will be slightly greater than that calculated from the overlap area. This is because of a "fringe effect", wherein additional capacitance appears between the edge of one plate and the surface of the other. The "fringe effect" is illustrated in Fig. 37 (*b*) by showing lines of electric force of the type we examined in Fig. 35 (*d*). These "spread out" at the edges concerned. The "fringe effect" has to be taken into account if the area of overlap is relatively small or the distance between the plates is relatively large (both of which infer a low capacitance), but may otherwise usually be ignored.

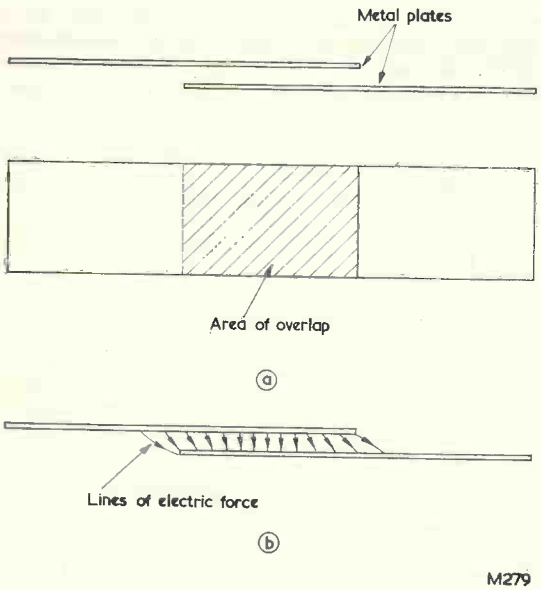


Fig. 37 (a). A capacitor is formed when two plates overlap, and capacitance can be calculated from the area of overlap
(b). The "fringe effect" referred to in the text can be demonstrated in terms of "spreading out" of the lines of electric force between the plates

When plates of equal area and shape are mounted directly above each other, a "fringe effect" can also take place between one plate (or set of plates) and the means of connection to the other. Again, this effect need only be taken into account if the capacitance of the plates is relatively low.

Leakage

There is no such thing as a perfect insulator. Because of this, it is impossible for a capacitor to hold a charge for an infinite length of time. Such a charge must, instead, gradually leak away between the plates via the material employed as the dielectric. (In an air-dielectric capacitor a second leakage path is provided via the insulated mounting for the plates.) The process is known as *leakage*.

In radio work a variety of materials are used as dielectrics, these having varying degrees of efficiency as insulators. In many practical circuits insulation efficiency is not a criterion in the selection of a particular dielectric, although some circuits require capacitors having dielectrics with exceptionally high insulation efficiency. We will deal with the efficiency of various dielectrics when we consider practical capacitors.

Because of the development of a fault, a capacitor dielectric may exhibit an insulation efficiency which is significantly lower than it should normally have. The charge on such a capacitor will leak away rapidly in consequence. A capacitor having a fault of this nature is said to be *leaky*.

Dielectric Strength

A material functions as an insulator because it has very few free electrons to allow the passage of an electric current. If, however, a sufficiently high e.m.f. is applied across two faces of an insulator its electrons may be forced out of their proper orbits and a current will flow. In the case of a solid insulating material the rupture in the molecular make-up of the material caused by this flow of current is usually permanent, and may incur a chemical breaking down of the material into its constituent parts. This effect is especially true of organic insulating materials, in which the rupture may cause the appearance of carbon along the path through which the current has passed. In such a case, the insulating material now becomes useless, because a conducting path exists between the two faces.

If the insulating material is air, the sudden flow of current causes the breakdown of oxygen molecules and the appearance of a spark. In this case, however, new air takes the place of that broken down, and the effect of permanent damage does not exist.

In radio work, it very frequently happens that relatively high voltages appear across the plates of capacitors. When solid dielectrics are employed, they must oviously be capable of withstanding such voltages, or the associated capacitor will soon become useless. Table VII shows *breakdown voltages* for typical insulating materials when they are 0.001in thick. The breakdown voltage of an insulating material increases with thickness, but not in direct proportion; doubling the thickness of the material causes an increase in breakdown voltage which is somewhat less than twice.

Breakdown in an insulating material normally occurs at a point where the ability to withstand the applied voltage is at its weakest. If the insulation is in the form of a thin sheet, or film, the material is usually described as being *punctured* at the point at which breakdown has occurred.

The ability of the dielectric of a capacitor to withstand breakdown is known as its *dielectric strength*. Dielectric strength is not constant, but tends to decrease with rise in temperature and age. It may also decrease if an intermittent high voltage is applied to the plates. Practical capacitors are normally specified not only by their capacitance but also by the voltage across the plates which they can safely withstand without the risk of breakdown. This voltage is referred to as the *working voltage* of the capacitor.

TABLE VII
Representative Breakdown Voltages (approximate) for Materials 0.001in thick

Material	*Breakdown Voltage*
Air	19.5–23
Bakelite	450–750
Glass	200–250
Mica	500–1,500
Paper	1,000–1,500
Porcelain	50–100
Rubber	400

Since dielectric strength increases with the thickness of the dielectric, it follows that capacitors having a high working voltage will be more bulky in size than capacitors of the same capacitance but with a lower working voltage. This point is borne out in practice.

Temperature Coefficient

In practical capacitors employing solid dielectrics it is found that capacitance varies with temperature, the change in capacitance being due to a change in dielectric constant. If the capacitance increases as temperature increases, the capacitor is stated to have a *positive temperature coefficient*; and if the capacitance decreases as temperature rises it is said to have a *negative temperature coefficient*.

Temperature coefficient is expressed by the letter P (for positive) or N (for negative) followed by a figure which defines the change in capacitance in parts per million for a rise in temperature of 1° Centigrade. If a capacitor has a value of 1μF and a temperature coefficient of P100, this means that its capacitance would increase by 100 parts per million for a rise of 1° C in temperature. A millionth part of a microfarad is a picafarad, and so the increase of 100 parts per million would, in this instance, consist of an increase of 100pF.

The temperature coefficient of most capacitors employed in radio work is small and may, in many circuits, be ignored altogether. In other circuits it becomes important, especially if the equipment in which the capacitor is fitted suffers high rises of temperature due to the heat dissipated by valves, resistors, and other components.

"Stray" Capacitance

We have considered cases, up to now, where we have purposely caused capacitance to appear by mounting two plates parallel to each other. It happens, however, that capacitance exists between any two conductors, whether we purposely wish this to happen or not. In just the same way as capacitance exists between two plates it may also exist between two wires, even if the latter are placed well away from each other.

In radio work, we introduce capacitance purposely by connecting physical capacitors into a circuit. At the same time, "unseen" capacitances appear also, such capacitances being formed between connecting wires, between wires and terminals, and between any other metal items which take part in the circuit. These are "*stray*" *capacitances*, and they usually have very low values. In some instances the "stray" capacitances are unimportant and can be safely ignored. In others they are a nuisance and have to be reduced in value by spacing out the conductors concerned or by other means.[5]

Frequently, "stray" capacitances between the conductors of a circuit are inevitable and have to be accepted. In this instance it is customary to design the circuit as though the "stray" capacitances were actual physical capacitors.

Next Month

In next month's article we shall carry on to practical capacitors.

[5] Such as screening, which will be covered in a later article.

Eight EMI Television Cameras for Switzerland

EMI Electronics Ltd., through its agent Silectra of Zurich, has obtained an order from the Swiss P.T.T. for eight EMI 4½in image orthicon television cameras and associated equipment. Value of the order is £35,000.

For the first time EMI will supply the cameras in special weatherproof fibreglass carrying cases. These will enable the cameras to be left safely on site between programmes, under the most adverse weather conditions—for example, on a mountain slope in a snow-storm.

The EMI cameras will be used to equip two mobile outside broadcast vehicles which are being built by the Swiss P.T.T. to improve the coverage of outside sporting events in Switzerland. They were selected for this purpose in the face of fierce competition.

NEWS and COMMENT . . .

Technology and the Grammar Schools

It is with pleasure that we learn, from time to time, that this magazine plays a part in fostering an interest in scientific subjects in some of our schools. We were therefore interested to see some of the papers read at a conference entitled as above.

The Capitol Radio Engineering Institute of Washington, D.C., made a grant to the Oxford University Department of Education to finance a study, expected to take two years, of recruitment to higher technological education. The conference was part of this study. It is believed that boys have tended to enter higher technological education only when they were unable intellectually to pursue pure science to a high level. In other words, pure science tends to claim the cleverest boys and technology tends to attract those not quite so able.

Electronic Nursing

Some readers may remember that in our November issue we gave a brief report on an American system of centralised supervision of hospital patients in regard to such things as temperature, pulse rate, etc. We can now give some details of a similar system now available in this country.

It is a system for automatically transmitting to a central point information regarding the general condition of up to 900 patients in various wards of a hospital. A nurse seated at a central receiver console can read off dials the temperature, blood pressure, pulse rate, respiratory rate and other similar information for any particular patient or all patients in turn.

Where any abnormality is shown, immediate attention can be given to the patient in question. In all cases, the data shown on the dials can be recorded on the patient's history cards and filed centrally for easy reference. If the characteristics of a particular patient should at any time go outside the individually set limits for that patient, an alarm is immediately given on the receiver console, and the bed number and other information for that patient are automatically displayed. This alarm system overrides any data for another patient which may be shown on the console at that moment.

A simple attachment is made to each patient which causes no discomfort even during sleep. Each attachment is connected to a small box fitted to the headrail of the bed. These boxes are connected in turn, via a bed selector to a transmitter for each ward. Several transmitters are wired to the hospital automatic local telephone exchange, from which a normal telephone line runs to the receiver console. In large hospitals, the installation can incorporate a teleprinter to print out the routine observations, leaving the nurse to deal only with special cases. EMI Electronics are responsible for the system.

Symposium on Batteries

The third International Symposium on Batteries will be held under the auspices of the Inter-Departmental Committee on Batteries of the British Government, at the Pavilion, Bournemouth, Hampshire, from 2nd to 4th October next.

An international group of experts will present technical papers on subjects covering developments in primary and secondary batteries, solar cells, fuel cells, and other sources of electrical energy.

Helping the Schoolboy

Consequent upon our opening subject, we are giving publicity to a suggestion which in its modest way can create the background from which boys may be encouraged to take up scientific and technological careers.

It is reported in the monthly news letter of the Hastings and District Amateur Radio Club, that their Chairman recently put forward the idea of running a series of lectures and demonstrations in various schools in the Hastings district with the concurrence of Head Teachers, to show that very simple equipment which is cheap and easy to build can be made to give satisfying results.

The main object of the suggestion is to dispel a popular notion that to participate in amateur radio is an extremely expensive business. "We should be able to show the up-and-coming young men of today how to make their own apparatus and to profit by the experience in both theory and practice. Far more is learned in cleaning the bugs out of something made at home than is acquired by ploughing through text-books or in trying to find out what's wrong when a junk-shop receiver gives up the ghost and the offending component can't be found due to a lack of essential knowledge."

The foregoing sentiments explain our policy of not forgetting that the beginner of today may be the expert of tomorrow.

Transistor Expansion

Plans for a rapid build-up of production and an intensive world-wide marketing programme have been announced by the Transistor Division of Standard Telephones and Cables Limited.

They plan to capture a major share of the home market and to enter the European Common Market area in co-operation with their associated companies already well established there, and to extend marketing activities in many other countries.

"The combination of 'planar' techniques with those of epitaxy will be the main foundation upon which we shall expand our semi-conductor production," said Dr. Baumgartner, Manager of the Transistor Division. He continued: "STC first made silicon planar transistors in July 1960, and were first in Europe to produce silicon epitaxial planar transistors in 1961. We are now offering a complete range of these transistors for industrial switching and telecommunications applications." Dr. Baumgartner also described two other important product lines which would back up the Division's expansion: tunnel diodes and integrated circuits.

Development work on integrated circuits in the next few years will lead to the marketing of many different circuit "blocks" for use in computers and for electronic switching applications. These circuit blocks will incorporate transistors, diodes, tunnel diodes and passive components such as capacitors, resistors and inductors; will be able to perform specific functions in electronic equipment and will be supplied as single units requiring no wiring or adjustment.

STC transistor production at present employs about 1,000 men and women, it is likely to require "several thousand" in the next few years.

Ask Me Another

"Does a lady disc jockey have vital statistics 45–33–78?", from *Natter Net Notes*, published by the Hastings and District Amateur Radio Club.

The Decibel

by T. W. CARREYETT
Grad. Brit. I.R.E.

THE DECIBEL IS A UNIT USED TO EXPRESS LOSSES and gains, as would be given for example by the gain of an amplifier or the loss in an attenuator. It is also used as a reference to express the frequency response of an amplifier (e.g. 20 c/s—15kc/s±1dB). It has other attractive assets to offer in broadcasting and communication work.

Acoustics

The decibel started life in the field of acoustics, where sound tests were being carried out with groups of people under laboratory conditions in order to analyse the appreciation of the human ear to various levels of sound intensity. These experiments proved that the ear had an approximately linear response to the logarithm of the ratio of change in sound intensity. Putting this another way, if a sound intensity of J is changed to J_o, then the ear can be said to appreciate an increase of $\log_{10} J_o/J$ Bels. (The unit in which the increase is expressed is called the Bel in honour of Graham Bell). It can be seen that 1 Bel corresponds to an intensity ratio of 10 to 1. In practice the Bel proved to be too large a unit so, for convenience, the decibel was introduced, whereupon

$$N(dB) = 10 \log_{10} \frac{J_o}{J}$$

Thus imerged the decibel, which proved to be the minimum perceptible difference of sound intensity appreciated by the ear.

Power

Before proceeding, we should clear up one point, this being that intensity and loudness are not the same things. Loudness is subjective and is assessed by a listener to a sound. Intensity, one the other hand, is a measure of the rate of flow of sound energy. The intensities J and J_o in the equation can be construed as powers, since energy is potentially power (because it can be said that power is dissipated where energy is absorbed). This shows the principle on which the decibel scale is built, it being based on the ratio of two powers.

Let us now find the necessary change in intensity (or power) required to cause a difference of one decibel.

If $1dB = 10 \log_{10} \frac{J_o}{J}$ then antilog $(0.1) = \frac{J_o}{J}$ and $J_o = J \times 1.26$.

Therefore the increase in power required to give an increase of one decibel is 26% of the original power. This may also be translated as meaning that the minimum perceptible increase in sound intensity noticeable by the ear is equal to an increment of 26% of the original sound.

Gain and Loss

How does this tie up with amplifiers and attenuators? The answer is that, by comparing input and output powers, both the gain of an amplifier and the loss in an attenuator may be expressed in decibels. Further, instead of multiplying or dividing the gains and losses in a chain of equipment to find the net gain, the latter may be evaluated by simple addition and division. An example will make this clear. Let us assume that we have two amplifiers, each of which has a power gain of 1,000 times, together with two coupling circuits, each of which causes a power loss of 100 times. The total gain of the two amplifiers will be 1,000 x 1,000 times, i.e. 1,000,000 times. At the same time the total loss given by the two coupling circuits will be 100 x 100 times, or 10,000 times. The net gain of the whole arrangement is the total gain divided by the total loss; and this comes to 1,000,000÷10,000, which is 100 times. Even though simple figures have been employed here, labour is involved in the calculations and there is risk of error.

If the figures just quoted indicate true power ratios, then the gain of each amplifier (1,000 times) is given by

$$\begin{aligned} dB &= 10 \log_{10} 1{,}000 \\ &= 10 \times 3 \\ &= 30 \end{aligned}$$

So the total gain for the two amplifiers is 30+30=60dB.

The loss of each coupling circuit (100 times) is given by

$$\begin{aligned} dB &= 10 \log_{10} 100 \\ &= 10 \times 2 \\ &= 20 \end{aligned}$$

The total loss, therefore, is 20+20=40dB. The net gain of the complete arrangement may now be expressed as 60dB (total gain) minus 40dB (total loss), giving us 20dB.

We previously obtained a figure of 100 times as net gain, and we have just seen that this corresponds to 20dB. So the two results agree.

As may be seen, the use of decibels enables gains to be added and losses to be subtracted when evaluating the net gain of a chain of equipment. Addition and subtraction is possible here because the decibel figures correspond to logarithms of the figures which were previously multiplied and divided.

Current and Voltage

The decibel is dimensionless because it is a ratio. In an amplifier, if P_1 is the input power and P_2 is the output power, then the gain in decibels is given by

$$N\ (dB) = 10 \log_{10}\frac{P_2}{P_1} \ldots (1)$$

Now, since a power $P = I^2R$

$$N\ (dB) = 10 \log_{10}\frac{I^2_2\ R_2}{I^2_1\ R_1} \ldots (2)$$

$$= 20 \log_{10}\frac{I_2}{I_1} + 10 \log_{10}\frac{R_2}{R_1} \ldots (3)$$

where R_1 and R_2 are input and output resistances respectively.

Also, since $P = \frac{E^2}{R}$, $N\ (dB) = 10 \log_{10}\frac{\frac{E^2_2}{R_2}}{\frac{E^2}{R_1}} \ldots (4)$

$$= 20 \log_{10}\frac{E_2}{E_1} + 10 \log_{10}\frac{R_1}{R_2} \ldots (5)$$

We now arrive at a rather important point. It can be seen that if $R_1 = R_2$ in equations (2), (3), (4) and (5) then

$$N\ (dB) = 20 \log_{10}\frac{I_2}{I_1} = 20 \log_{10}\frac{E_2}{E_1}$$

R_1 and R_2 do not appear here because, in equations (2) and (4) they cancel out. They similarly disappear from equations (3) and (5) because the log of 1 is zero.

It is only when resistance $R_1 = R_2$ that these modified equations for E and I can be used. If R_1 does not equal R_2 the previous equations must be employed.

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

Transistor Tx/Rx.—B. D. Dodd, Airwork Services Ltd., Turnhouse Airport, Edinburgh, requires any information concerning a circuit for carrying out underwater experiments. All information acknowledged.

* * *

Collins TCS12, TCS13 Tx/Rx and Detrola BC610E Tx.—3523016 Cpl. Pringle, A. H., S.H.Q. Signals Section, R.A.F. Idris, BFPO 57, wishes to obtain data and circuits of these equipments, also details of modifications to Collins receiver type C1H-46159A and Collins transmitter type COL 52245.

* * *

Type 28A Monitor Unit.—J. Bentley, Stafford House, 5 High Street, Buxton, Derbyshire, wants to obtain the circuit diagram and any other information on this ex-Air Ministry equipment.

* * *

Valve Tester.—J. D. Almond, 457 Whalley New Road, Blackburn, Lancs, has obtained this ex-Government unit marked 10S/658 and 10S/556. Incorporated in the circuit is a magic-eye and a milliameter. Has any reader any information or a circuit diagram?

* * *

CR100 Receiver.—P. W. Lee, 15 Cedar Road, East Croydon, Surrey, wishes to acquire, on loan, any radio books or magazines dealing with modifications to this receiver.

* * *

Amplifier and Oscillator.—S. E. Appleby, Physics Dept., the Manchester Grammar School, Rusholme, Manchester 13, has acquired an amplifier and oscillator from a Soundmirror tape recorder. The electronics were made by Thermionic Products Ltd., London, and the present address of this firm would be appreciated. If any reader could supply the circuits appertaining to this equipment, the physics department would be pleased to receive them.

* * *

Indicator Unit 110/QB1S.—G. Robinson, 34 Parnell Road, London, E.3, has obtained this ex-U.S. Navy equipment containing two 5FP7 c.r.t.'s. Information is required for converting to an oscilloscope or, alternatively, a circuit of an oscilloscope using a 5FP7 tube.

R206 and R1392D Receivers.—B. R. Cauthery, Willow Bank, Rural Route No. 1, Caledon, Ontario, Canada, would like to borrow or purchase the manuals for these receivers and also correspond with any reader who has converted the R1392 to cover the 30–100 Mc/s band.

* * *

Hallicrafters S38D Receiver.—S. E. Abell, 67 The Vale, Acton, London, W.3, wishes to obtain the circuit and service data.

* * *

R1392D Receiver.—M. J. White, 28 Chepstow Road, Newport, Mon., would like to receive any information, including power input requirements, on this receiver.

* * *

R1155 Receiver.—F. Barrett, 19 Iris Close, Clematis Road, Harold Hill, Essex, requires any information available and also a circuit diagram for a power supply suitable for this receiver.

* * *

Test Set 74A.—R. Kenny, 34 Derwent Street, West Benwell, Newcastle-on-Tyne 5, has recently acquired this equipment and requires the circuit diagram or manual and any information on converting to an oscilloscope.

* * *

Ferranti TV T1002/IF.—J. Ratcliff, 61 Fletching Road, Brighton 7, Sussex, wishes to purchase or borrow the service sheet.

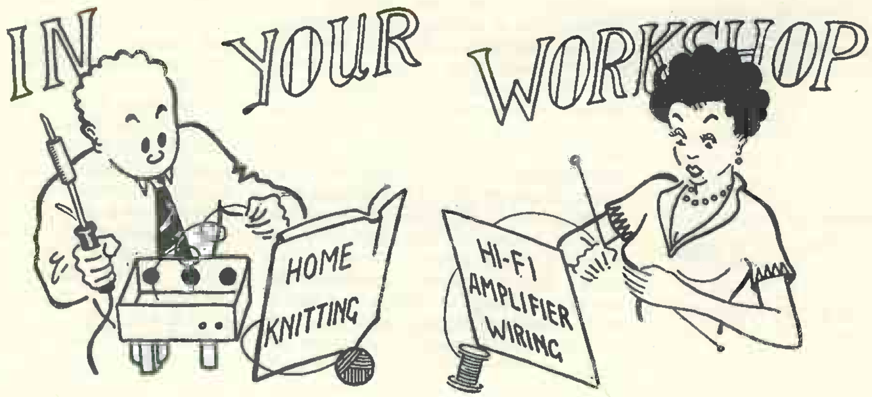
* * *

German Valves.—E. Roberts, 1 The Fitches, Knodishall, Saxmundham, Suffolk, requires the base diagrams of the following valves salvaged from a German wartime receiver —DF26, DF25, DAC25, DC25, DCH25 and DDD25.

* * *

AR88D Receiver and Frequency Meter Type CKB-74028.—R. Broadberry, 4 Temple Terrace, Louth, Lincs, would like to obtain the circuits and any other data on these equipments.

IN YOUR WORKSHOP



This month Smithy the Serviceman, aided by his able assistant, Dick, takes advantage of a quiet spell to discuss some of the more unfamiliar circuits encountered in radio and television servicing. Dick also tells Smithy of his difficulties in keeping up with the Joneses.

"DID YOU KNOW," SAID DICK, "that the Japanese have now got a man into space?"

Inevitably, Smithy fell for it.

"Have they really?" he asked interestedly "how do you know that?"

"It's easy," grinned Dick, "there's a nip in the air!"

Smithy the Serviceman gazed at his assistant with disfavour.

"Were it not for the fact that, because it's a slack day for once, we're in the process of having an elongated tea-break," he pronounced pompously, "I would feel obliged to protest against your frivolous approach to matters of this nature."

"Dig you!" remarked Dick, rudely.

"I have not the slightest desire to be dug," continued Smithy with dignity, "and I should point out that it is not seemly to refer to your superior in that manner."

Dick looked at the ruffled Serviceman and decided that he had better smooth things over a little.

"Sorry, Smithy," he said, contritely. "What it is is that when you're my age you've just got to rebel against authority every now and again. It said so somewhere in our new Sunday newspaper. How about another cup of tea?"

"As you like," said Smithy a little grumpily.

Voltage Dependent Resistors

Dick refilled the Serviceman's cup.

"Anyway," continued Dick, "now that we've got a few minutes away from the grind, I was wondering if we could have a natter about one or two things which have been puzzling me recently."

"Such as?"

"Well," said Dick, "over the last few weeks I've been bumping into all sorts of odd little points in the sets I've been servicing and I thought I'd make out a list so that I could ask you about them whenever we had a bit of spare time. Like we have," he concluded hopefully, "today."

"I think that's fair enough," conceded Smithy. "As I said just now, we've got a slack period at the moment, and it won't hurt us to get away from the benches for a while. So there's no reason at all why we shouldn't have a gen-session if you want one."

"That's fine," said Dick, promptly pulling out a sheaf of papers. "Now the first thing on my list is a gadget which has rather a peculiar circuit symbol."

Smithy looked at the symbol which Dick had sketched. (Fig. 1.)

"That," he remarked, "is a voltage dependent resistor. Or V.D.R. for short."

"I see," said Dick doubtfully. "What does it do?"

