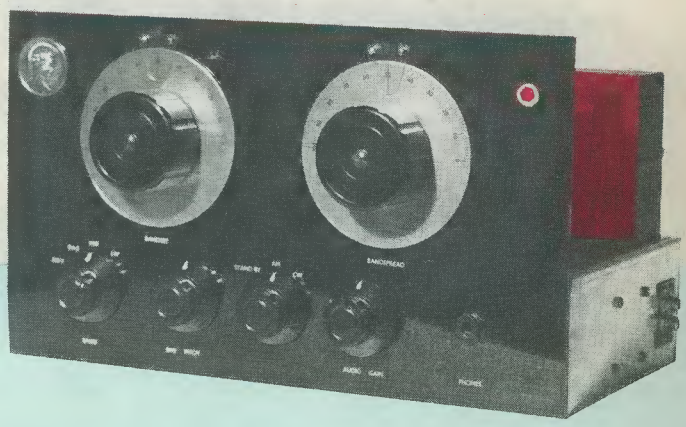
15 sp.

THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 18 NUMBER 9
A DATA PUBLICATION
TWO SHILLINGS & THREEPENCE

April 1965



The "ATHENIAN"

a 4-Band Beginner's Superhet Receiver, 16–2,000 Metres

2kc/s Sawtooth Generator ★ Transistorised Turning Indicator ★ BBC2 Pre-Amplifier ★ Electronic Metronome

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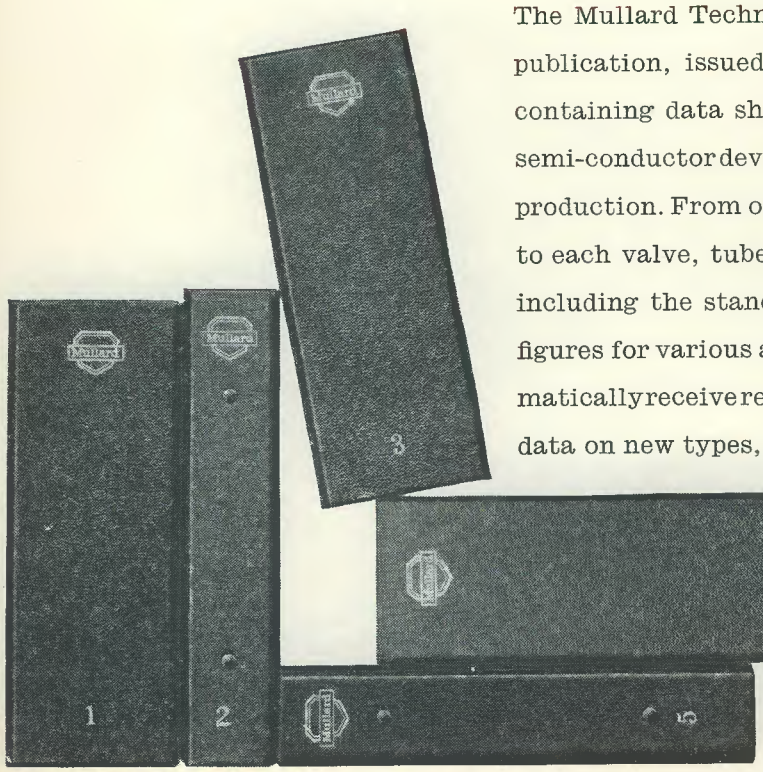
COMPREHENSIVE TECHNICAL HANDBOOK SERVICE

For complete data on Mullard Valves Tubes, Semiconductors and Components



The Mullard Technical Handbook is a loose-leaf publication, issued on a subscription basis and containing data sheets on Mullard valves, tubes, semi-conductor devices and components in current production. From one to twenty pages are devoted to each valve, tube or semiconductor type; data including the standard ratings and performance figures for various applications. Subscribers automatically receive revised sheets and supplementary data on new types, as they are introduced.

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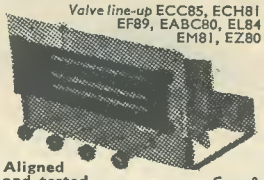
7 VALVE AM/FM RADIOGRAM CHASSIS

Three Waveband & Switched Gram positions. Med. 200–550m. Long 1,000–2,000m. VHF/FM 88–95 Mc/s. Phillips Continental Tuning insert with permeability tuning on FM & combined AM/FM IF transformers. 460 kc/s and 10.7 Mc/s. Dust core tuning all coils. Latest circuitry including AVC & Neg. Feedback. 3 watt output. Sensitivity and reproduction of a very high standard. Chassis size 13½" x 6½". Height 7½". Edge illuminated glass dial 11½" x 3½". Vert. pointer Horiz. station names. Gold on brown background. A.C. 200/250V operation. Magic-eye tuning. Circuit diag. now available.