"The V.D.R. has the property," pronounced Smithy, "that its resistance drops as the voltage across its ends increases. However, the resistance drops in rather a peculiar way."

Smithy took Dick's sheaf of papers and sketched a curve on the top sheet. (Fig. 2.)

"That," continued Smithy, "is a typical voltage-current curve for a V.D.R. At low voltages it draws only a small current but, when you get over a certain point, the current drawn increases much more rapidly with increase in voltage."

Fig. 1. The circuit symbol for a voltage dependent resistor

"I get the idea," said Dick thoughtfully.

He sat pensively for a moment.

"In that case," he exclaimed suddenly, "wouldn't a Metrosil be the same as a V.D.R.?"

"Metrosils aren't normally *called* V.D.R.s," replied Smithy, "although their effect is much the same. There are a number of Metrosil products for different voltages and currents, but the type we most frequently encounter in television work is the Metrosil which is used in some sets to improve e.h.t. regulation. Such a Metrosil is connected between the

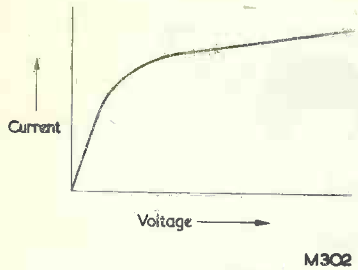


Fig. 2. A typical V.D.R. voltage/ current curve

final anode of the c.r.t. and chassis." (Fig. 3.)

"I know all about them," said Dick excitedly. "Round about the required e.h.t. voltage the current they draw varies at a much higher rate than the voltage applied, with the result that if e.h.t. voltage rises they draw an increased current to counteract it, and vice versa."

"That's right," agreed Smithy. "Actually, the current drawn varies as the fourth or fifth power of the applied voltage. Which is quite a lot, when you come to think of it."

"I can understand the action of a Metrosil on e.h.t. regulation," said Dick. "But the voltage dependent resistors I've bumped into aren't connected to the e.h.t. circuit at all. For instance, in one case, there was a V.D.R. connected across the primary of the vertical output transformer." (Fig. 4.)

"That's an easy one," replied Smithy promptly. "All it does is reduce the amplitude of the flyback voltage across the primary. Also, it reduces ringing".

"I'm not quite with it."

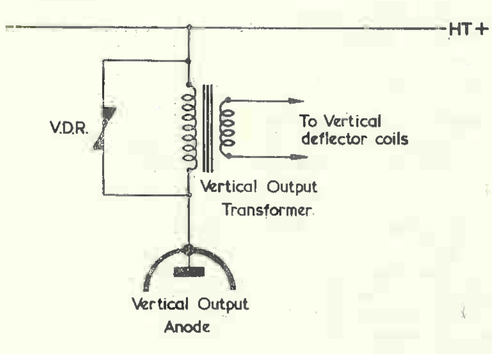


Fig. 4. A V.D.R. may be connected across the primary of a vertical output transformer to reduce flyback pulse amplitude and ringing. In practice, the transformer may be an autotransformer instead of the double-wound component shown here

"Well," continued Smithy patiently, "in a vertical output transformer you get a flyback pulse in just the same way as you do in the line output transformer. In the line output transformer the flyback pulse is of use and we employ it to give us e.h.t. In the vertical output transformer it's just a nuisance because it means that the primary has to be given sufficiently good insulation to withstand the high voltage which appears across it during flyback. Vertical output transformers are bitchy things to design and make at the best of times, and modern receiver layouts require that they be small in dimensions as well, which doesn't help the insulation situation. What is even more important, however, is that the vertical output valve will have a limiting peak anode voltage which mustn't be exceeded by the pulse voltage during flyback. If you put a V.D.R. of the right type across the vertical output transformer primary, this draws a heavily increasing current as the flyback voltage increases and thereby holds it down to a safe level for the valve and transformer. Also, since the V.D.R. applies a relatively low resistance across the primary during flyback, it helps to damp out ringing in this winding."

"Why, it's quite simple after all!" exclaimed Dick.

"Most V.D.R. applications *are*

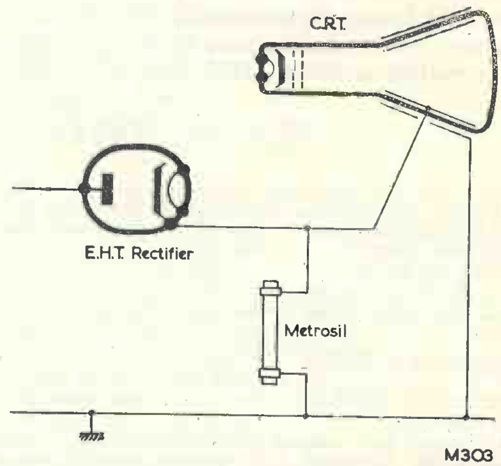


Fig. 3. E.H.T. voltage is frequently regulated by connecting a Metrosil between the final anode of the c.r.t. and chassis

simple," said Smithy. "One typical application, for instance, is where it's used as a rectifier to give you a voltage negative of chassis."

Dick sighed.

"I thought things were going a bit too smoothly," he groaned. "How can a resistor act as a rectifier?"

"Quite easily," replied Smithy, "if it's a V.D.R.! I'll give you a typical circuit (Fig. 5) in which the V.D.R. is coupled via a 1,000pF capacitor to a tap in the anode winding of the line output transformer. You get a voltage negative of chassis on the upper terminal of the V.D.R."

"Just like that?"

"Just like that,' confirmed Smithy, as he scribbled on Dick's sheets of paper. "To explain the action, let's introduce a few figures. Let us first of all assume that the resistance of the V.D.R. commences to fall rapidly around 1,000 volts, and that we are obtaining positive-going pulses

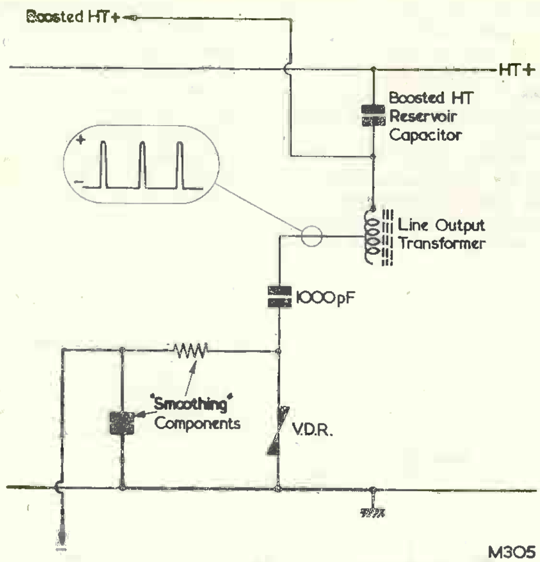


Fig. 5. A voltage negative of chassis is obtained with the aid of a V.D.R. in this simple circuit arrangement

via a simple R-C smoothing circuit and there you are!"

"Well, I'm dashed," said Dick. "It's rather like that gated a.g.c. amplifier we talked about last month."

"It's much the same, basically," agreed Smithy. "And you can say that, since the V.D.R. draws a rapidly increasing current above a certain voltage level, it acts rather as a diode. It doesn't go hard on, as a diode does when it conducts, but the effect is similar nevertheless. That's why I referred to the V.D.R. as a rectifier. I should add also that the voltage on the line output transformer tap between pulses wouldn't be steady, as I've shown in the waveforms. There would be a slight variation at line scan frequency, but this would be too small to affect the operation of the circuit."

"It's quite a knobby arrangement, isn't it?" said Dick. "What would you use the negative voltage for?"

"A.G.C. circuits mainly," said Smithy. "Although such an application is not frequent."

"Apart from seeing them connected across vertical output transformer primaries," put in Dick, "I've

of 1,500 volts amplitude from the line output tranny. These pulses appear at flyback time and they look like those I've sketched here. (Fig. 6 (*a*).) Notice that, between pulses, the potential on the tap into the winding is relatively steady at boosted h.t. voltage. For the sake of simplicity, we'll say that the boosted h.t. is 500 volts. In consequence, the peak potential of the pulses above chassis is 1,500 volts plus the steady 500 volts boost voltage, giving us 2,000 volts in all. Now, the V.D.R. draws a rapidly increasing current around 1,000 volts, so that its upper terminal will not go much higher than this potential during the period of the pulse. The result is that, during peaks, the series 1,000pF capacitor charges up to the difference voltage of 1,000, its lower plate being negative."

Smithy paused and sipped his tea.

"Between pulses," he continued, refreshed, "the voltage at the line output transformer tap is around boost voltage. Because of the charge held by the 1,000pF capacitor, its lower plate goes negative of chassis. You can see this in the second waveform I've sketched out for you. (Fig. 6 (*b*)) Now, the period in time *between* pulses is much longer than the period when they are present, with the result that the *average voltage* on the lower plate becomes negative of chassis. All you then have to do is to extract that voltage

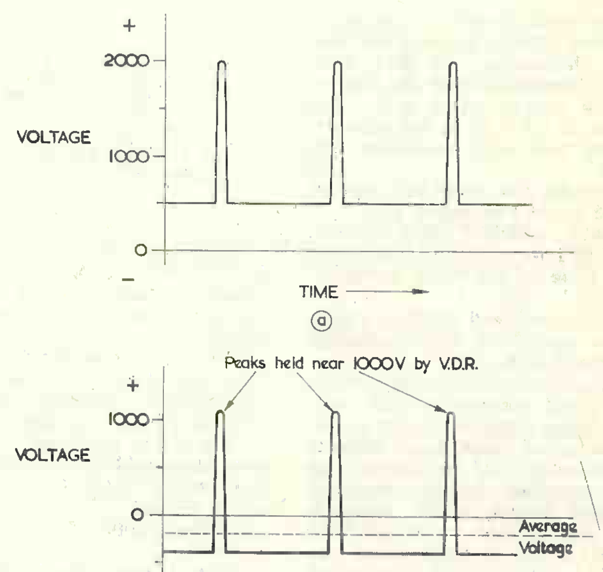


Fig. 6 (a). The pulses at the line output transformer tap of Fig. 5 have the potential above chassis shown here

(b). The V.D.R. holds the peak potential on the lower plate of the 1,000pF capacitor near 1,000 volts, with the result that the average voltage on this plate is negative of chassis

also seen voltage dependent resistors in line output stages."

"I'm glad you've mentioned that," said Smithy, "because the rectifier circuit we've just discussed is used most frequently *in* this part of the receiver."

"What does it do there?" asked Dick.

"It stabilises e.h.t. voltage," explained Smithy. "Now, we've just seen that the pulses from the line output transformer winding cause the series capacitor to take up a charge which results in the appearance of a voltage negative of chassis. O.K.?"

"O.K."

"It doesn't," continued Smithy, "need much further imagination to realise that, if the pulses increase in amplitude, the negative voltage will increase also."

"I'm still with it," commented Dick.

"Fine," said Smithy. "Now if, in the line output stage, e.h.t. increases for some reason, so also will the pulses and our negative voltage. We can, therefore, obtain e.h.t. stabilisation by the simple process of applying our negative voltage to the grid of the line output valve."

"Hey?"

"The result of such a connection," continued Smithy, ignoring his assistant's interjection, "is that when e.h.t. increases so does the bias on the line output valve grid. The increase in e.h.t. is, in consequence, opposed and e.h.t. regulation improves."

"How do you apply the negative voltage to the line output grid?"

"That's simple," said Smithy, "you just return the grid leak to the lower plate of the series capacitor. Like this." (Fig. 7.)

"But," protested Dick, "you've got no smoothing for the voltage from the V.D.R. then."

"Yes, you have," replied Smithy. "There will almost certainly be a fairly large capacitance, or a low impedance of some type, between the line output grid and chassis, this being provided by the sawtooth generator circuit which feeds it. Even without this, you'll still have a pretty hefty sawtooth going into the grid and this should override any small variations in voltage from the V.D.R. which appear at the grid end of the leak. I should add that it's also necessary to have some control over the voltage appearing on the lower plate of the series capacitor, and this can be easily achieved by applying a positive potential from a pre-set potentiometer, as I've shown in the diagram. You adjust the potentiometer until the range of voltages from the V.D.R. is just right for proper control."

Thermistors

Dick looked at his list and ticked off two items.

"Well," he said cheerfully, "that's cleared up my V.D.R. queries. My next one is about thermistors."

"A man," complained Smithy, bitterly, "could die of thirst in this Workshop."

Smithy nodded gravely.

"Some of the articles," continued Dick eagerly, "are written really beautifully, you know. I don't always understand them, mind you, but they're still really beautifully written. Mainly, though, it's the coloured magazine supplement we go for. It's dead artistic, man."

"No comic strips?"

"Well no, not really," said Dick a little regretfully. "But you can't have everything, can you?"

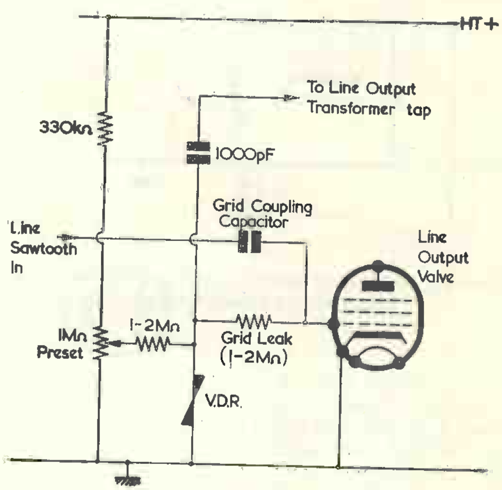


Fig. 7. Using the basic circuit of Fig. 5 for e.h.t. stabilising. The upper terminal of the V.D.R. connects directly to the line output valve grid leak

Obediently Dick rose and took Smithy's empty cup. As his assistant busied himself with the teapot a thought crossed the Serviceman's mind.

"I've just remembered something you said about your new Sunday newspaper," Smithy remarked. "Which one do you take?"

"Up till 4th February," said Dick, over his shoulder, "we used to have the *Sunday Pictorial* and the *News of the World*."

"What happened on 4th February?"

"We changed over," said Dick, grandly, "to the *Sunday Times*."

"What on earth for?"

"To get the new coloured magazine supplement, of course," said Dick impatiently. "The 'Pic' and the 'Screws' have got nothing like that. Of course, we had to get a wider letter-box for our front door, but then you must expect that sort of thing when you make a change of this nature."

"Of course not," said Smithy comfortingly.

Dick handed a full cup of tea to the Serviceman.

"By the way," he asked, "what Sunday papers do *you* have?"

"The *News of the World*," replied Smithy promptly, "and the *Sunday Pictorial*. Now, what's your query about thermistors?"

"Thermistors?"

"Yes," said Smithy patiently. "You had a query about thermistors."

Dick brought his mind back from the subject of Sunday newspapers and consulted his list.

"Ah, yes, here it is," he said. "I found a thermistor in one set connected into the vertical timebase circuit."

"There's nothing unusual there," remarked Smithy. "It might be more unusual if you *hadn't* found one."

"Well," said Dick. "I know about thermistors in the series heater chains of television receivers. They have a high resistance cold and a low resistance when hot, with the result that they prevent heavy heater current surges when you switch on. But in this case the thermistor was in the vertical timebase, and I just couldn't see what it was there for. I sketched out the circuit in which it appeared, and here it is." (Fig. 8 (*a*))

Smithy looked at the circuit momentarily, then put it on one side.

"The thermistor's doing quite a conventional job there," he commented. "But if I'm going to explain it to you I'll have to go back a little in history. Now, a big trouble with television sets produced some ten years or so ago was what is known as 'frame shrinkage'. When you switched on the receiver you got a picture of correct proportions. After that, however, it gradually shrank in height until, when an hour or so had gone by, it might be as much as one-half to three-quarters of an inch short. The trouble was mainly due to increasing temperature in the vertical deflector coils, this causing their resistance to go up and the deflection current which flowed through them to go down. Possibly, there was a slight increase in the resistance of the vertical output transformer windings as well, but it was the deflector coils which were usually considered to be the main culprit. The situation got worse when wider angle tubes came in, because the heavier deflection currents these tubes needed caused the deflector coils to get hotter, and because the smaller cabinets employed made the whole set get hotter as well. What we used to do with these old sets was to set up the height control so that the picture overscanned vertically by the amount of shrinkage. When the set had been on long enough the picture then shrank to correct height."

"Didn't the customers notice this?"

"Only when you didn't set up the initial overscan," replied Smithy. "If you didn't do this, the top or bottom of the picture would become visible inside the mask, and they'd get on to you and complain about a 'black bar' appearing at the top or bottom of the picture after the set had been on for some time."

Smithy sighed pensively.

"Dear me," he said nostalgically, "I wish I had a shilling now for every 'black bar' I've cured just by screwing up the height control!"

"Why didn't you get line shrinkage in the same way?" asked Dick, breaking into Smithy's thoughts.

"Line shrinkage?" said Smithy, collecting himself. "Well, the line deflector coils also go up in resistance as they warm up, but in this case the increase in resistance doesn't have so much effect. At line frequency, the impedance presented by the line deflector coils is largely provided by their inductance. At the much lower vertical scanning frequency, deflector coil impedance has a considerably larger resistive component."

"I see," said Dick. "How does the thermistor come into all this?"

reduced resistance will only slightly affect the circuit during the flyback period, and the conducting valve will discharge the capacitor to pretty well the same voltage as before. When the valve is off, however, the reduced resistance of the thermistor will have a much greater effect, and it will cause the capacitor to charge to a noticeably higher voltage before the next flyback period comes along to discharge it again."

"In other words," broke in Dick,

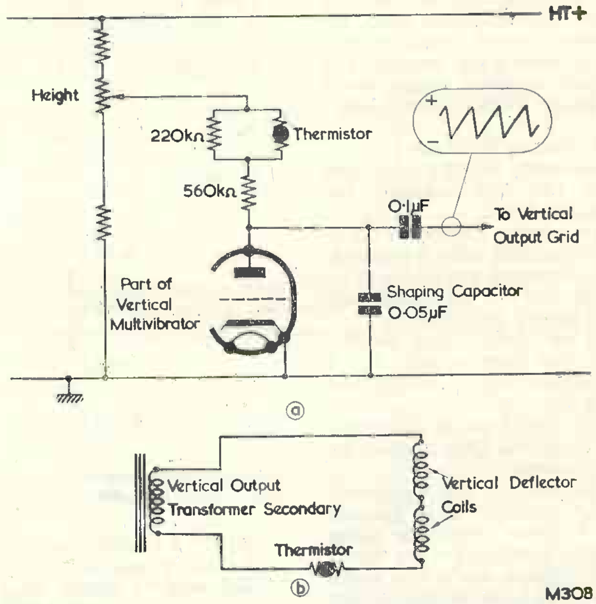


Fig. 8. Two common methods of overcoming "frame shrinkage". In (a) a thermistor controls the amplitude of the sawtooth applied to the vertical output grid, and in (b) a thermistor is inserted in the deflector coil circuit

"I'm trying to tell you," said Smithy, a little testily, "but you keep side-tracking me. Now, the obvious way to overcome 'frame shrinkage' was to introduce a temperature-sensitive component to counteract it, and the obvious temperature-sensitive component to use was a thermistor. Your circuit shows a typical thermistor application. If you look at the circuit more closely you'll see that the triode is the valve in the timebase which actually forms the sawtooth. During the flyback period the triode conducts, and discharges the shaping capacitor. During the scan period the triode is off, and the capacitor charges via the resistance in its anode circuit. Of which, please note, the thermistor forms a part. A sawtooth appears, therefore, across the shaping capacitor. As the thermistor warms up its resistance drops. This

"the amplitude of the sawtooth will increase."

"Exactly," agreed Smithy. "The next step is to mount the thermistor on or near the deflector yoke so that it warms up at approximately the same rate, whereupon an increase in yoke temperature is accompanied by a similar increase in thermistor temperature. The reduced deflection current in the vertical deflector coils is then counterbalanced by a sawtooth of increased amplitude passed to the vertical output grid. If you juggle around with the resistance values around the thermistor, the two effects can be made to counterbalance each other almost exactly."

"Well, that's a cunning scheme," commented Dick. "I must keep my eyes open for more thermistors in vertical timebases from now on."

"You'll see plenty of them," grinned Smithy. "Instead of inserting them in the timebase circuits, some manufacturers just pop them in series with the vertical deflector coils, like this. (Fig. 8 (*b*)) In this case you couldn't have a simpler circuit application because, as vertical deflector coil resistance increases, thermistor resistance decreases. The overall resistance, as seen by the vertical output transformer, remains pretty nearly constant all the time. The snag of this arrangement, from the design point of view, is that you lose a bit of vertical scanning power in the thermistor. On the other hand, the arrangement cannot affect picture centring, as having the thermistor in the vertical timebase might do if proper design steps aren't taken."

A.C./D.C./Battery Receivers

Dick ostensibly ticked a third item from his list, and scanned the remainder carefully.

"I've got another thermistor query here," he remarked, after a moment. "The set concerned was an a.c./d.c./ battery job and the thermistor was connected across the filaments."

"That's an oldie," said Smithy. "And we can soon explain it. I should imagine that the circuit was something like this."

Smithy scribbled on his assistant's papers (Fig. 9) and Dick nodded his head in agreement.

"The function of the thermistor here," said Smithy, "is to prevent excessive voltages appearing along the filament chain if one of the valves burns out. When you're on mains operation with a set of this nature the filament chain connects to the rectified h.t. supply via a series resistor, and if one of the filaments burns out, all those above it in the string can rise to h.t. positive potential if a thermistor isn't fitted. There's almost certain to be at least one electrolytic connecting into or across the heater chain—in my sketch I've shown one across it—and, assuming it doesn't break down, this will then charge up to full h.t. potential. If you fit another valve in place of that burnt out, the electrolytic will discharge into the filament chain and may well cause a further filament to go. When you put a thermistor of the correct type across the chain, however, this prevents excessive voltage rise. As soon as a valve filament burns out, a higher voltage is applied across the thermistor. The temperature of the thermistor increases, its resistance drops, and the voltage across it is held at a safe level."

"But there surely can't be much current flowing through the thermistor even when it *is* cooked up," objected Dick. "After all, the normal filament current in this sort of set would only be 50 or 25mA, you know."

"That's true," said Smithy, "and you use a pretty small thermistor because of this. A thermistor especially designed for the job is the CZ10, and it's only $\frac{5}{16}$in long by $\frac{3}{32}$in in diameter. Also, its maximum operating current is 75mA; so it will operate quite reliably at the small currents which would be given here."

"Well, that answers *that* query," said Dick with satisfaction. "Incidentally, I've noticed that a.c./d.c./ "this is a new one on me. All I can say is that it may have been put there to neutralise the field from, say, the sound output transformer. Perhaps the latter was distorting picture shape."

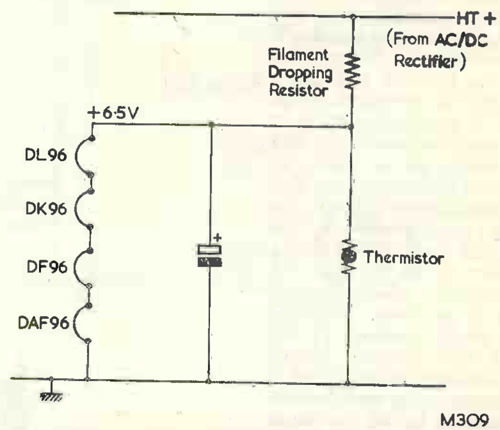


Fig. 9. A basic filament supply circuit in an a.c./d.c./battery receiver. The h.t. voltage applied to the filament dropping resistor will be of the order of 200 volts. A typical 25mA filament chain is shown, the voltage across which should be 6.5 with series operation

battery sets seem to be dropping off these days."

"Obviously they are," replied Smithy. "There's no point in making them now that transistors are available. I'm not sorry to see them go, either; the filaments took such low currents that you could easily burn out a complete set with just a single slip of a test prod!"

Magnet

"I've got another query here," said Dick, changing the subject abruptly. "I found a picture correction magnet mounted on the chassis of a television receiver."

This time it was Smithy's turn to look surprised.

"On the *chassis*?"

"That's right. It was purposely mounted there."

Smithy looked at Dick suspiciously.

"Are you sure?"

"Positive."

"Well," said Smithy, uncertainly,

"It *was* near the sound output tranny," said Dick. "So I suppose that was what it was for."

"I suppose so," repeated Smithy. "I haven't bumped into a case like this myself, though, so I can't be too certain."

Output Circuit

"Talking of sound output transformers," said Dick, completely happy with Smithy's explanation for the presence of the mysterious magnet, "there's a peculiar sound output circuit I've bumped into quite frequently, and which I've drawn out for you. (Fig. 10.) What I can't understand is why there is a tap in the output transformer primary."

"This is a common output circuit in a.c./d.c. sound receivers," said Smithy, "and its purpose is to allow the output pentode anode to have a nice high h.t. voltage without introducing too much hum."

"How does the circuit work?"

"If you look at it closely," replied Smithy, "you'll see that there is one stage of h.t. smoothing after the half-wave rectifier before you hit the tap in the output transformer primary. At this point, therefore, you've still got a fair amount of ripple. The h.t. current now flows through the primary in two directions. It flows in one direction towards the output valve anode and it flows in the opposite direction towards the second smoothing resistor and the remainder of the set. By choosing a correct position for the tap, the ripples on these two opposite currents cancel each other out in the transformer, and no hum is passed on to the speaker."

"I see," said Dick thoughtfully. "But the only ripple you're balancing out is that which is present after the first smoothing resistor."

"That's right," confirmed Smithy. "The ripple after the second smoothing resistor is so low that the h.t. line from this point can feed the rest of the set."

"Then why not," asked Dick, "take the pentode anode feed after the second smoothing resistor, and save the bother of using a tapped transformer?"

"Because," said Smithy, "the pentode anode draws too much current. A typical sound output valve these days is the UL84 and this takes some 60mA anode current in a normal circuit. A current of 60mA through the first smoothing resistor in your circuit is equivalent to a drop in h.t. of approximately 30 volts. Take it through the second smoothing resistor and you've lost another 40 volts. The available h.t. is limited because of the a.c./d.c. rectifier circuit and, by using a simple tap in the output transformer primary, you enable the output anode to have a high h.t. voltage without the introduction of hum due to the poor smoothing at this point."

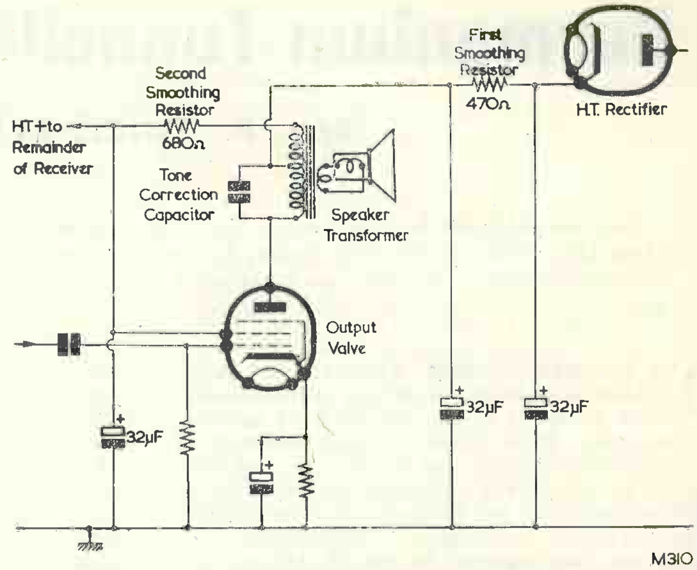


Fig. 10. A common speaker transformer circuit encountered in a.c./d.c. sound receivers. This enables the output valve to have a relatively high anode voltage without the introduction of excessive hum

Catching Up on Mondays

Smithy held out his cup and Dick once more filled it for him.

The pair were silent for a moment as Smithy sipped his fresh cup of tea and his assistant glanced through his sheets of paper. Dick seemed to be worried about something.

"Smithy," he started, tentatively, after some moments.

"Yes," said Smithy encouragingly.

"Do you still get Gammidge's cartoon?"

"Gammidge's cartoon?"

"In the *Sunday Pictorial*."

"Oh yes," replied Smithy. "*And* 'The Pickle'."

"And do you still have the astrology feature in the *News of the World*?"

"It's flourishing."

Dick swallowed.

"Yes?" prompted Smithy.

"I wonder," said Dick, "if it would just be possible for you to bring your Sunday papers round to the Workshop on Monday."

"What," exploded Smithy, "and have you read them during working hours?"

"Oh no," said Dick quickly. "I could read them at lunch-time. It's just, you know, that I don't want to get out of touch, and . . ."

But the rest of Dick's explanation was lost as the Serviceman fell into a paroxysm of helpless and completely unsympathetic laughter.

CLOSED-CIRCUIT TV aids Radar Controllers at Farnborough

Radar equipment is used nowadays at most airfields to advise the control room staff of the exact whereabouts of all airborne craft over or in the vicinity of the airfield. But, in order that the radar signals may be observed, the control room must be kept in darkness.

As most radar equipment does not indicate the positions of aircraft on the ground, and radar operating conditions make it unpractical to equip the control room with a window to give direct observation of the airfield, the radar controllers who authorise pilots to land and take off need some visual means of ascertaining whether the runways are clear of other craft.

This problem has been solved at the Royal Aircraft Establishment, Farnborough, by the installation of a closed-circuit television system by EMI Electronics Ltd.

A camera is mounted on the roof of the Air Traffic Control Tower where it has an uninterrupted view of the complete airfield, and a television receiver is situated in the darkened Approach Control Room. The camera, which is equipped with close-up and wide-angle lenses, is housed in a weatherproof housing fitted with a windscreen wiper and a sun visor. The interior temperature of the housing is thermostatically controlled.

Adjacent to the TV receiver in the Approach Control Room is the camera control unit, from which the radar controller can remotely operate the camera. He can cause it to rotate and tilt so that it will cover any part of the airfield, and he can select the appropriate lens to give a panoramic view or a close-up shot. He can also adjust the lens focus and operate the windscreen wiper. An automatic light control compensates for any changes in light on the airfield during the day.

The EMI television system gives the radar controller a continuous view of all runways, taxi-tracks and parking areas. It enables him to direct landings and take-offs with perfect safety.

Germanium Tunnelling Devices

by J. B. DANCE, M.Sc.

Since we published the 3-part series "The Tunnel Diode In Theory and Practice" by J. B. Dance (Nov, Dec, 1960 and Jan, 1961 issues) further developments have taken place in this country. The present article describes new tunnel diodes introduced by Standard Telephones and Cables Ltd.

OUR REGULAR READERS WILL RECALL THAT details of a range of British tunnel diodes were published in the January 1961 issue of this magazine. These tunnel diodes, manufactured by Standard Telephones and Cables Ltd., are now replaced by a new range which have a much lower junction capacitance and which can therefore operate at much higher frequencies. For example, the JK21A has been replaced by the JK21B and the resistive cut-off frequency has been increased from about 110Mc/s to about 980Mc/s. The new series of diodes are in the type "TO 18" encapsulation (see Fig. 1).

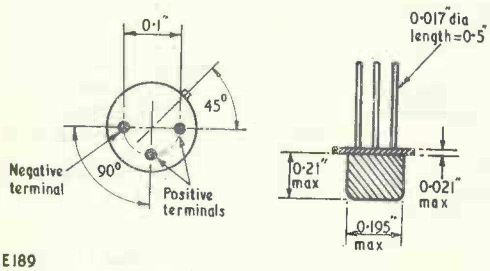


Fig. 1. S.T.C. general purpose tunnel diodes. The two positive leads are connected together internally. The polarity of the leads, as shown here, is that for a forward biased diode

Details of the electrical characteristics of the new range of germanium tunnel diodes are given in the accompanying table. The forward voltage quoted in this table is the voltage at which the current again becomes equal to the peak current, this voltage being greater than the valley voltage. These devices are general purpose tunnel diodes intended for use as oscillators, amplifiers and in switching applications. They are especially useful at very high frequencies (where most transistors cannot be used) and it is very fortunate that they are now available at prices which the average constructor can easily afford, these varying between £1 and £2 (according to type) for small quantities.

Maximum Voltages

The maximum forward and inverse voltages which can be applied to any of the tunnelling devices described in this article is determined by the maximum permissible current.

Other Diodes

In addition to the range of general purpose tunnel diodes shown in the table, Standard Telephones and Cables Ltd. manufacture a few other types. The JK30A is a germanium tunnel diode with a peak current of 5mA and is encapsulated in a special low inductance ceramic case (see Fig. 2). It is intended

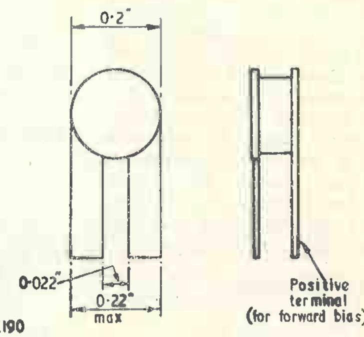


Fig. 2. The JK30A tunnel diode

for use in oscillators and amplifiers at frequencies up to 500Mc/s and in switching circuits where a low value of series inductance is required. In the case of the JK30A, the minimum series lead inductance is one milli-microhenry, at which value the limiting frequency of oscillation is 900Mc/s. The other characteristics of the JK30A are similar to the JK20B (see table).

Matched pairs of tunnel diodes are produced under the type number JK60A and these are also encapsulated in low inductance ceramic cases. They are mainly intended for use as computer elements in high speed logic counting circuits or as threshold amplifier/gates at the input of nanosecond* pulse amplifiers. The current maxima for each pair are matched to 2½% and the capacitances to within 10pF. The characteristics are similar to those of the JK30A.

* 1 nanosecond equals 10^{-9} second (or 1 milli-microsecond).—Editor.

TABLE

CHARACTERISTICS OF THE S.T.C. RANGE OF GENERAL PURPOSE TUNNEL DIODES

		JK9B	JK10B	JK11B	JK19B	JK20B	JK21B	Unit
Current Maxima (I_p)	Nominal (±10%)	1·0	5·0	15·0	1·0	5·0	15·0	mA
Current Ratio $\left[\frac{I_p}{I_v}\right]$	Minimum Typical Maximum	2 4 5	2 4 5	2 4 5	5 6 —	5 7 —	5 8 —	— — —
Peak Voltage (V_p)	Typical	45	50	55	55	55	55	mV
Valley Voltage (V_v)	Typical	170	150	270	290	300	310	mV
Forward Voltage (V_F)	Typical	330	380	460	460	480	490	mV
Negative Resistance (—R)	Typical	—111	—25	—7.7	—111	—25	—7.7	ohm
Series Resistance (r_s)	Typical	1·2	0·6	0·3	1·5	1·0	0·4	ohm
Junction Capacitance (C)	Typical	25	50	125	10	30	90	pF
Resistive cut-off frequency (fr)	Typical	540	810	810	1,200	1,500	980	Mc/s
Maximum Permissible Current (either direction)		10	50	150	10	50	150	mA
Limiting frequency of oscillation (f_L) with minimum series inductance of 6×10^{-9}H	Typical	400	280	180	650	400	220	Mc/s

Backward Diode

The backward (or unitunnel diode) is also a tunnelling device (see page 369 of the December 1960 issue of *The Radio Constructor*), but it cannot amplify or oscillate. In the low resistance direction it conducts at a lower forward voltage than normal diodes with the same junction capacitance. Standard Telephones and Cables Ltd. are now producing germanium backward diodes under the type number JK100A at less than £1 for small quantities. These devices are mainly intended for use in tunnel diode circuits as gating diodes. The maximum current in either direction is 75mA. The negative terminal is the lead which is tapered from the base seat when the diode is biased in the low conductance direction. The dimensions of this backward diode are the same as those of the tunnel diode shown on page 290 of the November 1960 issue of *The Radio Constructor*.

Pye Instrument Landing System for Greece

Pye Telecommunications Limited, of Cambridge, England, have received an order to equip the main runway at Athens Airport with a Pye Instrument Landing System. Thus another main route airfield is to use the Pye system, bringing the total airfields equipped by Pye to over 138.

The Athens decision follows the current trend in fitting I.L.S. even at airports where low visibility conditions seldom occur, in order to meet the jet operators' need for making coupled approaches and to permit the pilot to break cloud base at a known point in relation to the runway.

The Pye directional localiser was especially preferred at Athens because its beam is unaffected by nearby mountains, such as the Olympic Mountains, which dominate the approaches to Athens.

Aircraft on the eastern routes now have Pye I.L.S. available at civil aviation airfields in the United Kingdom, Geneva, Belgrade, Prague, Budapest, Athens, Nairobi, Bahrein and Hong Kong.

Cover Feature

Electronics in Car Servicing

by

GORDON J. KING
Assoc. Brit. I.R.E.

THE IGNITION SYSTEM IN A CAR IS RATHER LIKE the hairspring in a clock, for although the motive energy is available in the mainspring the clock will not function correctly until the hairspring is correctly adjusted and balanced. If the hairspring is broken or badly out of adjustment the wheels will not turn at all, while if there is a little misadjustment the overall performance will be impaired, giving intermittent operation and incorrect timing.

Exactly the same principles apply to a car ignition system, but here the timing is in terms of pulses of electricity in the ignition wiring and components and, since electricity is invisible, adjustments are made that much more difficult. Moreover, when a car is in motion and under power the problem of electrical diagnosis is considerably aggravated.

As an example, an engine may idle smoothly in a garage and only when it is under power on the road may it exhibit various ignition faults, such as irregular firing or an occasional or intermittent miss. Diagnosing this kind of trouble invariably calls for trial-and-error methods back at the garage, such as replacing in turn the points, plugs, coil and so on, and then taking the car on another test run in the hope that one of the replacements has cleared the fault.

There is a way, however, of making the electrical pulses visible so that one may see very quickly what is going on in the ignition system, not only when the engine is idling but also when the car is being driven normally or on test on a road. This is made possible by the oscilloscope (or electronic ignition analyser as it is often called in the car world) which converts the rapidly changing electrical ignition pulses into definite waveform patterns, and then displays them on the television-like screen of the instrument.

The waveforms are traced out rather like a television picture, but by a single fluorescent line on the screen. A display of the entire performance of the ignition system is possible, and this can show the simultaneous firing of each plug side by side for comparison or the magnified firing of just one plug, thereby revealing such faults as incorrect plug or contact breaker gap, contact breaker bounce, intermittent or defective capacitor (condenser), leaky ignition cables, faulty or intermittent coil and so on. In short, the oscilloscope portrays the sequence of current pulses occurring during the entire ignition cycle, and thus shows at a glance many of the faults which could take quite a lot of time to locate by other methods.

The basic oscilloscope is used extensively by radio and television service engineers and by amateur experimenters. Such instruments in their

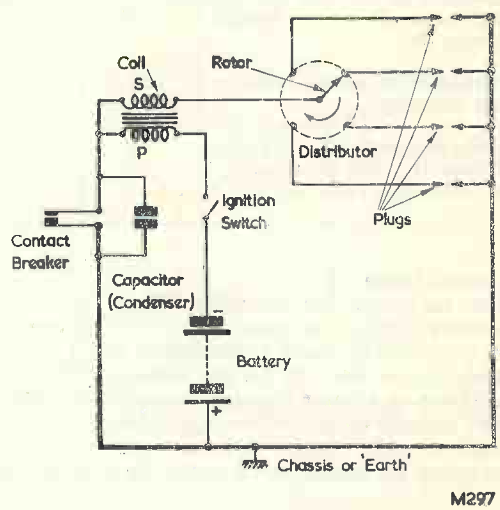


Fig. 1. The ignition system of a car

basic form are now available at very low cost from suppliers of ex-Government equipment and the like and, indeed, it is sometimes possible to obtain a proper ignition analyser from such markets which in past days were used for the analysis of aero-engine ignition systems. If an ordinary oscilloscope is adopted, then it is essential that this features a triggered timebase exclusively or in addition to the normal repetitive timebase.

Basic Ignition Theory

In Fig. 1 is given the basic ignition system for any car. When the ignition switch is turned on and the contact breaker points are closed current from the battery flows through the primary winding of the coil and sets up a megnetic field in the iron core. When the points open several fundamental things happen.

The magnetic field starts to collapse and induces a voltage across the secondary winding of far greater value than that across the primary because the secondary is made up of many more turns of wire than the primary. This is the normal voltage step-up effect with which all transformers are endowed.

At this instant in time the rotor is opposite one of the contacts on the distributor so the very high secondary voltage is reflected across the spark gap of the associated plug. The air across the gap ionizes and a spark occurs which ignites the gas and drives the piston. The points then close again and when they next open the rotor is opposite the distributor contact corresponding to the next plug to fire, and so the complete cycle of events continues.

Voltage Waveforms

Let us now analyse each "firing" cycle in greater detail. In Fig. 2 (*a*) is given a simplified version of Fig. 1, while at Fig. 2 (*b*) is shown a waveform of what happens to the voltage across the points during the time of one complete firing cycle.

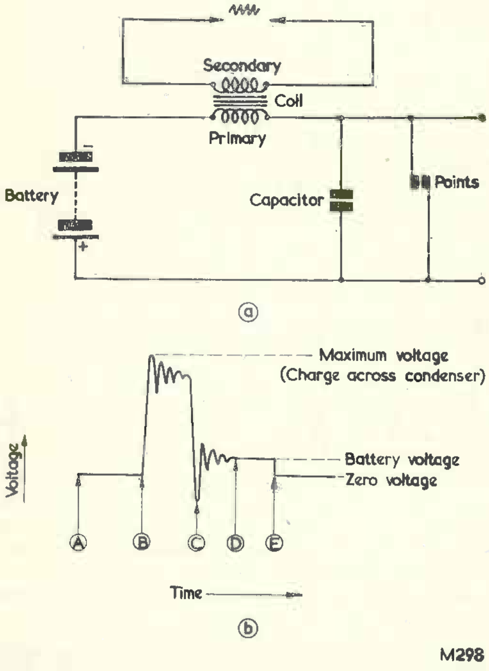


Fig. 2. Showing how the voltage builds up across the points during the firing cycle

When the points are closed there is obviously no voltage across them, as shown during the time period A–B on the waveform. At time B the points open and the collapsing magnetic field in the coil

Testing an ignition system. The author's assistant examines the waveform at the distributor

causes a back voltage in the primary which charges the capacitor to several hundred volts. At almost the same time a spark occurs across the plug and, due to this, a current flows in the secondary winding which sets up its own magnetic field. This reflects back to the primary a further oscillatory current which tends to hold constant the voltage across the capacitor, as shown during period B–C.

During the time of the spark (B–C) the primary has not itself been very active, but when the spark has finished (time C) the capacitor is left with an opposite charge to that with which it started.

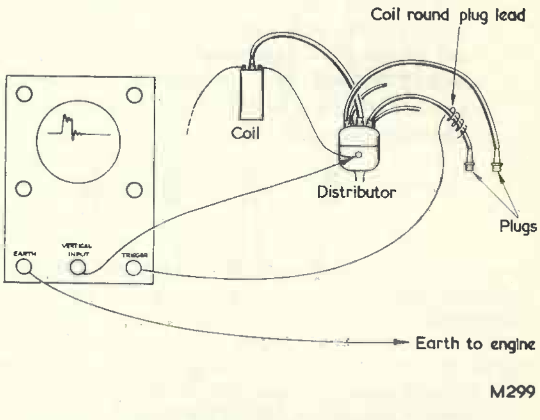


Fig. 3. How an oscilloscope or ignition analyser is connected to the ignition system

This produces a current in the primary which builds up a new magnetic field in the coil and, when the capacitor is almost fully discharged, this new field collapses and produces a smaller and opposite charge across the capacitor. This process continues, giving the oscillatory waveform C–D, until all the energy alternating back and forth between the coil and the capacitor is dissipated by the resistance of the circuit.

The circuit reaches a state of equilibrium at time D, and since the points are still open the voltage across them is equal to that across the battery. At time E the points close again and so the voltage falls back to zero, and the whole process is repeated on subsequent firing cycles.

Waveform Display

The electronic ignition analyser or oscilloscope is connected to the ignition system as shown in Fig. 3. It is not here intended to dwell too much on the detailed operation of this kind of instrument, as such information would be presented in the instruction manual and in articles and books dealing with oscilloscopes. Nevertheless, it is as well to have in mind a brief idea of how the instrument works.

On the screen of the cathode-ray tube is produced a bright spot of light which can be made to move both vertically and horizontally on the screen. The horizontal movement is initiated by a triggering pulse applied to the instrument from one of the spark plug leads. This pulse causes the spot of light to move swiftly from left to right across the screen. When the spot reaches the right of the screen it very quickly goes back to the left again whereupon a subsequent spark pulse causes another left-to-right "sweep", and so the action continues as long as the engine is running. The high speed movement of the spot gives the illusion of an uninterrupted bright, horizontal line.

The vertical movement of the spot follows the voltage waveform which occurs across the points during the firing cycle, and since the spot is also moving horizontally with time it follows that the spot will trace out a replica of the actual voltage conditions across the points. In this way, therefore, the operation of the heart of the ignition system can be seen while the engine is running, and the waveforms reveal at a glance any ignition shortcomings at all engine speeds.

Fault Diagnosis

Fig. 4 shows a series of ignition waveforms which may be encountered by the service engineer. Waveforms (*a*) to (*f*) were produced with the instrument adjusted to provide a single firing cycle display. At (*a*) the waveform is rather like that at Fig. 2 (*b*) and is representative of normal operation of one firing cycle. At (*b*) the height of the waveform is considerably suppressed, and this is caused by a very heavy leak or a short-circuit in the associated plug.

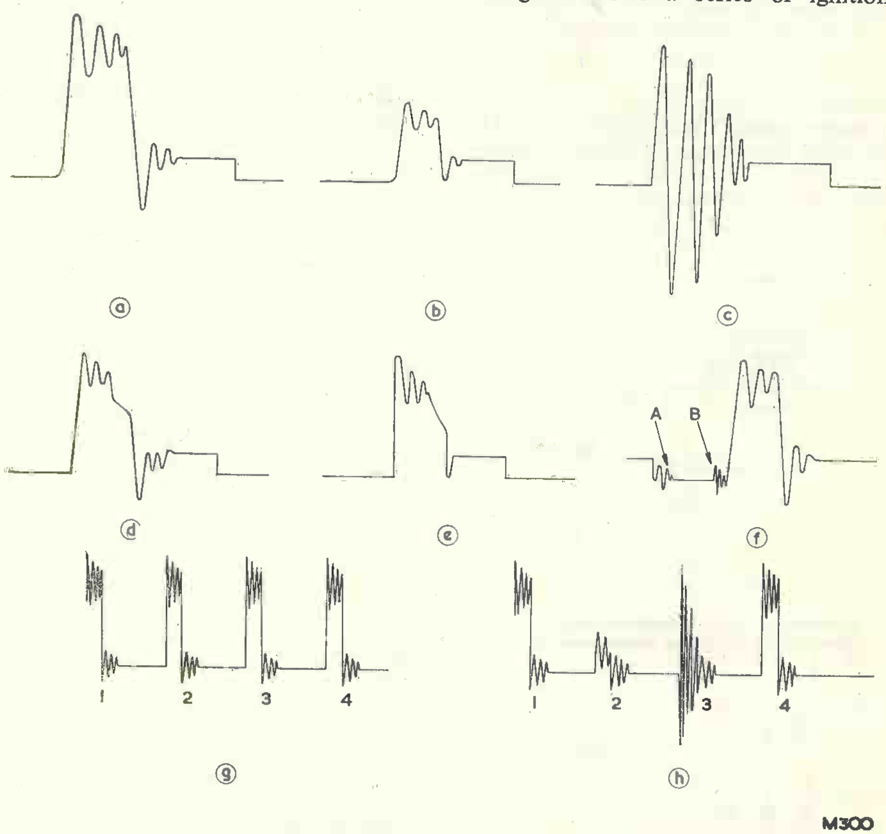


Fig. 4. Waveforms encountered due to various conditions in the ignition system

The large amplitude of the waveform at (*c*) is indicative of an open-circuit plug or a broken plug wire. This effect may also be caused by an open-circuit radio or television suppressor of the plug-lead type. The suppressed sparking cycle of waveform (d) almost always indicates a heavily-carboned plug. This shows that most of the spark energy is exhausted before the sparking cycle is completed as the result of losses in the carbon between the gap.

A defective capacitor will, of course, be revealed by difficulty in starting the engine and in maintaining smooth operation. However, waveform (*e*) shows how this fault is reflected in the voltage across the points, and is useful to have in mind since capacitors have been known to develop intermittent defects which may only show up on a road test.

At (*f*) is shown a normal waveform accompanied by spurious disturbances at points A and B. These indicate contact bounce at A when the points close and at B when they open again. A display of this kind should lead immediately to a check of the point tension spring and securing screws.

The complete waveform pattern of a smoothly running four-cylinder engine is shown at (*g*). Each waveform represents the firing of one cylinder in the usual firing order, beginning with the plug to which the trigger lead is coupled, and with the instrument adjusted to provide a simultaneous display of each plug firing side by side.

The waveform pattern at (*h*) shows obvious faults at 2 and 3. At 2 there is a short-circuit across the plug (see *b*), while the trouble at 3 is caused by an open-circuit plug or lead (see *c*).

Inconsistency between the firing of the plugs can be observed by connecting the trigger lead of the instrument to the distributor terminal along with the vertical input lead. A single waveform made up of all the waveforms (such as 1, 2, 3 and 4 of *g*) superimposed will then be displayed and variations, such as excessive wobble on the distributor shaft or irregular operation of the points, will be shown by the waveforms wobbling slightly from side to side in relation to each other.

Four Track Conversion for Collaro Tape Decks

by M. J. PITCHER, B.Sc.

In this article our contributor describes a conversion to four track recording successfully carried out by himself, and gives advice on similar conversions by readers. The photographs showing the upper surface of the deck are intended for general guidance only. **It must be pointed out that these illustrate the replacement heads in the lower track (right hand) position instead of in the upper track (left hand) position, as recommended in the text. It is necessary therefore that, in this particular respect, the text and not the photographs be followed.**

Acknowledgements are due to P. A. Marriott & Co Ltd., for the drawings reproduced here as Figs. 1, 6 and 7.—Editor.

HAVING OWNED A TAPE RECORDING MACHINE for a number of years, I find that I have acquired a number of fixed ideas and prejudices in the matter of getting top quality recordings. One notion, gained from reading books and magazines, was that four track recording produced so much background noise and degradation of quality as to be suitable only for unmusical, cloth-eared types. A visit to the Audio Fair entirely exploded this idea; four track reproduction appeared to be nearly the equal of the more usual two track. Given the listening conditions and equipment at the Fair are not the same as those at home, I felt that quarter track should be given a trial in the hope that results would not fall too far short of professional standards.

My machine is an Elizabethan de Luxe purchased in 1956, and in the passage of time, and tape, a lot of head wear had taken place. I therefore decided to replace the worn heads with a set of quarter track heads, the economy in tape offsetting the extra cost involved. One further advantage is that by using heads with a very narrow "micro-gap" there is a marked improvement in the upper frequency response; my tapes recorded at $3\frac{3}{4}$ in/s with the old half track heads can be replayed on the new heads and no longer sound as though the music has been strained through cotton wool.

The machine mentioned above is fitted with the Collaro Transcriptor deck and the conversion details given in this article apply to all models of this deck irrespective of the make of tape recorder. So far as the electrical details are concerned the Collaro Studio, and Brenell, decks may also be included when they are fitted with the pill-box shaped head of one inch diameter. The Transcriptor deck permits operation in two directions because it has two sets of heads; owners of such a deck will have to decide which set they will replace. They can then retain the other set for half track working, and obtain the best of both worlds at the push of a button.

The Four Track Heads

The heads used are supplied by P. A. Marriott & Co. Ltd., under type numbers L/RPS/7 (record/playback) and L/ES/9 (erase). This firm also provides a really excellent fixing bracket.[1] Brackets for certain decks other than Collaro are listed by this firm, but this article is concerned only with the replacement of Collaro heads. The Marriott four track heads were chosen because of their excellent electrical characteristics, making for easy conversion, and comparatively low price. Dimensional details of the heads are given in Fig. 6, whilst Fig. 7 shows typical current record/playback characteristics. A technical specification for the heads is given in the Table.

Now just a word to the uninitiated. At one time I thought, as you may do, that "four track" means that it is possible to record any one of four tracks at your choice. In fact there is a choice of two tracks when the tape is travelling from, say, left to right; two more tracks being obtained by turning the tape over and recording side 2. The four track head contains two coils and recording gaps, the connection to the coils being made to wire tags at the rear of the head. Fig. 1 shows the spacing of the tracks.

The author's Elizabethan de Luxe appears to perform as well at $3\frac{3}{4}$ in/s quarter track as it previously did at $7\frac{1}{2}$ in/s with half track recording. This improvement applies equally to new recordings and replay of existing half track recordings.

Removing The Old Head

The fixing bracket supplied with the heads is intended to be a direct replacement for the upper track heads. These are on the left hand side of the deck, looking from the front. It will be necessary to remove the pair of recording heads complete with mounting plate, together with the leads connecting them to the switch bank.[3] This is done in the following manner.

The plastic deck cover is first removed by unscrewing the six retaining screws and the speed change knob (which pulls off). This gives access to the top surface of the deck. With my Elizabethan recorder access to the underside is easily obtained by unscrewing four bolts holding down the deck mounting board. Owners of other models, or makes, of machines using the Collaro Transcriptor deck should be able to puzzle out how to release the deck from its mounting.

The head nearest the capstan is the recording head and a thick lead, probably grey, trails down through the deck from it, the soldered connection of its screened braiding and two inner conductors being made at the switch bank. *These, and all*

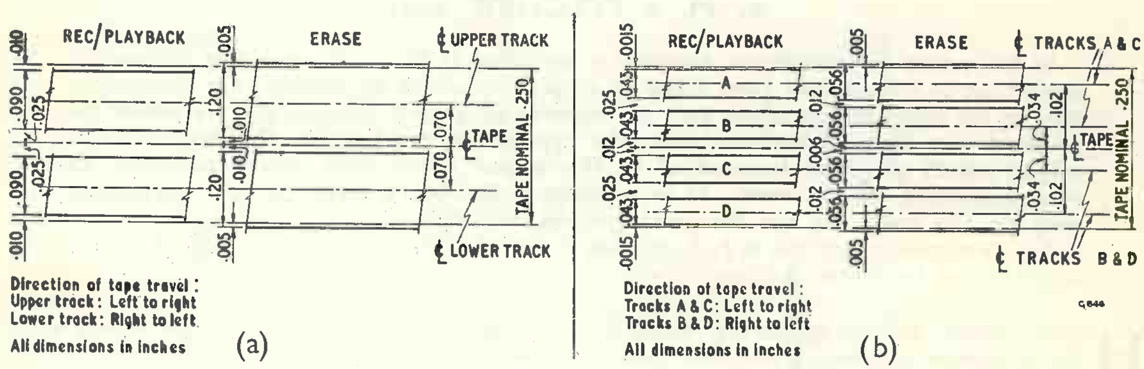


Fig. 1 (a). Two track dimensions and (b) four track dimensions

The recording gap is two and a half microns and the narrowest that is known to the author as being readily available to the amateur constructor.[2] The advantage of having an extremely narrow gap is that the range of high frequencies available on playback is greatly extended. While a specially designed amplifier would be needed to get the utmost in response there should be a significant improvement on the older type of head.

other connecting points, should be very carefully noted on paper before any attempts are made at circuit changes.

The erase head will probably have a pair of twisted unscreened wires also connected to the switch bank. The new erase head will be wired in to the same points with a series resistor which is discussed later.

Having made the necessary notes and diagrams

[1] The suppliers of the heads are P. A. Marriott & Co Ltd., 284A Water Road, Wembley, Middlesex. The price of the heads, together with the bracket mentioned, is £8. 14s. 0d.

[2] 1 micron = 0.0001cm. = 0.0004in.

[3] As was mentioned in the Introduction to this article, the accompanying photographs illustrate the replacement of the right-hand heads. However, the bracket available from P. A. Marriott & Co Ltd., is for the left-hand heads only and it is the replacement of these which is described in the text, and which is recommended by the author.

The deck with large mounting plate removed. Note the cigarette packet in G inserted between the plate and the capstan to prevent damage. The head leads can be seen at O and N

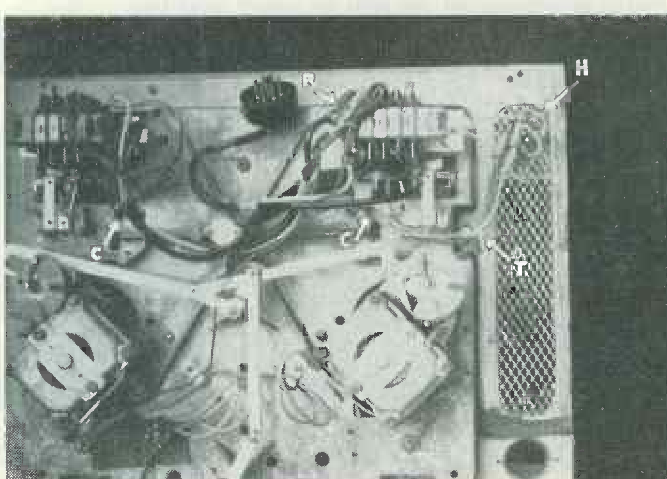
the leads are unsoldered. Returning to the top surface of the deck note that the heads, pinch wheel, and pressure pads are mounted on a very large plate held down by four screws. The four screws are removed to relase the plate, otherwise the leads cannot be withdrawn and the new ones put in. The four screws holding down the head mounting plate can be taken out and the plate, heads, and all leads withdrawn. It is *vitally* important to protect the capstan during this operation from accidental scratches or damage of any kind. Also careful note should be made of the position of all the wires before removal, so that the new wires will take up the same position and will not come into contact with any moving parts.

Fitting The New Head

When removing the old head plate it will be found that four spacers are under each screw. These will be needed again for the new head plate, which can now be placed loosely in position.

The new heads can also be placed, temporarily, in their brackets but should not have the adjusting screws tightened as yet. The heads must be mounted the correct way up. To enable this to be easily accomplished, the manufacturer has placed a coloured dot on the side which mounts nearest to the deck. It may not be too easy to identify them and the following points can be noted. The record/playback head has narrower pole-pieces than the erase head, but a more positive check is that the erase head has a double gap which shows up as two thin brass lines in the centre of the pole-piece. The constructors eye-sight will have to be exceptionally good to see any gap at all in the recording head. Also, the record/playback head has a red filling and the erase a blue filling. The record playback head is mounted nearer the capstan.

The record/playback head needs to be connected up with twin screened wire such as Radiospares miniature twin screened microphone cable. The



Underside of deck. The head switch is at H. The series resistor needed in the erase line is shown connected to the switch bank at R. The connections to the heads are at C and T shows the leads tied down

Top view of recorder. K is the new head switch knob. The plastic cover is removed after taking out the six screws at S and the speed control knob C.

p.v.c. cover, and screen braid, are both removed to allow about half an inch of the twin leads to project. This cable is drawn up through the deck to occupy the same position as the old cable. There is ample room to fit the second cable needed for the second track of the four track head.

The tag wires on the head should now be bent down and round into a loop so that they will not touch the plastic deck cover, and to make a firm anchor point for the leads. The leads should be marked in some way to identify them, and then soldered to the record/playback head.

It is not essential to wire the erase head with screened cable and thin stranded wire will do provided that the two leads are twisted together. The wire used by the author is about 1mm diameter and there is room for the two twisted pairs and the screened cables without having to enlarge the clearance hole in the deck.

The length of screen lead and wire needed will depend on the position of the head switch.

The Head Switch

To take full advantage of the new heads it will be necessary to fit a switch. The track to be used can then be selected according to the direction of travel of the tape.

Machines vary so much in the design of their casing that no specific details can be given except for the Elizabethan de Luxe. With this machine the switch can be fitted adjacent to the deck as shown in the photograph. The main considerations are to have it in an accessible position, as and far removed from the mains transformer as possible. Suitable places may be found on the socket panel at the rear, if fitted, or in the mains lead pocket.

A small two-way rotary switch was chosen and has proved to be quite satisfactory. The connections to the switch are shown in Fig. 2, and it will be noticed that the switch selects both the erase and recording track to be used. Care is needed to keep unscreened, or untwisted, leads as short as possible.

The recording amplifier. The bias control is shown at B

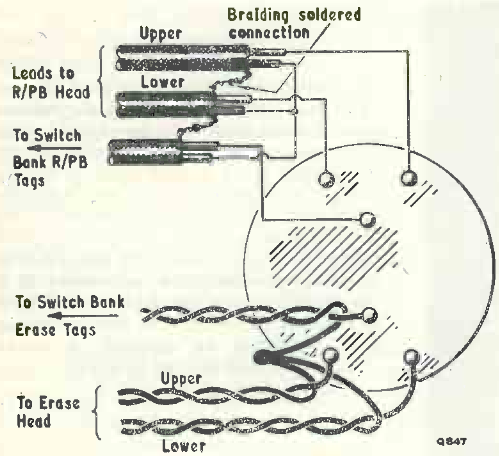


Fig. 2. The track switch viewed from the rear (2-pole, 2-way)

Wiring Up

The heads, which have been temporarily placed in their brackets, should be checked again to see that the recording head is in the position nearer the capstan. Also check the marking on the leads for later identification. The leads should be soldered to the head tags using a minimum of solder, and taking the least time possible. The tags look fairly robust, but it is a wise precaution to avoid heating them excessively.

While the large plate is loose, examine the guides at each side. If there is any sign of wear loosen the fixing screws, turn the guides through a small angle, and re-fix.

The wires are now drawn fairly tight and the large plate fixed down with its four screws.

The head plate is next bolted down tightly but the heads are left loosely in their brackets for the moment.

Moving now to the underside of the deck, the various wires may be dealt with. These should be tied down to suitable anchoring points, with string to ensure that there is no possibility of contacting moving parts, and making as direct a run as possible to the switch. Fig. 2 shows the connections to the switch and indicates the leads returning back to the switch bank. The head lead connection can be made directly to the tags, previously noted, on the switch bank.

Erase Voltage

The erase head leads must on no account be connected direct to the switch bank tags. The Marriott heads require much less power than the Collaro heads which they are replacing, and the surplus energy must be absorbed in a series resistor. This is achieved by placing a 390Ω 1 watt resistor in series with the live side of the erase lead. See Fig. 3. One end of the resistor is connected to the line from the oscillator, the other end is wired on to a spare tag on the switch bank. Look for a set of three unused tags on the bank associated with the fast wind button; and do not make use of a spare tag in a group of three if either of the other two are already in use.

In terms of voltage some measurements were made with a Weston 772 Analyser. (This was compared with a 'scope up to the oscillator frequency of 55kc/s, and beyond, and found to have a fairly flat response and give reliable readings.) While the Collaro head takes erase power at 30 volts, the Marriott head functions properly and gives excellent erasure at 10–15 volts.

Adjusting the Bias Voltage

Readers will, no doubt, be aware that during recording the tape amplifier supplies high frequency current not only to the erase head but to the recording head as well. The latter is referred to as "bias". The bias voltage measured at the Collaro head was 50 volts and proved to be too high for really satisfactory recording with the new heads. The value of bias voltage should be lowered to about 30 volts for recording on the normal types of tape.

The amplifier of the Elizabethan de Luxe machine has a bias voltage control mounted so that it is accessible when the deck is lifted up. This takes the form of a pre-set potentiometer. Before making any alterations to the setting its position was marked with a spot of paint. A number of machines are similarly fitted and readers may find that the bias can be lowered sufficiently by making a suitable adjustment.

Fig. 3 shows a method of incorporating an adjustable bias control. The circuit is typical of that used in recorders where the output valve is also used as an oscillator during recording. The siting of the control can be left to the reader's discretion but, if it is not mounted on the amplifier chassis some screening should be used, and it should not be sited near the high gain amplifying valves.

For those who like to set the bias accurately, and have plenty of time for the somewhat tedious

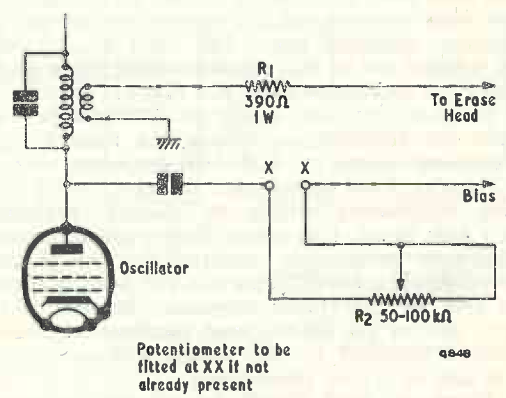
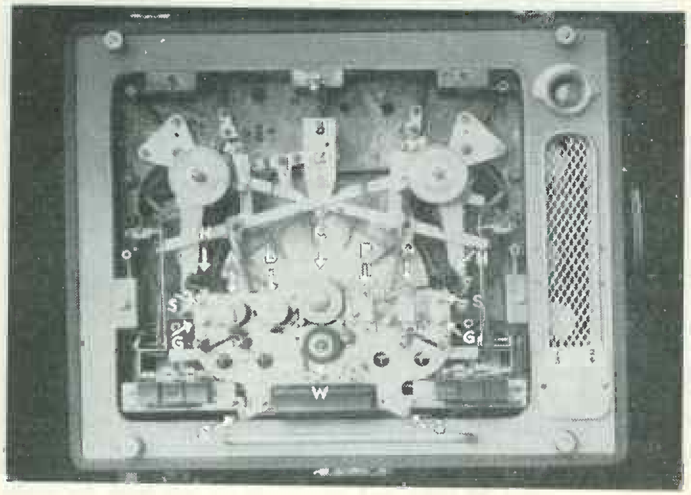


Fig. 3. Absorbing the surplus energy in a series resistor



Top view of deck. A and B are the half track "pill box" heads and P and Q are the new quarter track heads. The lower track heads are shown to have been replaced in this illustration, but it is much easier to replace the left hand set and this is recommended in the text. The capstan is shown at C. The large mounting plate carries the pinch wheel W, pressure pads and heads can be removed by undoing the four screws at S. The guide pillars G can be rotated if signs of wear are apparent. The hum cancelling coils H should be adjusted to secure minimum hum on playback

work involved, some notes will be given later. It will first be necessary to get the heads fastened down.

Head Alignment

The heads should be just clear of the tape when the deck is in the "Stop" position. To check this, thread some transparent leader tape between two empty reels and check that it lies evenly in the guides, including the new guide on the head plate. There must be no indication of buckling at any point when the tape is pulled tight. The heads are adjusted and the two screws tightened to secure them in place.

The location of the pole-pieces should now be checked with Fig. 1, bearing in mind that the top edge of the upper erase pole-piece should lie on the edge of the tape.

Azimuth Adjustment

To get the best possible results from existing half track tapes, or tapes from other machines, the head must be adjusted so that its gap occupies the same position relative to the tape as did the original recording gap. The head bracket rests on a metal bar so that rotation of the fixing screws gives it a rocking motion. See Fig. 4.

Readers who have access to a "Test tape" will have no difficulty in rocking the head to give maximum output at some high frequency such as 7.5 Kc/s. Most of us can, however, arrive at a very satisfactory setting by playing, preferably at a high speed, a recording from a reliable source. The best programme material for the purpose will contain a lot of treble and the head is rocked to give the best treble response. Because of the very narrow gap in the head excellent adjustment can be obtained by this means without using a test tape or special instruments.

The erase head should be adjusted to appear square with the tape. The exact relationship between the gaps and the tape is in no way critical.

Pressure Pad Adjustment

The machine is all set up and ready to go. Record on all four tracks and check that the volume is equally loud on all four tracks. The chances are that two tracks reproduce at less volume than the others.

Failure to obtain a good response from both tracks of the head is most likely to be due to having pressure pads that are too small for the width of the tape. For quarter track recording it is vital to have the pad covering the tape, and for half track recording it would seem to be essential. Yet a number of machines examined by the author are fitted with pads which fail to fully cover the recording gap. In any case the pads will have taken up the shape of the old head and may have picked up oxide dust from the tape.

The remedy is to carefully cut the pad off by running a razor blade along the metal support, then fix it back in position at right angles using latex adhesive. When the glue has set the pad is "teased" out with the point of a pencil so that it lies flat against the head. The pencil will recondition the felt pad and if any graphite rubs off on

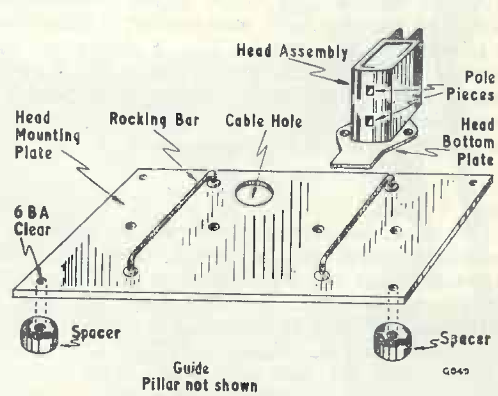


Fig. 4. Fitting the head assembly

to the pad it will merely act as a lubricant. This is, incidentally, a good way of curing a squeaking pressure pad.

Recording Level

Very little precise information can be given regarding the recording level. The information supplied by Marriott & Co. Ltd. indicates that their four track heads require less recording current than the Collaro heads. I found that the tape appeared to be fully modulated with the Magic Eye just closed. It is possible that other machines may fully record with the Magic Eye not fully closed.

The adjustment of recording level for best results will be a matter of experience, as it should be with any head. The indicator, whatever the type, is only a guide and not always a reliable one. The need for careful regulation of the level is more important with the new head in order to achieve as good a signal-to-noise ratio as possible.

A Few Do's and Don'ts.

While it does no harm whatever to switch from one track to another during playback, it is most inadvisable to switch while the machine is recording. The sudden cessation of bias current in the recording head is likely to leave it magnetised, and this will increase the noise level and may even make an otherwise good tape noisy. So be warned.

Do not expect the noise level to be quite as low with quarter track recordings as with the half track. In this connection a clear distinction should be made between tape noise, which is a hissing or high pitched fizzing sound, and amplifier hum. The latter is reduced in the Elizabethan, and other recording machines, by means of hum cancelling coils. These will be mounted on, or near the heads. See Fig. 5 for circuit connections.

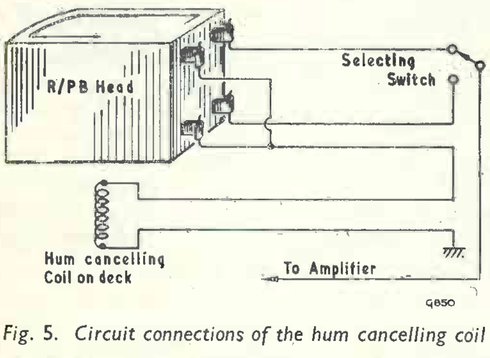


Fig. 5. Circuit connections of the hum cancelling coil

The coil is likely to be series connected with the head only during playback. A small hum voltage is generated in this coil and if this is equal in amplitude and opposite in phase to hum from other sources cancellation takes place. To check the coil for best setting, switch the machine to maximum volume on playback (no tape is necessary), rotate the coil to produce minimum hum, and secure in position.

It is necessary to "de-flux" the new four track heads more frequently than one has been accustomed to do with the old heads. Micro-gap heads are much more sensitive to permanent magnet effects than the old, wider gap, heads.

Bias Setting

Variation of the bias setting will produce recordings with either too much, or too little, treble. The usual aim is to set the bias so that the response is as even as possible over the whole range. This can be done with a fair degree of accuracy by recording some music while the bias is varied in definite steps. The most acceptable setting is noted during playback and the control is turned to the appropriate position. The music used should contain plenty of treble and the author favours music, for this purpose, in which brass instruments predominate. If an audio generator is available record a signal at about 3 kc/s and select the bias setting which gives the best signal-

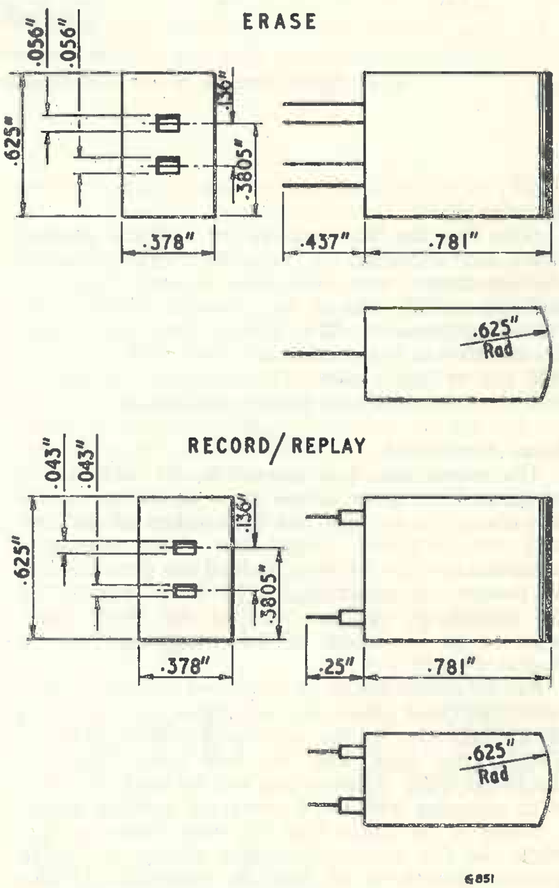


Fig. 6. Dimensions of the Marriott heads employed for the conversion

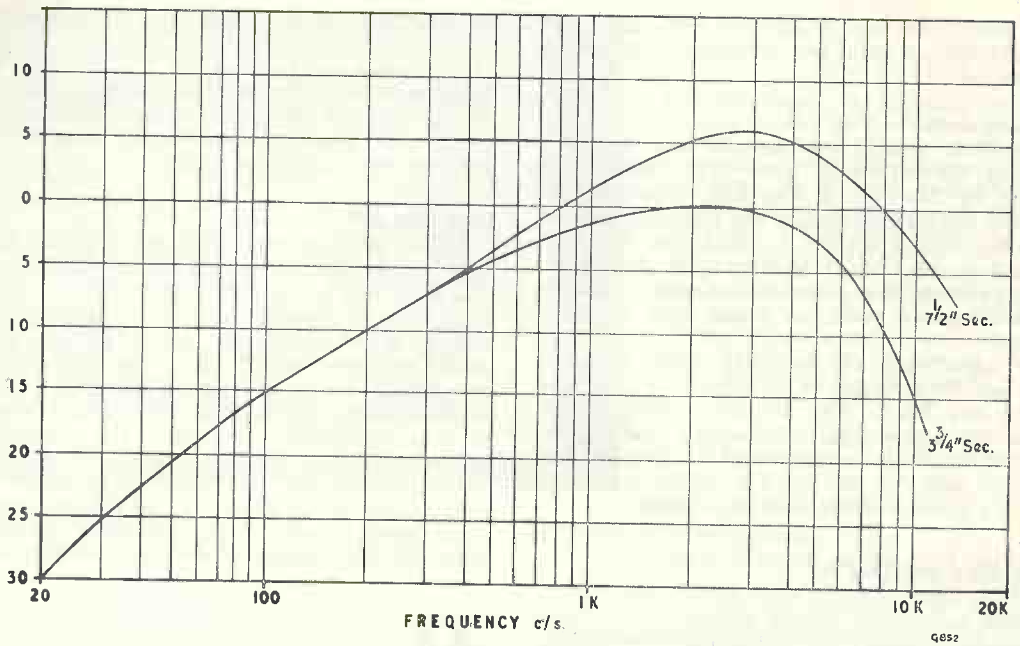


Fig. 7. Typical constant current record/replay characteristics for the Marriott head type L/RPS/7

to-noise ratio.

Note that the bias settings for half and quarter track are different. A suitably marked control will overcome any difficulties in this direction, and its setting should be checked before each recording session. The author feels that, once the conversion has been made, the half track heads will not be much used. Consequently the control will be permanently set for the new heads.

Final Assessment

The conversion has proved to be well worth while and has given a new lease of life to an old recorder. No account has been taken of the fact that the amplifier circuit has fixed frequency compensation for 7½ in/s. Indeed the circuit seems to favour reproduction at 3¾ in/s. Replay of old recordings, or new ones, at the lower speed seem to be the equal of those previously to be had at 7½ in/s.

Readers may like to be reassured that the alterations described above do not affect the operation of the recorder in the reverse direction. Thus a Transcriptor deck with the four track heads in the upper track position can still be used as a half track recorder with the lower track existing heads.

There is no doubt that the conversion to four track, in the manner outlined above, is of the greatest benefit to all but the professional, who demands, and can afford to pay for, absolute perfection.

TABLE

Specification for the Marriott record/playback head type L/RPS/7.

Track Widths	0.043in
Track Spacing	0.136in
Gaps	0.0001in
Inductance 1 kc/s	0.4 H
Impedance 50 kc/s	45kΩ
Bias Current	0.45–0.8mA
Record Current	30–80μA
2 kc/s output, own recording, 3¾in/sec.	2.1 mV*
3 kc/s output, own recording, 7½in/sec.	3.7 mV*
1 kc/s output, E.M.I. Test Tape T.B.T.I.	0.65mV
Recorded Crosstalk	Better than-70dB
Playback Crosstalk	Not measurable

* Quoted for Scotch Boy Tape, Type 111

Specification for the Marriott head type L/ES/9.

Track Widths		0.056in
Track Spacing		0.136in
Gaps, Double each		0.005in
Impedance	50 kc/s	200Ω
Volts	50 kc/s	13 maximum
Current	50 kc/s	80 mA
Power	50 kc/s	0.25 W. approx.

Items Required For The Conversion

Record/replay head L/RPS/7, Erase head L/ES/9, Set of Fixing Brackets — P. A. Marriott & Co Ltd., 284a Water Road, Wembley, Middx.

390Ω 1 watt resistor.

50–100kΩ potentiometer (If bias control is not already fitted).

Twin screened wire, single 1 mm. stranded wire, length according ot position of head switch.

Part 4

Emitter Follower Circuits

By PETER WILLIAMS,
B.Sc.(Hons.), Grad.Inst. P., Grad.I.E.E.

This last article in the present series deals with an LC oscillator using the basic emitter follower circuitry which has been discussed in the previous contributions.

Also described are two units which, by means of simple switching circuits, enable two, or three, of the previous circuits to be combined with common components. The second unit discussed, a combination multivibrator, low impedance amplifier and high impedance amplifier, can be of particular value in servicing applications.

There are several different ways of looking at the LC oscillator about to be described, each being interesting in its own way. The straightforward approach is that of a tuned stage with positive feedback, but it is also instructive to derive it from the multivibrator described in the article published last month.

A multivibrator has a square wave output at the collector, this being a complex output composed of one fundamental frequency with varying amplitudes of harmonics. In fact, a square wave can be synthesised by adding to a sine wave of the same frequency appropriate portions of each harmonic. The problem is, as the reader will find if he attempts it, that for a perfect square wave we need an infinite number of them. Thus a wave lacking higher harmonics will have rounded edges and vice versa.

If there is included in the multivibrator an LC circuit, parallel resonant tuned to one of these harmonics, then this will be selected and all other harmonics, as well as the fundamental, rejected. Practice as usual ignores the simplified theory outlined above and various harmonics succeed in creeping through the tuned "barrier" leaving us with a rather "Brand X" sine wave.

Basic Circuit

Returning to the more straightforward standpoint, Fig. 1 shows TR_1 as a grounded base amplifier with a tuned collector load. The output is fed to the emitter follower TR_2 and is emitter coupled back into TR_1. No change of phase occurs in the emitter follower, and so the feedback is in phase with the current producing it. Oscillation takes place, tending to be too powerful because of the high gain of the first stage and the perfect coupling given by the second. The frequency is again that of the tuned circuit because at all other frequencies the gain, and hence the tendency to oscillate, is severely reduced. This last statement is, however, over-optimistic, and is true only if the oscillations are limited to a level where excessive clipping does not occur. In practice, vicious squaring will take place unless precautions are taken to reduce the overall gain, and the frequency is considerably lowered.

Most oscillators using inductors in the frequency determining section require them to be tapped (as

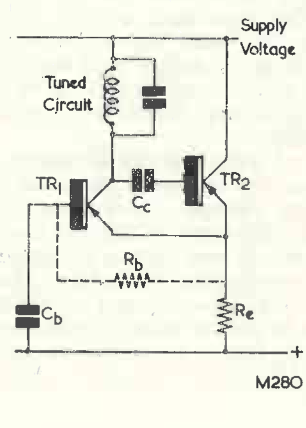


Fig. 1. Earthed emitter LC oscillator. R_b is shown dotted and it serves no purpose. It may be convenient to leave it in place for easy conversion

in the Hartley oscillator), to have a single winding tuned by tapped capacitors (as in the Colpitts oscillator), or to be provided with a separate feed-back winding. In the present arrangement any untapped coil can be used together with any suitable capacitor. If r.f. transistors are used, the oscillator can be made to generate anything from low audio, through i.f., and right into the broadcasting band by using the appropriate tuned circuits and a single pole switch.

As described, the transistors are receiving no d.c. bias current but are being driven heavily by the oscillations. This leads to a very distorted waveform and some form of biasing and gain reduction will be required if sine waves are wanted. For most ordinary test purposes, the sort of noise that this circuit produces will be quite adequate and it may be in its simplest form.

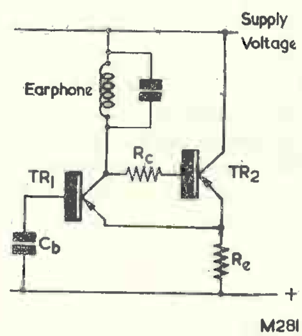


Fig. 2. The original collector load R_e (20kΩ) is inserted to improve the d.c. conditions and limit amplitude

Component variations may be quite wide as in the previous units. The capacitors may both be electrolytic components of any value and the emitter resistor can be anything from a few hundred ohms to several kilohms. Almost all transistors will be suitable, those with higher leakage currents coming into their own in this unit as the lack of bias still leaves them with enough current for near-optimum operation.

The similarity of this oscillator to the previous circuits means that the same components can be adopted with the exception of the tuned circuit. Even this can be provided conveniently by the earphone suggested as a microphone for the low-impedance pre-amplifier described in the first article of this series. In many cases the self-capacitance of the earphone, together with that of the rest of the circuit, is sufficient to tune it to a resonant frequency, but this may be too high in the audio range for comfort.

Adding a capacitor of 0.01μF–0.1μF across the earphone usually brings the frequency down to a more comfortable level, though it does add an extra component. If the earphone or inductor used has a high d.c. resistance of one or two thousand ohms, then a further simplification is possible. The current through the inductor now causes a sufficient voltage drop across it to permit direct connection from collector to base. Direct connection would mean that there would be a negligibly small potential difference between the collector and base of TR_1. The original collector load can now be inserted as shown in Fig. 2 between the collector of TR_1 and the base of TR_2, giving a potential difference due to the base current of TR_2. The resistor can be increased appreciably, but not indefinitely because this would reduce the a.f. transfer and finally prevent oscillation. An alternative and better system is to connect the collector of TR_1 directly to the base of TR_2 and tap the first emitter low down on the emitter load of the second.

It should not be thought from the above digression that the original circuit will not work. On the contrary, it works enthusiastically, providing a satisfactorily high output into quite low impedances. The other suggestions are included for the experimentally minded and, with care in adjustment, provide improved performance.

A final possibility not investigated by the author would be to use the primary of a medium impedance transformer as the inductor and tap a loudspeaker into the secondary. With higher voltage supplies satisfactory signals should be obtained in the speaker. Use as a Morse practice oscillator with either an earphone or loudspeaker and transformer can probably be attained by using the key to make and break the collector-base connection.

Combination of Units

It would be of little advantage to have this series of circuits using components of the same value unless the components could be interchanged or switched to provide the several differing functions. It is not possible to produce all of them with simple switching but, as the two pre-amplifiers and the multivibrator are so closely related, they are shown together in Fig. 3 so that the switching required can be visualised more clearly.

The first switching combination, shown in Fig. 4, involves only a single-pole two-way switch which earths one or other of the two input sockets. Earthing the base input allows the emitter to receive signals from its microphone and the circuit has a low impedance, grounded-base, input. If the emitter input is short-circuited, the circuit reverts to grounded emitter operation with medium impedance. The low impedance earphone can be left permanently in socket 2 and the medium impedance source, e.g. moving iron pick-up, connected to socket 1 since the switch automatically short-circuits the input not in use.

To include the multivibrator a three-pole three-way switch is used since there are now three different functions to be carried out. These are short-circuiting the coupling capacitor, earthing the input not in use and connecting the emitters together in the case of the multivibrator. (See Fig. 5.)

In position 1 of the three-pole switch, the base capacitor is grounded, the emitters joined and the coupling capacitor is in circuit, thus providing the multivibrator action. In position 2 the base capacitor is still grounded, the coupling capacitor is short-circuited and the input is to the emitter,

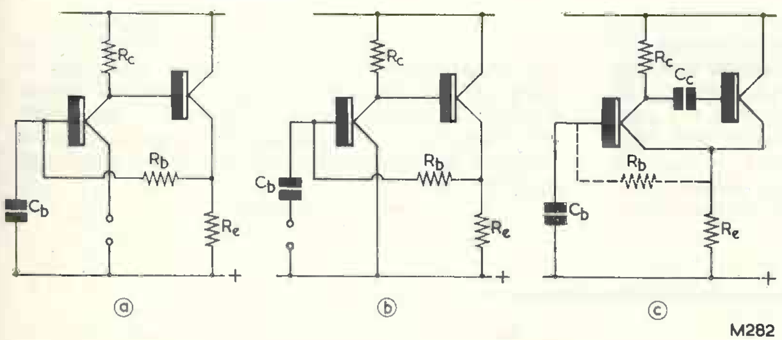


Fig. 3. The three circuits previously described, illustrating common features. (a) Low impedance pre-amplifier, (b) Medium impedance pre-amplifier, and (c) multivibrator

giving the low-impedance pre-amplifier. Finally, position 3 connects the emitter of TR_1 to earth and releases the base capacitor to act as the input isolating component for grounded emitter operation. Further complications in switching are possible to include the LC oscillator but the increased usefulness is marginal as the arrangement of Fig. 5 makes a very versatile test unit of itself.

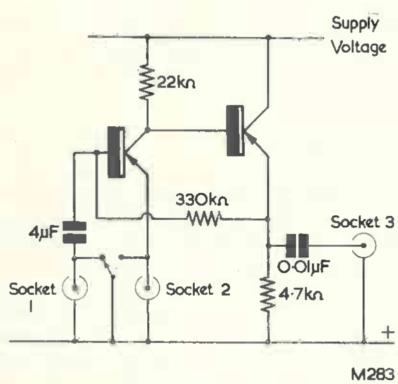


Fig. 4. Low and medium impedance pre-amplifier

Test Unit Outputs

It can be used in the following way to test radios and amplifiers. Insert a low impedance earphone into socket 2, and the output from a medium impedance pick-up or radio tuner into socket 1. The output from socket 3 will now provide three different signals with which to test the suspect unit.

Switching to position 1, the multivibrator gives a powerful, harsh audio signal, with sufficient harmonics if r.f. transistors are used to penetrate the i.f. and even the r.f. sections of a radio set. Placing the output leads between earth and the grid of the output valve and working backwards, the signal at the loudspeaker should increase as more and more of the amplifier is brought into use. When the output ceases or weakens considerably the faulty stage has been reached and can be corrected.

Should the fault appear in the audio section of the receiver or in an audio amplifier, the quality can be checked by switching to position 2.

Speaking into the earphone produces some hundreds of millivolts out on peak, and should adequately drive the amplifier at any point. The quality will be limited by that of the "microphone" but it is more than adequate for indicating gross errors of biasing, etc. It is very difficult to adjust components whilst still talking into the "microphone", and if the alternative signal source, gramophone or radio tuner, is now switched in via the third position of the switch, testing can continue unhindered.

The great advantage of this system is that once the microphone and signal source have been plugged in there is no need for any unplugging or disconnecting of input or output leads, the single switch doing all the work. The output level will depend on those of the inputs and will vary from a few hundred millivolts with earphone as input to 6 or 7 volts peak-to-peak from the multivibrator. Because the grounded emitter pre-amplifier requires a small input signal it may be necessary with high level inputs to insert some series resistance. For example, a crystal pick-up can be fed in via a 50kΩ series resistance to give, say, 20mV at the input and 4 volts out at a low impedance.

Since each circuit individually can accept a wide range of component values then the combined unit is equally happy. Though a standard set of values has been specified, provided the constructor keeps

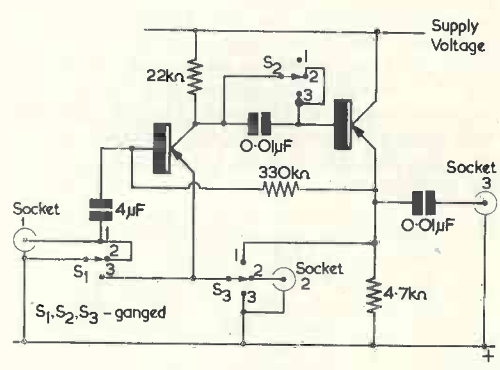


Fig. 5. Low and medium impedance pre-amplifier and multivibrator

within the ratings of the transistors, satisfactory operation should follow. R.F. transistors work well in the audio band for such circuits as these and offer considerable advantages in the multivibrator with their higher harmonics. It may be that the extra cost of a pair of good r.f. transistors will seem justified by the improved performance in frequency response of the pre-amplifiers also; although any transistors, including the really low-priced surplus audio types, will give quite satisfactory results.

Finally, the writer would like to make clear that the possibilities of direct-coupling and emitter follower circuits are by no means exhausted. Crystal oscillators, series resonant LC oscillators and super-high-gain pre-amplifiers using positive feedback are practicable, and are being developed by him.

(Conclusion)

A LINEAR SCALE RESISTANCE-CAPACITANCE BRIDGE

PART 2

By W. E. THOMPSON, A.M.I.P.R.E.

Range Coverage

THE BASIC BRIDGE CIRCUIT IS SHOWN IN FIG. 13, from which it will be seen that three standards of resistance and capacitance are selected by one switch, while the other switch performs the functions of selecting the required multipliers and reversal of the balance control RV. This circuit is incorporated in the full circuit of the prototype bridge given in Fig. 14. As these two circuits stand, there are three multipliers for each position of S_1, which results in overlaps of some ranges. The complete coverage is 1Ω to 10MΩ, and 10pF to 100μF.

In Fig. 13 the values of the multipliers are shown as exact calculated values. These multipliers in the circuit of Fig. 14 are made up of fixed and preset variable resistors in series, so that the required values can be obtained during initial calibration of the bridge.

The modification of the range switching shown in Fig. 15 does not require alteration to circuit values; it entails only the use of different switches. Opportunity has been taken to so arrange the circuitry that no overlaps of ranges occur. The switch S_2 changes the circuit for resistance or capacitance ranges as required, while S_1 selects the correct multiplier and standard together for each range. The full coverage of the bridge is as shown in the table below:

S_1 Switch Position	*Range Covered* R	C
1	1–10Ω	10–100pF
2	10–100Ω	100–1,000pF
3	100Ω–1kΩ	0.001–0.01μF
4	1–10kΩ	0.01–0.1μF
5	10–100kΩ	0.1–1μF
6	100k–1MΩ	1–10μF
7	1–10MΩ	10–100μF

For Fig. 14 the scale of the balance control RV is marked 0.1 to 1, but for the circuit of Fig. 15 the scale should be marked 1 to 10 to make interpolation easier.

Bridge Sensitivity

It was said in an article describing an earlier design for a bridge[1] that some difficulty could be encountered in obtaining a clear visual balance with a magic-eye null indicator when measuring high values of resistance and small values of capacitance. Provision was made for improving this defect by suggesting means of increasing the alternating voltage excitation for the bridge of such measurements. However, it is not always good policy to have high voltage in the arms of a bridge, and the

[1] A Mains Operated Bridge—W. E. Thompson, *The Radio Constructor*, Vol. 5 Nos. 9 and 10. May-June 1952.

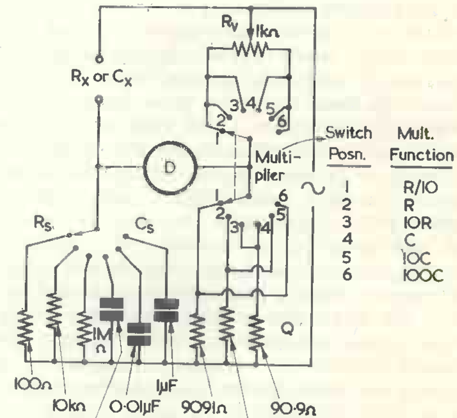


FIG.13

50V normally provided in the previous design is about the most that should be used.

Referring to Fig. 14 here, it can be seen that when very low values of resistance are being measured, a fairly heavy current can be demanded from the voltage source, and this current must of necessity flow through the 100Ω standard resistor R_4. This current can be restricted with a limiting resistance, as was done in the design mentioned earlier, but this is not necessary with the circuit of Fig. 14 where the excitation voltage is only 6.3V. With this arrangement, if the test terminals are short-circuited, either deliberately or by accident, the short circuit current of 63mA flows through the 100Ω standard. The power dissipated is 0.4W, the 1W resistor easily withstanding this, but it is advisable not to subject R_4 to high currents for longer than is necessary.

The use of low excitation voltage is an advantage where stability of circuit values is to be preserved, but it rather conflicts with the requirement of high voltage to secure good sensitivity when measuring high resistances and small capacitances. To overcome this, an amplifier is incorporated in front of the magic-eye balance indicator. This part of the circuit is similar to a design by Dr. Koster[2] where an SP61 valve was used. The same valve could be used here in place of the EF91, and in fact almost any r.f. pentode would be a suitable alternative.

Control of bridge sensitivity is effected with the potentiometer R_7 in the triode grid of the 6U5G magic-eye. Normally the lowest sensitivity commensurate with ease of obtaining a clear shadow outline should be used, but when measuring high resistance or low capacitance the control can be advanced to produce a sharper image. Quite good accuracy can be obtained in this way with capacities of the order of 10pF, when the impedance offered at 50 c.p.s. is nearly 320MΩ. It is necessary under such stringent conditions to take stray capacities into account, and better accuracy for small values can be secured by first measuring a relatively high value then placing the small value directly in parallel with it. A second balance is then made so that the *difference* between the two readings can indicate the value of the smaller capacity. As strays due to wiring and proximity of test leads are included in both balances, their effects cancel out.

Power Factor and Leakage

Referring to Fig. 14 to discuss the few remaining features in this diagram, provision is made to indicate power factor of capacitors of 0.1μF upwards. A leakage test is also available for all capacitors, and the power supply follows normal practice.

The power factor control is a variable resistor in series with the 1μF standard. This control is calibrated in percentages from zero to 30%. The writer described this method of measuring the "goodness" of a capacitor in a previous article.[1] It has been found that indication of power factor above 30% is seldom necessary, for capacitors with such small phase angles are on the way to the dustbin anyway! Consequently advantage can be taken of the comparative linearity of the calibration for this control for values up to 30%, and it suffices to mark equally-spaced divisions on the scale to cover practical requirements.

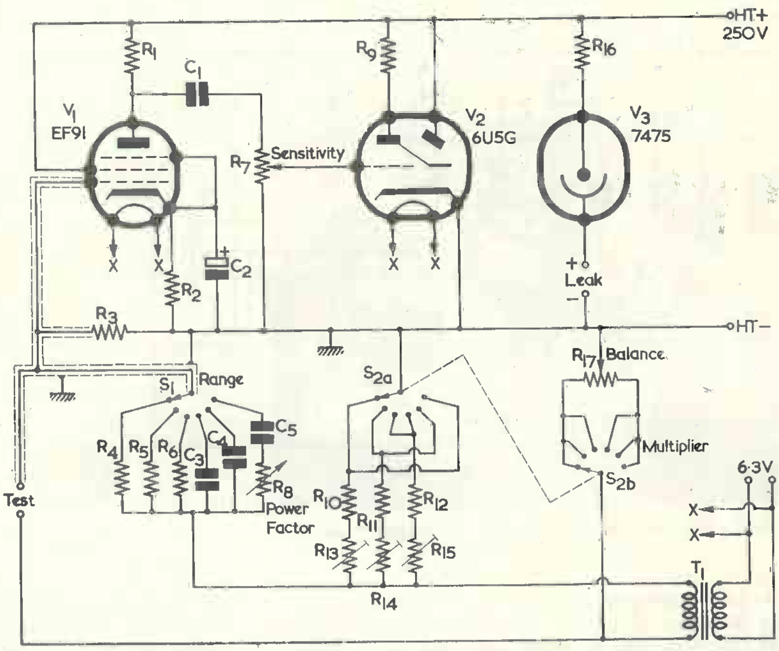


FIG.14

The neon leakage indicator enables the "goodness" of a capacitor to be judged. This kind of test has to be regarded with a certain amount of discretion. A small value capacitor may produce a fast rate of flash, and a much larger capacitor may do the same. The latter component would be suspect, but the small capacitor could be perfectly sound. One has to pay due regard to the value of capacitance, for it is the amount of charge the capacitor can assume, and the time it takes to charge up and discharge, which decides the rate at which the neon will flash. A certain amount of experience is necessary to judge whether a capacitor is sound or not with this test, and some guidance can be obtained by testing

[2] Resistance Capacitance Bridge for the Amateur—A. H. Koster *R.S.G.B. Bulletin*, Vol. 31 No. 10. April 1956.

several known good and doubtful ones.

The Mullard 7475 neon tube shown in Fig. 14 can be obtained as an ex-Government type CV1070. The type of tube used is not critical, but it should have a fairly low striking voltage. The series resistor R_{16} should be suitable for the tube chosen. It should limit the burning current of the tube to a value within its rating when the leak terminals are short circuited, yet at the same time it should allow striking of the tube through low value capacitors. Some experiment to determine a suitable value for R_{16} may therefore be necessary.

If one should have grave doubts about including the neon leakage indicator, there is some consolation in the fact that it does at least match with the magic eye and produce a symmetrical panel layout!

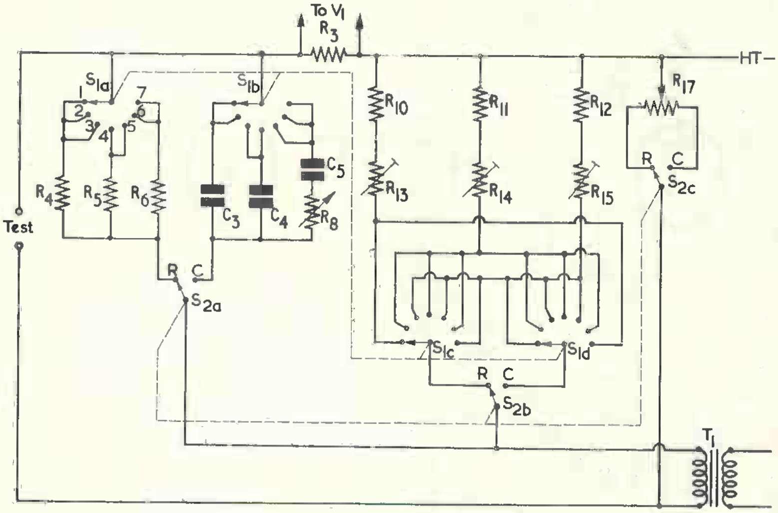


FIG.15

M287

Power Supplies

The modest requirements for h.t. and heater supply can be provided by any small valve or metal rectifier and smoothing circuit of conventional design. The circuit for the prototype does not show the power supplies since the model made was powered from a variable voltage source which the author uses for such purposes. It was found that the bridge required 4mA at 200V h.t. or 5mA at 250V for the EF91 and 6U5G together, while heater current was 0.6A at 6.3V. With the leak terminals short circuited, an additional 3mA at 200V, or 4mA at 250V, is required. From this, a power supply giving about 10mA would be adequate.

Separate 6.3V windings for low voltage supply are preferable in order that the bridge arms are kept isolated from the valve heater supply. It is possible to power both circuits from the same supply, in which case the valve heater current will also pass through the balance control. Although this is permissible, it would seem desirable to avoid it if possible.

As the writer's power unit has no separate 6.3V outlet, providing an isolated 6.3V for the bridge arms necessitated the use of the 1:1 ratio transformer shown in Fig. 14. This can be made quite easily with the stampings and bobbin from a small output transformer. The one used here had waste free type stampings, the centre limb being $\frac{11}{16}$in square. The bobbin was wound with two windings consisting of 80 turns of 22 s.w.g. enamelled wire, with three layers of Empire tape between windings. About 2oz of wire is sufficient.

Construction

The model seen in the photographs has a front panel 12in by 8in. The small chassis is 6in long and $3\frac{1}{2}$in in depth. A $\frac{1}{2}$in lip serves to secure it to the front panel, and the rear apron is $2\frac{1}{2}$in high. The design shown is not finalised by any means, though a similar layout could be adopted in an instrument of better appearance. As stated earlier, this unit was made for experiments with the circuit and was not intended to be a showpiece.

The only critical part of the circuit is the screened wiring to the grid of V_1. This will be found necessary, otherwise instability may result on the high-impedance ranges.

The scales seen were made of paper and the calibrations were done with indian ink. For the small controls and lettering, one could use *Panel-Signs* transfers.

A scale for the balance control will need to be made, and some care should be taken with this, the method of fixing datum points being described below in the instructions for intial calibration of the bridge.

The scale shown is 5in in diameter, mainly because a protractor of that size was used to set it out. Each of the small divisions is 3mm. Assuming that the two end marks of 0.1 and 1 have been obtained, the angle of arc should be measured carefully with the protractor. If other datum points have previously been plotted they will serve as check points. Divide the total number of degrees in the arc by 9. This gives the number of degrees between each main division; for instance, between 0.2 and 0.3. Set off these points on the circumference with the protractor.

To set out the subdivisions, the following method is as easy as any. Lightly draw a radius from the centre of the circle through the point marked 0.1 and project the line beyond the circumference. Draw a similar line through 0.2. Lay the protractor base on the radius passing through 0.1 so that 0° coincides with that point. Suppose, for example, that the arc between 0.1 and 0.2 is 27.5°; this reading will now appear under the 0.2 mark on the circumference. Now lay a rule along the base of the protractor, and slide the protractor to the left until the next highest multiple of ten, in this case 30°, appears under the line which passes through the 0.2 mark. The angle between the two points can now be equally divided with the protractor into ten parts, that is, a point every 3°. Repeat this procedure all round the arc, thereby obtaining 100 divisions.

Other markings inside the main arc can be seen in the photograph of the front panel. They show the tolerance limits of 5%, 10% and 20% tolerance resistors. The length of each small arc is first determined by working out the upper and lower limits of tolerance for each resistor, and the values obtained give the limits of the arc. As an example, a 33kΩ 10% resistor will have an upper limit of 33+3.3=36.3 and a lower limit of 33−3.3=29.7. These points are marked off on an inner arc, and joined with a heavy line. The figures 33 placed above the line show to which value resistor the figures apply. It is then a very easy matter to note whether any resistor measured on the bridge is within its marked tolerance. This facility can be most useful at times, and the space available on the scale presents no problem for including the markings on the bridge. The limits of tolerance will, of course, apply to resistors in any decade.

The cursor for the balance control scale is made from a piece of Perspex or similar transparent material. A line is scribed on the underside and filled with indian ink. When dry, surplus ink can be carefully removed with a slightly damp cloth, thus leaving a clean line.

Initial Calibration

The calibration procedure to be described is carried out against the 100Ω standard in the bridge. The other standard value components in the bridge have tolerances which are comparable, so it is sufficient for general purposes to make the initial calibrations on one range only, since the error on other ranges will not be great. If closer accuracy is desired, means of correcting the errors in the standard values would have to be adopted.

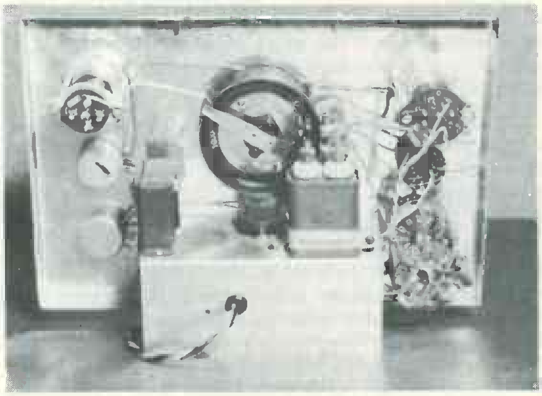
It is possible to fix the main datum points on the scale of the balance control R_{17} with the aid of only four close tolerance fixed resistors. A greater number will naturally enable more reference points to be fixed for checking purposes. If the use of an accurate resistance box can be obtained, any number of points can be plotted. For this purpose, it may not be generally known that the resistance box on a bridge-megger can be pressed into service if connections are made to the outer ends of the box, and the function switch turned to "Megger". In this condition of the tester the resistances are isolated from the megger testing circuits.

If separate resistors are used, they should be 1% close tolerance with values of 10Ω, 22Ω, 33Ω and 100Ω. The 22Ω and 33Ω resistors should be joined in series to make 55Ω.

First, mark a point on the scale arc of R_{17} which is exactly at the top point of the arc, that is, vertically above the centre of the fixing hole for R_{17}. Adjust the positions of the cursor, and the potentiometer itself, so that the cursor swings an equal distance either side of the mark on the scale. Having found the right settings they should not be disturbed.

If the bridge is wired to Fig. 14, proceed as follows:

Set the range switch S_1 to 100Ω and the multiplier switch S_2 to R (position 2). Set the cursor of the balance control R_{17} so that the line is exactly over the mark that was made on the scale. Connect 55Ω to the test terminals. Adjust the 200Ω preset R_{14} and obtain an accurate balance on the magic-eye, adjusting the sensitivity control if necessary. Do **NOT** move the balance control to achieve this balance point, and, when it has been found, R_{14} should not be disturbed during the tests which follow.



Chassis and rear panel view of the instrument constructed by the author

Replace the 55Ω at the test terminals with 10Ω. Turn the balance control to the left until a clear balance is again shown on the magic-eye. No other adjustments should be altered for this setting. When the point has been located, mark its position on the scale and label it 0.1.

Replace the 10Ω at the test terminals with 100Ω. Turn the balance control over to the right hand side of the arc until the magic-eye again shows a clear image. Again, no other controls should be shifted. This point on the arc should now be marked and labelled 1.0.

Replace the 100Ω at the test terminals with 10Ω. Set the multiplier switch S_2 to R/10 (position 1). Leave the balance control set on the 1.0 mark located in the previous test, and adjust the 2kΩ preset R_{13} for a correct balance on the magic-eye. This sets the position for R_{13}, which should not now be disturbed.

Replace the 10Ω at test terminals with 100Ω. Set the multiplier switch S_2 to 10R (position 3). Set cursor of balance control exactly over the 0.1 mark previously found. Adjust the 25Ω preset R_{15} to obtain a clear balance on the magic-eye.

If the bridge is wired to Fig. 15, proceed as follows:

Set range switch S_1 to position 2 (10–100Ω) and the R-C switch S_2 to R. Connect 55Ω to test terminals. Set the cursor of the balance control R_{17} exactly over the mark made at the top of the scale. Adjust the 200Ω preset R_{14} for balance on the magic-eye.

Replace the 55Ω at the test terminals with 10Ω. Turn the balance control to the left to obtain balance. R_{14} should not be touched for this adjustment of balance. Mark the point on the scale and label it 1.

Replace the 10Ω at the test terminals with 100Ω. Turn the balance control to the right until balance is again indicated. Mark this point on the scale and label it 10.

Replace the 100Ω at the test terminals with 10Ω. Set range switch S_1 to position 1 (1–10Ω). Leave balance control on the mark labelled 10 which was located in the previous test. Now adjust the 2kΩ preset R_{13} to obtain correct balance.

Replace the 10Ω at the test terminals with 100Ω. Set range switch S_1 to position 3 (100Ω–1kΩ). Set cursor of balance control exactly over the 1 mark found previously. Adjust the 25Ω preset R_{15} and obtain a balance at this point.

With these main points now located on the arc and the preset controls set to their correct positions, work can proceed on sub-dividing the arc in the manner described earlier. If facilities have been available for checking other points around the arc, it will be possible to confirm their accuracy with the protractor. It can be expected that such errors will be small. If wide errors should appear, the resistors used for calibrating should be suspected. If these are beyond suspicion, then the grading of the resistance element in R_{17} is not truly linear, although this will not normally be found in a good quality potentiometer.

The only other calibration required is that of the power factor control R_8. As stated earlier, sufficient accuracy for this can be provided by simple division of the scale. Seven points spaced at intervals of 45° around the arc are necessary, numbered 0 to 30 clockwise, with the 15% mark at "12 o-clock". These divisions can be sub-divided into fives if necessary, to give intervals of 1% power factor.

It should be remembered that this control is effective only on capacitance ranges above 0.1μF. If the bridge is wired to Fig. 15, this will apply to ranges 5, 6 and 7. When using the control it should be adjusted in conjunction with the balance control to secure a clear balance on the magic-eye. The balance control will then indicate the value of capacitance, and the power factor control will show the percentage of loss of the component. In actual fact, the percentage figure is an indication of the cosine of the capacitor's phase angle due to its inherent resistance.

Final Points

The reliability of this bridge, like most of its kind, depends mainly on two things; the accuracy of the standards used and the quality of the potentiometer chosen for the balance control. Close tolerance resistors should be used where specified. Those who wish to attain very close accuracy of the standards can do so by specially selecting suitable resistors. For example, if the 10kΩ standard resistor is made from two 20kΩ in parallel, one +1% and the other −1%, their actual values will be 20kΩ+200Ω =20200Ω, and 20kΩ−200Ω=19800Ω. In parallel, these will produce a value of:

$$\frac{20200 \times 19800}{20200 + 19800} = \frac{399960000}{40000} = 9999\Omega$$

This figure is only 1Ω less than the required 10kΩ, and is therefore 0.01%, or 100 times better than either of the two resistors comprising it. The same process can be applied to the capacitances although it is a more difficult task.

Components List

Resistors

R_1	100kΩ ½W carbon
R_2	4.7kΩ ½W carbon
R_3	1MΩ ½W carbon
R_4	100Ω 1W 1% H.S.
R_5	10kΩ 1W 1% H.S.
R_6	1MΩ 1W 1% H.S.
R_7	1MΩ carbon pot.
R_8	1kΩ linear W.W. pot
R_9	1MΩ ½W carbon
R_{10}	8.2kΩ ½W 2% H.S.
R_{11}	820Ω ½W 2% H.S.
R_{12}	75Ω ½W 2% H.S.
R_{13}	2kΩ linear W.W. preset pot.
R_{14}	200Ω linear W.W. preset pot.
R_{15}	25Ω linear W.W. preset pot.
R_{16}	33kΩ ½W carbon
R_{17}	1kΩ 10W linear W.W. pot.

Capacitors

C_1	0.1μF 350V paper
C_2	25μF 12V electrolytic
C_3	100pF 1% silver mica
C_4	0.01μF 2% mica
C_5	1μF 2% paper

S_1	1p–6w for Fig. 14
	4p–7w for Fig. 15
S_2	2p–6w for Fig. 14
	3p–2w for Fig. 15

Transformer

T_1	1:1 transformer (see text)

Valves

V_1	EF91 or similar valve
V_2	6U5G valve
V_3	7475 neon regulator

Miscellaneous

- 1 B7G valveholder (V_1)
- 1 I.O. valveholder (V_2)
- 1 B_4 valveholder (V_3)
- 4 terminals
- 4 small knobs
- 1 large knob
- Panel-Sign transfers

Concerning the balance control R_{17}, this should be the best potentiometer that one can afford. With a bit of luck, suitable large diameter potentiometers may be found on the surplus market, but if not they are available from several manufacturers to special order. That shown in the photograph is 1,000Ω 10 watts, 3in in diameter.

Acknowledgments

The writer desires to record his thanks to his friend J. L. Warne for the photographs in this article. He would also like to acknowledge the fact that he has derived a certain amount of pleasure at the expense of several colleagues for their expressions of surprise due to the fact that they had not thought of the trick themselves.

(Conclusion)

We regret an error which occured on page 624, top of column 2, in the March issue. The last expression should read $9a - 2P = 0$, and not $9a + 2P = 0$.—Editor.

RADIO topics

By RECORDER

If you are confronted with a new piece of electrical or electronic gear, what is the first thing you do? Do you at once waggle the knobs to see what happens, or do you first of all sit down and read the manufacturer's instructions? My guess is that, with the simpler gear at any rate, nearly all of us waggle knobs first. Indeed, some of us probably never read the instructions at all. So far as more complicated equipment is concerned my own experience has been that the knob-twiddlers still considerably outweigh the instruction-readers. I have, in fact, seen development engineers using highly complicated and expensive measuring equipment for weeks on end, without ever having once bothered to obtain, and certainly not to read, the instruction manual that comes with it! In many cases the measuring instruments are, admittedly, obvious enough in function and it is possible to operate them successfully by the application of common sense, so that no harm results. In other instances, however, it is quite possible to adjust equipment of this type incorrectly, whereupon false readings or even damage may result.

A Universal Failing

The perverse resistance to instruction manuals is not confined to development engineers only. It seems to be a common human failing and one which manufacturers of domestic electronic equipment attempt to overcome by making all controls as fool-proof as possible. An interesting light on the state of things in America appears in the February issue of the British edition of *Analog* science-fiction magazine, whose Editor refers to the "somewhat plaintive tags and labels manufacturers stick on their electronic equipment these days. 'If at First You don't Succeed . . . TRY IT OUR WAY!'" The Editor refers also to a bright red tag on an f.m. unit which said: "PLEASE . . . try it OUR way FIRST".

Even the most innocent of us turn out sometimes to be members of the Anti-Instruction Brigade. A friend of mine recently became the proud owner of a B.S.R. UA14 record changer which he operated exactly as described on the front of the customer's instruction sheet. He noticed that the pick-up needle seemed to be dropping a groove or two too near the centre on 45 r.p.m. records so that, with some of these, the first few bars of music were lost. He accepted this state of affairs for quite a few weeks, during which he painstakingly made enquiries amongst his more technically minded acquaintances. Eventually, he tracked down someone who knew how to adjust the needle position. All that was required was to raise the pick-up arm, identify the needle adjusting screw, and adjust this so that needle set down was correct (i.e. ⅛in from the edge) for a 10in record. This adjustment, which should preferably be carried out with a stack of 10in records on the turntable, would then hold good for 12 and 7in records. Pleased as Punch, my friend quickly carried out the adjustment and all went well. He then happened to look at the *reverse* side of the customer's instruction sheet which, of course, he had in his possession all the time. The very first item on this side was headed "Needle Set Down", and described the adjustment in precisely the same manner as he had been told!

A thought which occurs to me is that the opposition to equipment makers' instructions is a trait which must have lain dormant in the human character for many thousands of years, and that it is only in the present time that circumstances have allowed it to be indulged. On the other hand, prehistoric times *might* have seen the technical writers of the day fruitlessly chipping out instructions on the use of The Improved Flint-Axe Mk. II, or How to Assemble the Cave-Dweller's Bludgeon Kit (Success Assured).

Returning to the present, it cannot be denied that practically all manufacturers nowadays do their best to make their instructions as simple and straightforward as possible. The clearest instructions I have ever encountered personally are given by Grundig (Great Britain) Ltd. The booklet supplied with the Grundig TK14 tape recorder gives large clear illustrations of the control panel, each button and knob being numbered to correspond with the instruction step number. Thus, under "To hear your recording" we have the following:

1. Push THIS
2. Push THIS
3. WHEN TAPE IS WOUND BACK ON press THIS
4. THEN push THIS—and sit back and listen
5. Adjust THIS for volume—
6. THIS for tone.

You can't have it simpler than that!

Plated Circuits

In last month's issue, "News and Comment" made a brief reference to the manufacture of plated circuits. This is an interesting subject, and we thought that more detailed information would be welcomed by readers.[1]

Plated circuits are a form of printed circuit which are produced in quite a different manner to the more familiar etched foil type. They are manufactured in this country at the Slough factory of Radio and Allied Industries Ltd. (McMichael and Sobell) and employ laminated resin bonded boards made by Formica Limited. These boards are supplied direct from the Formica plant at Cricklewood to Slough in 2ft by 1ft panels, and they are not copper-clad as would be the case with the etched foil process.

The first stage in production consists of piercing all the holes and slots which will be required in the final board. The sheets are then completely coated, on both surfaces and through all holes, with a synthetic resin-rubber adhesive lacquer. This makes the effects of moisture and humidity less apparent than with etched foil boards, and it also prevents contact between the laminate and acids or alkalis during manufacture.

The boards have next to be electroplated and this requires that they be coated initially with a conductive surface. The conductive surface is achieved by covering the faces and the inside of every hole with a layer of metallic silver, the silver being chemically deposited from an aqueous solution. The faces of the panels are then printed with the pattern, the areas over which conductors will eventually be required being left blank and the areas over which conductors will not be required being covered with the printed resist.[2] This is the opposite to the etched foil process in which the resist is applied to the areas which are eventually required as conductors.

After printing, the boards are placed in copper electroplating baths, whereupon both metallised faces of the board become coated with copper over the areas not covered by the resist. The inside surfaces of holes also become plated. The thickness of copper plate is not less than 0.002 to 0.003in. To improve solderability and obviate any deterioration which could occur during prolonged storage a solder plating process may also be carried out at the final electroplating stage.

The next process consists of removing the resist, this being achieved with suitable solvents. After this, the unplated silver under the resist has also to be removed, and this is done either by acid treatment or by an abrasive process. The boards are washed and dried, and the adhesive lacquer is finally cured. The board is then ready for use.

Advantages

Plated circuits are stated to have a number of advantages over conventional printed circuits. These may be listed in the following manner.

1. Conductors on both sides of a board interconnected by the plated-through holes give an improved layout by eliminating jumper wires and enabling cross-overs to be easily achieved.

2. Plated-through holes permit a more effective and robust soldered joint to be made by having a solid fillet of solder in the hole as distinct from the relatively thin film of solder on the underside of etched foil boards.

3. Plating-through of holes enables these to be larger in diameter and thereby simplifies the insertion and assembly of components as well as their removal in the event of failure.

4. Because of the ease and effectiveness of soldering through the hole it is not necessary to clinch component leads on the underside of the panel to bring these into contact with the copper foil.

5. Copper conductors are plated with a stress-free and malleable copper, completely eliminating the possibility of cracking.

6. The minimum thickness of conductor is never less than 0.002in and is usually greater, making it exceptionally strong in comparison with foil types.

7. When the solder plating process is employed there is no corrosion of the copper and no necessity for surface preservatives.

8. Since the first step in manufacture is to cover all surfaces and holes with a lacquer, the boards are more impervious to the effects of moisture and humidity, and of acids and alkalis during manufacture. Protection against the ingress of moisture into the laminate edge at holes is greater.

9. Plated circuits are distinguished by their flatness at all stages. This is because no stresses are set up in manufacture or soldering, both sides of the board being plated with unstressed copper.

The peel strength (i.e. the effectiveness of the bond between panel and copper) is comparable with etched foil boards. A disadvantage with plated circuits is a higher self-capacitance between adjacent conductors due primarily to the capacitance of the plated-through holes. In circuits where self-capacitance is important, this effect can be minimised by obviating the plated-through holes.

It is finally stated that boards manufactured by Formica Limited have proved to be the flattest and most reliable for the process ever experienced at the Slough plant.

Two New Components

Another addition to the list of miniature potentiometers manufactured in this country is announced by Ardente Acoustic Laboratories Ltd. The new Ardente potentiometer, type VC2760, includes a switch and was originally designed to meet Post Office specifications. It is especially suited for printed circuit

[1] The details of plated circuit manufacture given here are taken from *Formica Industrial Journal* Vol. 3 No. 1, to which due acknowledgment is made. *Formica Industrial Journal* is published by Formica Limited, 84-86 Regent Street, London, W.1.

[2] "Resist" is the "ink" applied during printing, its name being due to the fact that it "resists" later processes by protecting the surface underneath.

transistor applications and has a diameter of 0.72in only. Depth, excluding printed circuit tags, is of the order of 0.25in. The potentiometer may be edge operated.

Advance data from Erie Resistor Ltd. gives details of an innovation in this country—a non-expendable fusible resistor. The Erie fusible resistor type FWW1 functions as a conventional component under normal load conditions and as a fuse under overload. Excess current causes the resistance unit to overheat and an external solder joint to melt, thereby releasing a bronze spring and breaking the circuit. The resistor can be continually re-used after fusing by soldering the spring back into position with ordinary 60/40 solder. Resistance range is from 10Ω to 1kΩ at tolerances of ±5 or ±10%. Continuous dissipation rating is 3.5 watts at 20°C and 1.8 watts at 70°C. The speed of fusing depends upon the magnitude of the overload, typical examples (at 20°C ambient temperature) being 10 to 15 seconds at 50 watts, 20 to 25 seconds at 30 watts, and 40 to 60 seconds at 10 watts. Fusing time decreases for ambient temperatures above 20°C.

Right-hand Down a Bit!

Despite the impression created by Sub-lieutenant Leslie Phillips in "The Navy Lark", the docking and tying up of a large ship is by no means an easy matter. The situation is made considerably more difficult if the vessel is one of the mammoth tankers or bulk carriers of 50,000 tons and upwards which are now afloat, because the bridge in ships of this nature is mounted well aft and the pilot's view of objects immediately ahead is obscured by the bows.

Recent tests undertaken by Marconi's Wireless Telegraph Company Ltd., in collaboration with Common Bros. Ltd., may result in the use of closed circuit television as a permanently fitted navigational aid. After initial experiments had shown the feasibility of the idea, a temporary closed circuit installation was set up on the *Border Chieftain* during her trials in late January. A camera was fitted right in the bows, this feeding a monitor in the wheelhouse and another in the radar room aft of the bridge. The camera was of the remotely controlled pan and tilt type, the control position being installed in the radar room. For protection against the weather, the camera was mounted in a weatherproof casing fitted with a heater, the latter stabilising its performance and drying out any internal condensation that might be caused by cold spray striking the casing.

The installation showed its advantages right from the start. When it was switched on before casting off it revealed the presence of a small craft ahead of the *Border Chieftain* which was quite invisible from the bridge. On leaving the berth and going down river, the camera gave a continual picture of tug movements despite the fact that the latter were often hidden by the foc'sle head.

The *Border Chieftain* returned in darkness, and this gave the closed circuit system an excellent opportunity to demonstrate its usefulness under these conditions. All lights, buoys and small craft ahead were easily discernible on the monitors, although the bow obscured the actual view from the bridge. As a final touch the camera was swung through 180° to face inboard whilst the vessel tied up, giving therefore a perfect close-up of the foc'sle head party at work.

These are early experiments, but they certainly seem to indicate that the desirability of having closed circuit television on present-day tankers is so great that it will not be long before this facility becomes a standard installation.

VALVE HEATER VOLTAGES

by M. J. DARBY

EQUIPMENT DESIGNERS SHOULD NORMALLY TAKE care to ensure that valves are operated at a heater voltage which is, on an average, almost exactly equal to the rated figure. Fluctuations of heater voltage due to mains voltage changes will occur, but provided they they are not greater than ±10%, the life and performance of the valve should not be seriously affected. The recommended British practice is, generally, that heater voltage fluctuations should not exceed ±7%. These remarks apply to indirectly heated valves.

High Heater Voltage

If the heater voltage is too high, the oxide coating will tend to evaporate from the cathode, resulting in some loss of emission. Some of the oxide coating will almost certainly move across to the grid where it will emit electrons and lead to reverse grid current. Heater failure or heater-cathode leakage may also be caused by an excessive heater voltage.

Low Heater Voltage

Valves operated at low heater voltages will have a much reduced emission, but unless the valve is operated for long periods under conditions such that the anode current is large enough for the smaller space charge to be exhausted, no permanent damage will occur. At low heater voltages oscillators may stop functioning. Output valves and rectifiers which operate at nearly their maximum cathode ratings are the valves most likely to be damaged by the use of a low heater voltage. Resistance-capacitance coupled stages will often operate satisfactorily at low heater voltages if their anode voltage and current are comparatively low.

If valves *must* be operated at heater voltages which differ from their correct value by more than 10%, the valve ratings (anode voltage, anode dissipation, etc.) should be reduced.

Valves For Car Radios

Valves used in car radio receivers have to withstand large changes in heater voltage (up to 30% or even 35%) because a battery having a nominal 12 volts will supply 14 volts or more whilst it is being charged by the car dynamo, but when the battery is being discharged, the voltage may be less than 12 volts. Valves expressly designed for such purposes (e.g. the "loctal" series) have heaters which will give a satisfactory performance under such conditions. Their nominal heater voltage is that of a battery on charge, but their normal operating voltage is 6.3 or 12.6.

Simple OSCILLOSCOPE

USING AN INEXPENSIVE SURPLUS TUBE

by **S. G. WOOD, G5UJ**

IT IS POSSIBLE TO BUILD A SIMPLE AND INEXPENSIVE oscilloscope around a cathode ray tube which is currently available on the surplus market at low cost. This particular tube is the CV320 (commercial equivalent E4103–B–4) and is capable of offering a usable brilliance with an e.h.t. as low as 450 volts. Other characteristics of this tube are: screen diameter 1½in, screen colour green, heater 4 volts at 1 amp. Typical operating conditions are: V_{a1} and V_{a3} 600 volts, V_{a2} 150 volts, V_{g1} 15 volts. Higher e.h.t. voltages may be applied.

Tube Circuit

A suitable tube circuit is shown in Fig. 1 and is for e.h.t. voltages of up to some 750 volts. Timebase and Y amplifiers may be of any conventional type. It should be noted that, assuming an earthed negative e.h.t. line, the 500kΩ potentiometer requires adequate insulation from chassis.

A Novel Power Supply

A suitable e.h.t. supply for the tube (or for any similar tube) may be obtained by the novel device of using one of the early Ferranti intervalve a.f. transformers. Such transformers may still be present in many junk boxes, and pre-war experimenters will almost certainly remember the sturdy construction and high grade insulation employed in these components. The writer has successfully employed these transformers for e.h.t. purposes by applying the mains voltage to the primary winding as in Fig. 2. Either the AF3 or AF5 transformer may be employed.

Note: We understand that the CV320 tubes referred to in this article are available at 12s. 6d. from Messrs N. R. Bardwell & Co., Sellars Street, Sheffield, 8.—EDITOR.

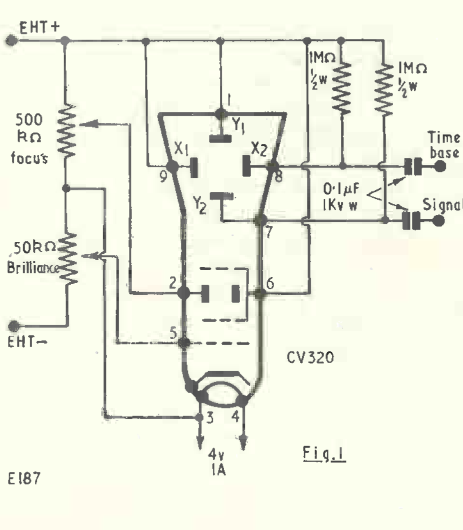


Fig.1

E187

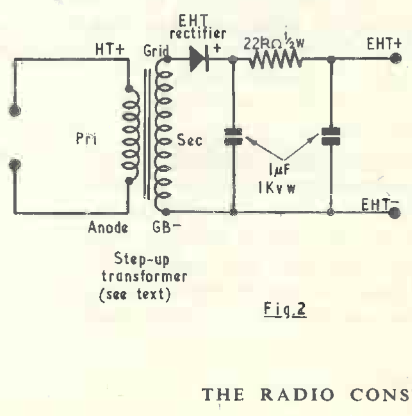


Fig.2

TRADE REVIEW . . .

THE PARISTOR

Parallel Resistor and Series Capacitor Calculator

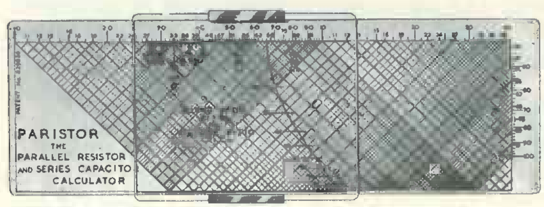
ONE OF THE MORE ANNOYING LABOURS WHICH bedevil the work of the electrical and electronic engineer is the calculation of the total resistance of two resistors in parallel, or the total capacitance of two capacitors in series. The total values are given by $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}$ or $\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$; and these are equations which can waste quite a lot of time in their solution, especially when the denominators have preferred values.

The Paristor calculator obviates this drudgery and enables total parallel resistance and series capacitance to be found at an accuracy of better than $\pm 1\%$ by a process which takes no longer than that of multiplying two numbers on a slide rule. Indeed, the Paristor functions in rather the same manner as a slide rule, as may be seen from the accompanying illustration which shows the stock member and the sliding transparent cursor.

The stock member has a logarithmic scale from 1 to 41 extending along its upper horizontal dimension, this being extended to 120 down the right hand side. Lines at 45° to the horizontal are drawn from each point on the scale, producing thereby a log $\times$ log graph area. Preferred values in the $\pm 10\%$ tolerance range are engraved on the graph area in heavy line, $\pm 5\%$ preferred values in less heavy line, and non-preferred values in light line. This practice assists considerably in the location of particular values in the graph area.

The transparent cursor is marked with a hyperbola which extends downwards across the whole graph area. To find a total value, the cursor is moved along the stock member until the hyperbola lies over the intersection of the two 45° lines corresponding to the individual resistor or capacitor values. R_1 (or C_1) is always made the lesser value, with the result that the intersection occurs at the point where the right hand 45° line from R_1 crosses the left hand 45° line from R_2 (or C_2). The total value is then read from a reference line on the cursor marked "R or C", this line directly indicating the required figure on the horizontal scale of the stock member. By using the same principle the instrument may be employed, also, to find either R_1 or R_2 (or C_1 or C_2) when the total value and only one of the complementary values are known. It can, again, find suitable values for R_1 and R_2 (or C_1 and C_2) if only the total value is known.

A tolerance scale from 0 to $\pm 20\%$ is marked on the cursor on either side of the "R or C" reference line and this enables tolerances on any value, including those found with the aid of the instrument, to be read directly.



The hyperbola on the cursor is cut by a series of horizontal lines ranging in whole integers from the ratio 1:1 (at the top of the graph area) to 10:1 (at the bottom of the graph area). These indicate the power dissipation ratio between resistors R_1 and R_2, the ratio being read from the point of intersection between the two 45° lines corresponding to their values on which the hyperbola lies. With capacitors the ratio indicates the voltage ratio between C_1 and C_2. The ratio reading may be taken at the same time as the total value reading.

The total values of more than two resistors in parallel, or capacitors in series, may be obtained in successive steps by finding the total value for the first two individual values and carrying this over to the next individual value.

The Paristor is made of high impact and dimensionally stable plastic material, measures 9.6 by 3.55 by 0.34in, and retails, complete with instruction book and plastic wallet, at 44s. 6d. The manufacturers are Paristor Ltd., 96 Park Lane, Croydon.

New Leaflet on EMI Tape Recorder Now Available

A portable stereophonic tape recorder, Type TR52/2, designed for professional use on those occasions when it is necessary to leave the studio is the subject of a new leaflet released by EMI Electronics Ltd. A versatile instrument, it is ideally suited for use when critical assessment and judgment of performance is important, or for recording noise and sound effects in scientific and industrial research establishments.

The TR52/2 is a simultaneous twin channel machine with separate record and replay amplifiers.

Overall frequency response of the TR52/2 at a tape speed of $3\frac{3}{4}$in/sec is within ± 3dB, from 40 c/s to 7 kc/s. Playing at 15in/sec, overall frequency response is within ± 3dB, from 40 c/s to 16 kc/s. The signal-to-noise ratio is better than 50dB unweighted.

Full technical specifications are given in the leaflet which can be obtained from Recording and Relay Equipment Division, EMI Electronics Ltd., Hayes, Middlesex.

Workshop Tools and Practice —— FOR THE BEGINNER

By D. W. EASTERLING

ONE OF THE ADVANTAGES IN RADIO AS A HOBBY is that very few expensive tools are required, although possibly a few more than the screwdriver and soldering iron mentioned in kit advertisements. Most enthusiasts have found that their tool kit, starting from small beginnings, has grown throughout the years, often with expensive duplications which could have been avoided in the light of later experience. It is the aim of this article to summarise a basic tool kit which the writer considers is adequate for most radio constructional work, although it does not cover specialised carpentry tools which may be required for cabinet construction.

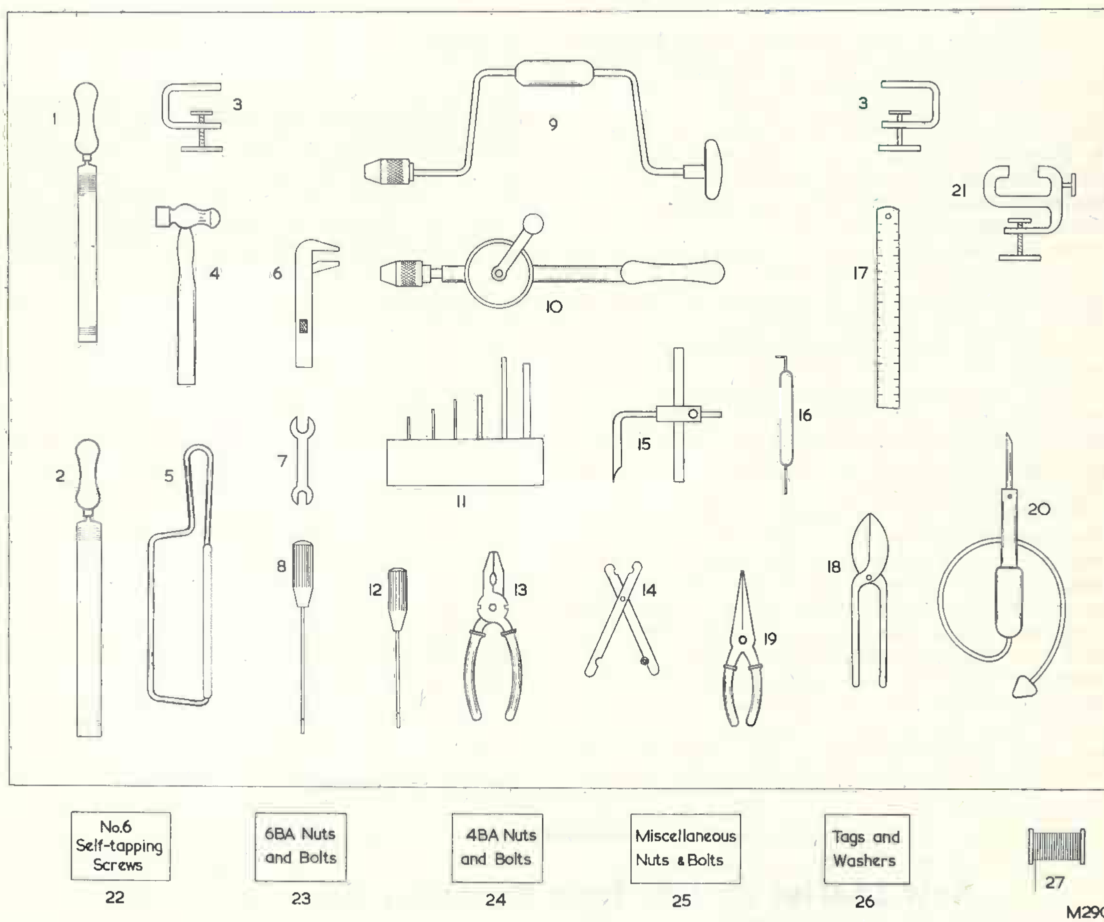


Fig. 1. The tools shown here are as follows: (1) ¼in round file; (2) 6in half-round file; (3) 3in G clamp; (4) 1lb hammer; (5) small hacksaw; (6) 1in adjustable spanner; (7) 4BA-6BA spanner (or set of connected BA spanners); (8) small screwdriver (insulated handle); (9) carpenter's brace; (10) drill stock; (11) drills and centre-punch; (12) large screwdriver, blade 8in long by ¼in wide (insulated handle); (13) electrician's pliers (insulated handles); (14) BIB wire stripper; (15) tank cutter; (16) scriber; (17) rule; (18) metal shears; (19) long nose pliers (insulated handles); (20) 25 watt soldering iron and (21) small bench vice

The suggested basic tool kit is shown in Fig. 1, and it is proposed to discuss every item, describing how it can be used. Fig. 1 is not, by the way, accurately to scale, but is simply arranged as a means of identification.

Chassis Construction

Radio equipment can be mounted direct into a case, or mounted on a chassis, baseboard, or tagstrip. In its turn, the latter may or may not be fitted into a cabinet. Chassis and equipment panels are usually of metal plate such as tinplate or aluminium, the latter being a favourite with home-constructors as it is easily worked. Aluminium is not always easily obtained from shops in the smaller towns but, since it is light and easily rolled into a convenient shape for transport, it can be purchased through the post from firms specialising in car and caravan bodies. 18 to 16 s.w.g. aluminium is suitable for chassis and panels carrying weight, 22 guage being adequate for small screens, etc.

When starting to make a metal chassis or case the first job is to mark out on the metal where cuts, bends, and holes will be made. For this, a rule and scriber (items 17 and 16) are required.

With marking out completed, sections can be cut to size with metal shears (18). However, these are only suitable for plate metal, the small hacksaw (5) being more useful for light jobs on heavier material. These include, for example, shortening control spindles, and cutting brackets and tag panels made from plastic materials.

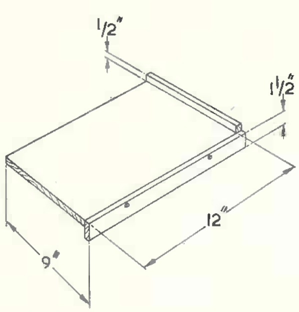


Fig. 2. Drilling board

Controls are normally mounted on the chassis by a locknut fitted to the spindle bush, and this requires a ⅜in diameter hole. A hole of this size is also useful for mains leads grommets, or as a starting hole for larger holes. Other components not suspended by their wiring leads are often secured by 4 or 6BA nuts and bolts, requiring size 27 or 34 drills. Sometimes nuts and bolts are not convenient, since the occasion can arise when it is impossible to get to the other side of a bolt with a nut. To avoid the necessity of tapping threads, which in any case is not really satisfactory in aluminium sheet, self-tapping screws can be used.

Components including valveholders, pilot lamps, and fuseholders, are mounted partly through the chassis or panel, and these require holes exceeding ⅜in diameter. This is when the tank cutter (15) is used. It will be seen that the cutter consists of a centre spindle fitted with a bush carrying the cutting head. The head is set to the required radius, which can be any distance from ⅝in to 2in, and turned with the centre spindle running in a hole previously made with a ¼in drill. It should be noted that the cutter is normally purchased with a ¼in drill already fitted as a centre spindle. The edges of such a drill tend, however, to cut into soft metal after the hole has been made, causing the cutter to wander. It is best, therefore, to replace the drill with a ¼in rod (control spindle is ideal), with the advantage that the drill is then available as a separate item.*

Drills placed on a smooth surface are likely to slide off the intended mark during their initial revolution unless a small indentation is made with a centre-punch first. Drills and punch are illustrated in Fig. 1 by block item No. 11. Drills up to ¼in are turned with the drill stock (10), and larger drills, including the tank cutter, require the carpenter's brace (9).

Some components require holes with diameters less than can be obtained with a tank cutter, but greater than ⅜in (the largest drill which would normally be employed). In this case the ¼in round file (1) is used to enlarge the ⅜in hole. As finish and great accuracy are unimportant with holes taking flanged components, a coarse grain file is most suitable, particularly where aluminium is concerned. Item 2 is another file having one surface flat, and the other half round. A 6in medium grain is useful for finishing off larger round holes, and for general touching up.

The material being drilled should be supported in some way. When it is a flat sheet, the easiest method is to rest it flat on the bench but, in order to avoid spoiling the bench surface, a piece of scrap wood is usually put down first. The torque developed by drill rotation tends to rotate metal and wood, but this can be avoided by using the drilling board shown in Fig. 2. The board consists of a piece of fairly hard planking fitted with batten down the short edge on one side, and down the long edge on the other side; thus the board can be set down on whichever side is most convenient. During drilling one batten locks against the bench front and the other prevents the material being drilled from turning.

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* Although this article is concerned mainly with minimum requirements, mention should be made of the "Q-Max" and "Osmor" type chassis cutters. These are available in various sizes and shapes, and consist of male and female members which screw together with sufficient force to punch sheet metal cleanly, and without stressing the surrounding metal. They are particularly suitable, therefore, when modifying a chassis already assembled. Because of the quality in material and workmanship necessary in their manufacture, a full set of these punches would be expensive, but they can be purchased separately and as required, and consequently should not stretch the budget too severely. To begin with, a usefu size would be ⅝in dia. (hole size), which is suitable for B7G types valve holders, and fills the gap between the ⅜in drill and minimum tank cutter size available.

Bending The Metal

Once the chassis metal is cut and drilled it is ready to be bent into shape, and the small bench vice (21) is often useful for this and other purposes. Long bends, however, require larger vices which are also more expensive, and there comes a time when even the biggest vice is unsuitable. The writer has found the solution in 3in G-clamps which, together with strips of hard wood, enable various shapes and sizes of material to be held securely for bending and cutting (item 3). When the unclamped section of material to be bent over is reasonably large, bending is easy, especially if the inside of the bend is heavily scribed first. Smaller bends may have to be tapped with a hammer (4), using a small strip of wood as a buffer. Item 4 is of course employed for all kinds of jobs including dotting the centre-punch, and the most useful size is 1lb.

Coming to the assembly part of the job, nuts and bolts require spanners and screwdrivers. A double-ended 4BA–6BA spanner is very useful (7), although a set of connected BA spanners as used for car electrical equipment maintenance is just as handy. Larger nuts used for securing controls and other bushed or flanged components come in so many different sizes that the best solution is to use a 1in adjustable spanner (6).

Two screwdrivers (items 8 and 12) are shown. The smallest is the usual odd job type with insulated handle used for mending fuses, etc. It should be mentioned that these can be obtained with a built-in neon indicator which glows if the blade comes into contact with high (mains) voltages; thus the tool is also a useful tester and safety device. Similar types can be obtained for testing car ignition, but these are not so useful in radio work. The larger screwdriver should have a blade about 8in long by ¼in wide, and be fitted with an insulated handle.

Wiring

After assembly comes wiring. Signal and h.t. circuits are usually connected by 18–22 s.w.g. tinned copper which may or may not be insulated. If necessary to avoid shorting, bare wire may be covered by plastic sleeving, or alternatively, plastic covered bell wire can be used. L.T. heater circuits may carry current in the region of several amps, and the usual plastic covered lighting flex is suitable for these. For stripping and cutting wire the handy gadget shown as item 14 is very useful. Whilst this, the BIB Wire Stripper, is capable of cutting really heavy conductors, it can also remove insulation without damaging even the finest connecting wire.

For bending wire, and the general handling of wire and small components in confined spaces, the long-nose pliers (19) are used. The pliers may also act as a heat shunt during soldering process, when heat can be absorbed from a conductor to avoid damage to the associated component. The larger electrician's pliers (13) should be used for heavy jobs, since the long-nose wiring pliers are easily damaged. Both pliers should be fitted with insulated handles.

The 25-watt soldering iron (20) is suitable for most radio work, although it is often referred to as an instrument iron. Killed spirits or any other liquid flux must not be used for electrical soldering, because of the necessity of washing the work afterwards to prevent corrosion. Soldering for radio work should be carried out with cored solder, which contains the necessary flux. Suitable "home-constructor" packs are available from radio dealers for about 5s.

Immediately prior to soldering, tags or leads frequently require to be tinned to ensure a rapid but reliable job and so prevent component damage due to overheating. Tinning is accomplished by bringing the solder and soldering iron bit to the conductor simultaneously, whereupon the solder should flow freely; failure to do so indicates that tag or conductor surfaces are dirty, and they should be cleaned with medium grade emery cloth or a small file. If the soldering iron bit is below the joint, surplus solder flows on to it and can be discarded by gently flicking the iron (not over polished furniture or floor coverings). The flux present in new cored solder is not present after the solder has been used.

Once it was considered good practice to thoroughly twist a conductor on to the tag in order to obtain a strong mechanical joint before soldering. This is now disfavoured because a good mechanical joint may easily mask a poor electrical one, and give rise to odd crackles and bangs which are difficult to trace. Also, unsoldering for test or maintenance purposes is more difficult, and can lead to overheating adjacent components. The best method is illustrated in Fig. 3 where conductors are simply hooked through the tag, if necessary giving them a half-bend so that they remain in position for soldering. When adjacent tags are closely spaced, the effective distance between them can be increased slightly by bending alternate ones slightly in or out. Sometimes a convenient tag is not available at the junction of two or more conductors. This problem can be neatly overcome by hooking the wires together before soldering as shown in Fig. 4. A well soldered joint appears

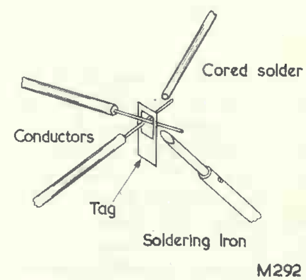

Fig. 3. Showing how various leads should be soldered to a single tag

shiny, and can be tested by pulling the leads (not components) gently.

Miniaturised Equipment

The emphasis of this article so far has been mainly on large chassis built equipment. Similar tools and methods are, of course, used when dealing with miniaturised transistor equipment, although the materials employed may be more fragile and demand more care in consequence. Plastic and laminated board may be worked with the same tools as for metal, but it is necessary for the material to be firmly supported, and cutting or drilling speeds must be reduced. For instance, the tank cutter can be used to make a large meter mounting hole in a plastic box, but it may be better to turn the tool directly by hand rather than use a carpenter's brace. Metal shears are of little use for cutting rigid plastic sheet, but the hacksaw is, provided the blade pitch is not too fine. (18 teeth per inch is suitable for most plastics as well as aluminium.)

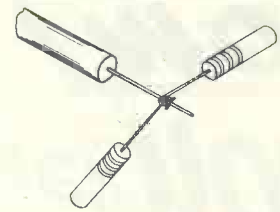

Fig. 4. A method of joining the wire ends of several components without using a solder tag

One final point. The beginner is often told that in the long run, it is more economic to buy expensive tools. This advice is suspect, since if tools are only used in connection with a hobby, they do not get the same wear and tear as those in a professional's workshop. Cheap tools purchased by the writer from Woolworth's are still going strong after fifteen years.

New Twin Panel, Short Neck TV Tube

Mullard have announced a new 19in "twin-panel" television tube (AW47-10) which has a safety guard bonded direct to the tube face, eliminating the need for a separate glass or plastic window mounted within the cabinet.

The bonded guard is made from I.C.I. Diakon acrylic polymer.

The twin-panel tube gives the same complete protection against possible implosion as the conventional safety window, and at the same time offers several new advantages.

★ Dust cannot collect between the guard and the tube face
★ Picture contrast is improved because there can be no reflection between the tube face and the guard (which is neutrally tinted)
★ Simple, secure mounting in the cabinet by integral corner lugs
★ The Diakon guard is only half the weight of a glass window of equal size—a saving of about 4lb
★ Dispensing with the separate guard gives designers more freedom in producing new cabinet styles, and makes possible a useful reduction in cabinet depth.

The tube is a new 110° short-necked type with an overall length of only 302mm—an inch shorter than standard 19in 110° tubes. The saving in length is given by a new, shorter electron gun and by reducing the size of the base sealing pip.

An additional feature is the near-flat screen, which permits a wider viewing angle without any increase in picture distortion.

Focusing is electrostatic, the focusing lens being of the unipotential type, which prevents deflection defocusing and thus ensures good spot quality over the whole picture area.

The tube is also available without the bonded Diakon guard as type number AW47-91.

Brief Data

Under typical operating conditions the final anode voltage is 16kV and the anode 1 voltage 400V. Visual extinction of a focused raster is obtained over a grid voltage range of −40V to −77V (grid modulation and voltage measured with respect to cathode) or cathode voltage range 36V to 66V (cathode modulation and voltage measured with respect to grid). The heater is rated at 6.3V, 300mA.

The useful screen area is 305mm x 384mm. Maximum overall length is 302mm (plus 5.5mm for the Diakon guard). A B8H base is used.

CAMBRIDGE LIBYAN EXPEDITION PRAISES EMI TAPE RECORDER

The Cambridge University Libyan Expedition 1961—object: "To make a comparative survey of the two Libyan oases of Ghadames in the west and Sebha in the north"—has now published its report.

P. H. Judge, a St. Catharine's second year law student who led the expedition and controlled all stores, says of the EMI portable tape recorder which was carried on the 7,000 mile journey:

"The most valuable item of academic stores was a portable tape recorder and microphone. This was battery operated and quite compact, being about 14 x 9 x 9ins. It was stowed on a low shelf and very well padded. This was found to be perfect for two purposes. The first was to record the voices and sounds of local chatter and singing. To this end we recorded soldiers' songs in Tunisia, and in Libya a shepherd boy playing his flute (merely a hollow tube with holes at suitable intervals) and an "ensemble" in Ghadames that consisted of a blind woodwind instrumentalist and five wailing drumming women.

"The second purpose to which the recorder was put was to play back music that had already been placed on tapes in England. This was only used when the radio was unable to pick up any clearly transmitted programmes when in the desert. We found the quality of the recordings of a high standard, and thanks are due to EMI for the loan of this expensive equipment."

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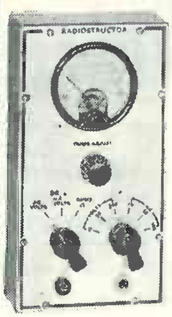

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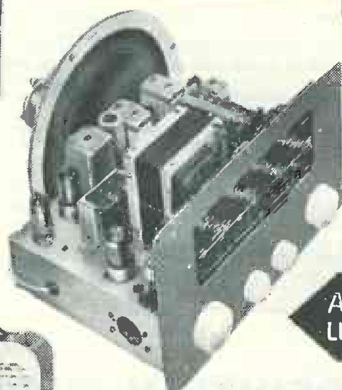

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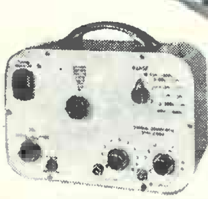

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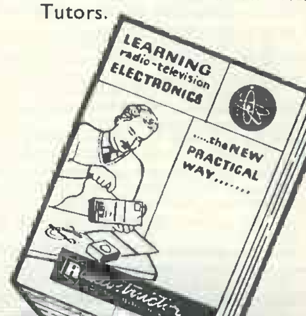

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continued from page 715

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METALWORK. All types cabinets, chassis, racks, etc., to your specifications.—Philpott's Metalworks Ltd., Chapman Street, Loughborough.

RADIO AMATEUR COURSE. A postal course for those wishing to take the Amateur Examination. A sound basic training in radio communication. Very reasonable terms. Send for brochure. —Premier School of Radio, 3 Kerry Crescent, Calne, Wiltshire.

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"AMPLIFIERS AND FEEDERS." Covers the construction of direct-coupled amplifiers and an assortment of radio feeders. Price 3s. 6d.—High Fidelity Co., 18 Melville Road, Birmingham 16.

FIND TV SET TROUBLES IN MINUTES from that great book *The Principles of TV Receiver Servicing*, 10s. 6d., all book houses and radio wholesalers. If not in stock, from Secretary, I.P.R.E., 20 Fairfield Road, London, N.8.

continued on page 719

SITUATIONS VACANT

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SKILLED INSPECTORS

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No Quantity too small — List on application

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Also at Liverpool, Birmingham, Manchester, Leeds

The thrills of VHF can now be yours for only 39/6d, complete kit! Tunable 150-100 Mc/s, simplified construction, write today for leaflet. Also, if a newcomer to Amateur Radio, ask for free copy of the world famous "Globe-King" kits and receivers, stamp please to cover postage:

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18 and 38 SET OWNERS

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WITH MINIATURE LOUDSPEAKER

Absolutely NO soldering

39/6 Superb appearance. Simple instructions. Built in an evening. No drilling. No soldering. Complete in every detail. Receives entire broadcast band. Aerial required in certain areas. Pocket size 4¼" x 2⅞" x 1¼".

Or the more powerful SAVOY SUPER-3: 3 transistors and 2 diodes in a 5-stage reflex circuit. Dimensions as above. **49/6**

Battery 1/- extra P. & P. 2/- — ALL PARTS SOLD SEPARATELY

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SPARES, VALVES, TUBES 1930-1960

Guaranteed perfect, set tested, ex-working equipment

5U4	4/6	10P13	4/6	ECH42	4/6	PL33	4/6	U25	10/-
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6X4	4/6	185BT	12/6	KT67	7/6	PZ30	4/6	UL41	4/6
7S7	4/6	B36	4/6	N37	4/6	U14	5/-	UL44	6/-
7C5	4/6	ECC85	4/6	PCC84	4/6	U22	4/6	UL46	4/6
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Most pre-war 4, 5, 7, 9-pin valves 5/- each. P. & P. 6d. per valve

VALVE PARCEL. 12 assorted, all different, 8/6. Postage 1/6.

CONSTRUCTOR'S PARCEL. 2 lb mixed resistors, condensers pots, valveholders, electrolytics, etc. 7/6, postage 2/6.

Send S.A.E. with enquiries or for list of 1,000 valves

ST. JOHN'S RADIO 3 Jews Row, SW18 *Tel.* VAN 8822

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Small Electric Motor (4½ volt battery) driving 2 saws, grindstone, fan, all mounted on plywood, ready to use 19/6. *Postage and packing 2/6.*

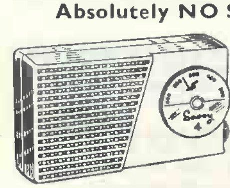
The NEW "SAVOY"

4-TRANSISTOR POCKET RADIO

WITH MOVING COIL SPEAKER

Absolutely NO Soldering : NO Drilling

NO Aerial Required



4 transistors and 2 diodes; 5-stage reflex circuit; push-pull output; size 5¼" x 3" x 1¼"; full medium wave; simple instructions and assembly tool provided. **All parts sold separately.**

95/- plus battery 2/- extra. postage and packing 3/-.

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SMALL ADVERTISEMENTS

continued from page 717

TRADE—*continued*

FOR SALE. A few 6+1 superhets L/M wave, very sensitive, with OC81 push-pull output and 6in x 3in speaker. All mounted on vynair covered board 9½in x 6in complete with escutcheon and controls. Cabinet only requires completion. Aligned and working, £5 17s. 6d. each.—Box No. F.151.

KITS CONSTRUCTED/ALIGNED. Servicing. Moderate terms. Free advice on electronics problems. S.A.E. please.—R. J. Torrens. Forest Hill, Corfe Mullen, Dorset.

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THE INTERNATIONAL HAM HOP CLUB is a non-profit making organisation open to RADIO AMATEURS AND SHORT WAVE LISTENERS. OBJECT: To improve international relationships through an organised system of hospitality. MEMBERS offer overnight hospitality to visiting members, subscription 10s. per annum. ASSOCIATE MEMBERS invite radio amateurs to visit their stations. Associate membership 5s. per annum. FAMILY EXCHANGE holidays arranged, also FRIENDSHIP LINKS between radio clubs. The Club's official journal is free to both Full and Associate members.—Hon. Gen. Secretary: G. A. Partridge, G3CED, 17 Ethel Road, Broadstairs, Kent.

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HENRY'S RADIO LTD. require a young man (over 18 years) to work in busy radio shop in London. Previous knowledge essential. Write giving details to The Manager at 5 Harrow Road, London, W.2.

METROPOLITAN POLICE: Engineering Dept. require Wireless Mechanics for maintenance of V.H.F. R/T equipment in Brentford and South East London areas. Basic Pay 200/8 per 42 hour week, also merit pay scheme up to 50/- per week according to skill and experience. Overtime and allowances averaging 100/- per week, payable when working shifts. Written applications to: Wireless Engineer, M.P. Wireless Station, Grove Park, Camberwell, S.E.5.

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TELECOMMUNICATIONS STAFF required for development and/or maintenance work on VHF R/T equipment and associated apparatus.

TECHNICAL OFFICER GRADE IV
Salary scale £701 (age 25)–£924. Maximum starting pay (age 28) £773.
Written applications to: Wireless Engineer, M.P. Wireless Station, Grove Park, Camberwell, S.E.5.

BATTERY ELIMINATOR AND CHARGER
Replaces PP3 or T6003 9 volt batteries to run transistor radios from mains. Also charges to give 5 times normal battery life. Fitted neon indicator and supplied with full details. 29/6. P.P. 1/6

BABY SITTER

ALL TRANSISTOR BABY OR INVALID ALARM

Housed in Attractive gold hammer finish portable cabinet.

Battery operated, push-pull, 400mW output. Low impedance microphone enables unit to be used up to 200 yards. Output on quality speaker. **Used All Night, Every Night.** Battery Life 3 to 4 months.

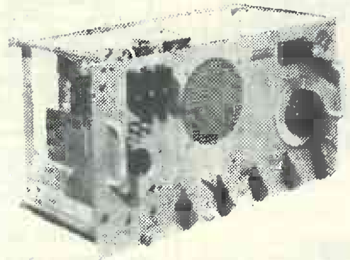
★ GUARANTEED for 12 MONTHS

★ MICROPHONE is placed within 10ft. of baby; twin flex is taken to amplifier unit and placed in any room required.

COMPLETELY BUILT & TESTED. P.P. 2/6 **£5.10.0**

TELEPHONE AMPLIFIERS
£5.10.0 P.P. 2/6

R208 COMMUNICATIONS RECEIVER
"SPUTNIK SPECIAL"



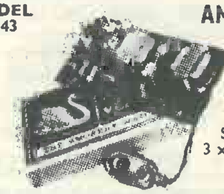
New offer of the well-known reception set R208. Coverage extends from 10–60 Mc/s (5.30 metres) in three switched fully tunable bands. Circuit is a 6-valve superhet for reception of C.W., M.C.W. or R.T. Contains BFO, RF stage with Mc/s I.F. Built-in 6½" speaker, Muirhead slow-motion drive. Alternative outputs to phones or 600 ohm line. Input is 100/250 volts A.C. mains with a built-in vibrator pack for alternative 6 volt mobile use.

IN ABSOLUTE NEW CONDITION WITH FULL HANDBOOK IN STEEL CASE.

£11.19.6
Carriage 15/-

TYPE 38, TRANSMITTER RECEIVER
Complete with 5 valves. In new condition. These sets are sold without guarantee but are serviceable.
7.4 to 9 Mc/s. **22/6** P.P. 2/6
Headphones **7/6** pair Junction Box **2/6**. Throat Mike **4/6**. Aerial Rod **2/6**.

4 TRANSISTOR PUSH-PULL AUDIO AMPLIFIER
MODEL PK-543



Size 3 x 1¾ x ⅞"

A ready built miniature push-pull amplifier incorporating input and output transformers, 4 transistors, 9 volt battery snap cord (for Power) speaker and volume connection leads. Ideal for use with record players, intercoms, hearing aids, tape recorders, etc. Complete with full instructions and circuit diagram.

PRICE 52/6 P.P. 1/6
SUITABLE 2½" SPEAKER 16/6

WE CAN SUPPLY MOST OF THE COMPONENTS USED ON CIRCUITS PUBLISHED IN THIS AND OTHER MAGAZINES QUOTATIONS BY RETURN

MINIATURE PANEL METERS
(D.C.)—Brand new

0/50 microamp	39/6
0/500 microamp	32/6
0/1 milliamp	27/6
Vu meter	42/6
"S" meter	35/-

TAPE HEADS
Record/Play Back Head
Type FR7 12/6
Erase head type FE7 7/-. P.P. 1/- per head

TELEPHONE ADAPTOR
★ Ideal for recording telephone conversations. Supplied with screened cable. Fitted rubber sucker. 14/- P.P. 9d.

CONTACT MICROPHONE
High impedance fitted Clip and lead. Ideal for Guitar. Suitable any valve amplifier 12/6 P.P. 9d.

PERSONAL EARPHONES
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P.P. 9d. any type Fitted leads, Jack Plug and Socket.

JACK PLUGS AND SOCKETS
★ Miniature Plug and Socket 3/6
★ Sub-min. version of above 3/6
★ Screened Plug with Socket 3/6

CRYSTAL MIC. INSERTS
★ACOS 43-22" round, 10/6. ★ ACOS 1½" round, 7/6. ★ ¾" square, 3/6.
P.P. 6d. any type.

TRANSISTOR TAPE HEAD RECORD/PLAY
Miniature Head 850 ohms with mounting block. Ideal for all miniature circuits 12/6 P.P. 9d.

1k ohm DYNAMIC MICROPHONE
Hand held or desk stand, complete with screened cable. Excellent response. 49/6 P.P. 1/-

SIGNAL GENERATOR
All transistor. 220 kc/s to 220 Mc/s in 8 ranges. RF/Mod/AF outputs. £7.10.0. P.P. 2/-. Details on request.

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Complete set of test leads. Suitable for most instruments. Complete with pouch, 8/6. P.P. 1/-

TAPE RECORDER MOTOR
Miniature motor 4½ to 9 volts for tape units. Brand new 12/6 P.P.1/-

CRYSTAL MICROPHONES FULLY GUARANTEED

ACOS 39-1. Stick Microphone with screened cable and stand (list 5 gns.), 32/6. P.P. 1/6.

ACOS 40. Desk Microphone with screened cable and built-in stand (list 50/-) 15/-. P.P. 1/6.

ACOS 45. Hand Microphone with screened lead, very sensitive, 25/-. P.P. 1/6.

100 C. Stick Microphone with muting switch and screened cable, detachable desk stand, and neck cord, 39/6. P.P. 1/6.

MC 24. Stick Microphone with muting switch and cable, 25/-. P.P. 1/6.

"BAIRD" RECORD PLAYER AMPLIFIER

★ 2-watt output.

★ Ready built with valves and 8" x 5" speaker, tone and volume controls. Printed circuit.

75/- P.P. 2/-

Ideal for Portable Record Player.

★ UA14 4-speed Record Changer, ideal for above. £7.10.0. P.P. 3/6.

PRACTICAL TRANSISTOR CIRCUITS
3/6
Contains easy to follow plans of 40 all transistor units, including light operated switches, amplifiers, transmitters, receivers, test oscillators, signal tracers, hearing aids, radio control, etc. All parts available separately. ★*Designed for the Home Constructor.*

CRYSTAL LAPEL MICROPHONE
Ideal for portable tape recording etc. 15/- P.P. 1/-

12/6
P.P. 1/-.

4000 OHM HEADPHONES
Lightweight, very sensitive with leads.

1 WATT TRANSISTOR AMPLIFIER
★ EMI 4-Transistor Amplifier with 7" x 4" speaker, tone and volume controls. Ready assembled. For use with crystal pick-ups. 6–9 volt operated. 89/6. P.P. 1/6.

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Famous Multi-meter. Reconditioned and fully guaranteed. Full A.C./D.C. voltage and current, resistance, dB, power, etc., etc. Supplied with Batteries, Leads and Instructions.

£11.10.0 Regd. Post 5/-.

(Normal Price £19.10.0.)

LEATHER CASE 30/- EXTRA

HIGH QUALITY DYNAMIC MICROPHONE
Special Offer of a Quality Mic. Made by a well known British manufacturer. 49/6. P.P. 2/-

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COMPONENTS AND EQUIPMENT.

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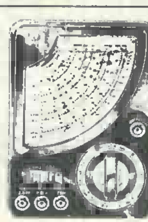

MODEL 200H

20,000 ohms per volt

Size 4½ x 3¼ x 1⅜in.

£6.19.6 P.P. 1/6.

With Test Leads, Battery and Instructions.

6 Ranges D.C. voltage to 2½ kV.
5 Ranges A.C. voltage to 1 kV.
3 Ranges D.C. current to 250 mA.
Resistance to 6 megs.
Capacity and dB ranges

ALSO **MODEL TE10**
10,000 ohms/volt version of above, identical in appearance.
£5.19.6 P.P. 1/6. Fully Guaranteed.

BATTERY RECORD PLAYER

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

★PORTABLE RECORD PLAYER CABINET for above player & amp. 22/6 P.P. 1/6

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PADdington 1008/9
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Open Monday to Sat. 9–6, Thurs. 1 o'clock
Send 1/- stamp for Illustrated Price List

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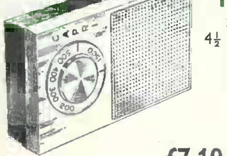
"CAPRI" – POCKET SIX RADIO



Size only 4½ x 2¾ x 1¼in.

Really Pocket Size!

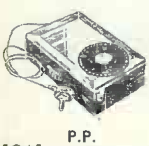
£7.10.0 P.P. 2/- (Battery 2/6)

A new design 6-Transistor Printed Circuit Superhet for Medium and Long Waves. Uses all sub-miniature parts. Sub-min. Mullard Transistors. Quality speaker output, fitted earphone. Record Sockets. Cabinets Red/White or Blue/White with Gold fittings.

DETAILS ON REQUEST

"RANGER 3"

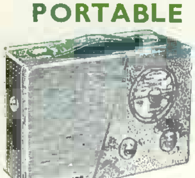
Size 4⅜ x 3 x 1¼in.



A Three Transistor Two Diode Personal Radio for Medium Waves. Amateur top band and shipping. Quality output on personal 'phone. Fitted air-spaced tuner, vol. control. No aerial or earth. **Luxembourg guaranteed.**

69/6 P.P. 1/6

"TRANSFIVE" PORTABLE RADIO



Medium and Long Wave Portable

8½ x 6½ x 3½in.

£6.19.6 P.P. 2/6

A 5-Transistor (Mullard) and Diode, Printed Circuit, Medium and Long Wave Portable. Features 5in. speaker Car aerial socket, Mullard transistors and carded components. Excellent results guaranteed. **DETAILS ON REQUEST**

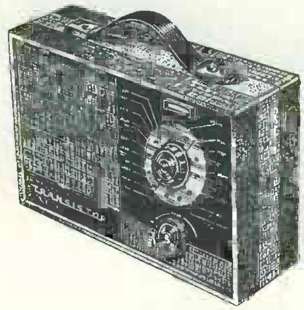
"CONTESSA"

6 TRANSISTOR MEDIUM AND LONG WAVE SUPERHET

★ **TERRIFIC SENSITIVITY** ★

UNBEATABLE IN PERFORMANCE AND APPEARANCE

COMBINED PORTABLE AND CAR RADIO



Employs the latest techniques. Double tuned IF'S AVC and first-grade components are standard features. Excellent tone, sensitivity and selectivity on both wavebands.

Descriptive Leaflet on Request.

- ★ 425mW Push-Pull Output.
- ★ 6 "Top-Grade" Ediswan Transistors.
- ★ New Type Printed Circuit with all Components marked.
- ★ Full Medium and Long Wave Tuning.
- ★ High "Q" Internal Ferrite Aerial.
- ★ Car Radio Adaptation and AVC.
- ★ Slow Motion Fingertip Tuning with Station Names clearly marked.
- ★ "Hi-Fi" Quality Speaker.
- ★ Attractive Rexine Covered Cabinet, Red/White or Blue/White.

TOTAL COST OF ALL PARTS

£10.19.6 P.P. 3/6

★ **NO EXTRAS TO BUY** ★

WITHOUT DOUBT THE "CONTESSA" IS THE FINEST PORTABLE AVAILABLE TO THE HOME CONSTRUCTOR. GOOD LOOKS, QUALITY OUTPUT, AMAZING SENSITIVITY, EASE OF CONSTRUCTION. SIZE 10½ x 8 x 3½ ins.

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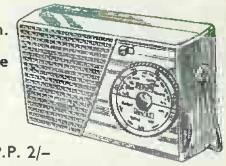
Size 5¼ x 3 x 1¾in.



Red or Blue with Gold trim

£5.10.0 P.P. 2/-

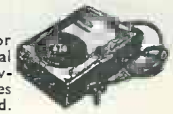
A Five Transistor and Diode Medium and Long Wave Printed Circuit Loudspeaker Radio, with Excellent Results including Luxembourg, guaranteed with full station separation. Supplied with Mullard Transistors and Carded Components. Fitted earphone/record socket.

Full Details and Diagrams On Request

Performance will amaze you

"RANGER 2"

A Two Transistor Two Diode Personal Pocket Radio. Covering medium waves and top band.



Supplied with battery and quality Personal 'Phone.

Size 4⅜ x 3 x 1¼in.

No aerial or earth. **55/-** P.P. 1/6

"PW-6" SUPERHET RADIO

Medium and Long Wave Radio

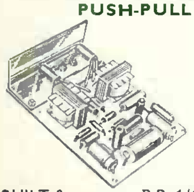
Size 5¾ x 3⅜ x 2in.

£8.10.0 P.P. 2/-

Modified version of previously advertised "PW" Superhet. Now with new style Two Tone Cabinet. 1st grade components and transistors. Printed circuit.

DETAILS ON REQUEST

750mW 4-TRANSISTOR PUSH-PULL AMPLIFIER



(over 1 watt peak output).

- ★ Uses OC71/OC81D, 2—OC81.
- ★ ±3dB 70 c/s to 12 kc/s.
- ★ Overall size 4" x 2¾" x ¾".
- ★ Built on printed circuit.

BUILT & TESTED **69/6** P.P. 1/6 OR COMPLETE KIT **62/6** P.P. 1/6

Ideal for Record Player, Intercomm., Baby Alarm for Tuners, etc.

3 ohm output, fully guaranteed, 9 volt operated Descriptive leaflet with uses FREE on request.

TRANSISTOR SIGNAL INJECTOR

A new design pocket size tester for fault finding on valve or transistor radios, T.V., amplifiers, etc. Built-in indicator and batteries with detachable probe, **52/6** P.P. 1/6.

MODEL TH-L33

2,000 ohms per volt AC/DC. Size 5" x 3½" x 1½".

79/6 P.P. 1/6.

with test leads, battery and instructions.

0/10/50/250/500/1000 volts D.C., 0/10/50/250/500/1000 volts A.C., 0/500μA/10/250mA., D.C.

3 ranges resistance 0/10K/100K/1 Meg. Capacity and dB ranges.

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