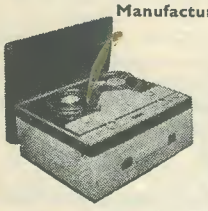
Valve line-up ECC85, ECH81 EF89, EABC80, EL84 EM81, EZ80

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

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

ANOTHER TAPE RECORDER BARGAIN

Manufacturers' end of production Surplus Offer



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

Completed Kit comprising items below

BARGAIN PRICE 15 Gns. + 10/– Carr.

2-tone Cabinet and 8" x 5" Speaker. Size 14" x 10½" x 7½"	£3	10	0	+ 5/– Carr.
Wired Amplifier complete with 4 Valves, front Panel, Knobs, etc.	£5	15	0	+ 3/6 Carr.
B.S.R. Monardeck Type TD2	£7	7	0	+ 4/6 Carr.
Accessories: Mike, Tape, empty Reel, screened Lead and Plugs, Instructions, etc.	£1	0	0	+ 2/– Carr.

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

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

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

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

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

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

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

RECORDING TAPE

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

	Standard		Double Play		Long Play	
5"	600'	13/–	1,200'	31/6	900'	17/6
5½"	900'	16/–	1,800'	37/6	1,200'	19/6
7"	1,200'	21/–	2,400'	47/6	1,800'	28/6

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

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

TAPE REELS. Mnfrs. surplus 7", **2/3;** 5½", 2/–; 5", 2/–; 3", **1/3;** Plastic spool containers, 5", **1/9;** 5½", 2/–; 7", **2/3.**

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

Electrolytics All Types New Stock

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

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

DE LUXE R/PLAYER KIT

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

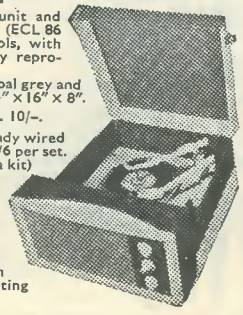
Contemporary styled two-tone cabinet, charcoal grey and off-white with matching blue relief. Size: 17½" x 16" x 8".

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

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

STANDARD RECORD PLAYER KIT

Using BSR UA14 Unit, complete kit **£11.10.0,** carr. 7/6. Ready wired Amplifier, 7" x 4" quality Speaker and O/P trans., **£3.19.6,** carr. 2/6. BSR UA14 Unit, **£6.10.0,** carr. & ins. 5/–. Rexine covered cabinet in two-tone maroon and cream, size 15½" x 14½" x 8½" with all accessories plus uncut record player mounting board 14" x 13", **59/6,** carr. & ins. 5/–.



6 VALVE AM-FM TUNER UNIT

Med. and VHF 190m–550m, 86 Mc/s–103 Mc/s, 6 valves and metal rectifier. Self-contained power unit, A.C. 200/250V operation. Magic-eye indicator, 3 push-button controls, on/off, Med., VHF. Diodes and high output Sockets with gain control. Illuminated 2-colour perspex dial 11½" x 4", chassis size 11½" x 4" x 5½". A recommended Fidelity Unit for use with Mullard "3-3" or "5-10" Amplifiers. Available only at present as built-up units, aligned and tested ready for use.

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

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1½" diam. Guar. 1 year. LOG or LIN ratios less Sw. **3/–.** DP. Sw. **4/6.** Twin Stereo less Sw. **6/6.** D.P. Sw. **9/6** (100 k. to 2 Meg. only). ½ Meg. VOL Controls D.P. Sw. ¼" flatted spindle. Famous Mfrs. 4 for **10/–** post free.

COAX 80 OHM CABLE

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

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

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

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

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

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

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

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

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

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

KNOBS—Modern Continental types: Brown or Ivory with Gold Ring, 1" dia., **9d.** each; 1¼", 1/– each; Brown or Ivory with Gold Centre, 1" dia., **10d.** each; 1¾" **1/3** each. LARGE SELECTION AVAILABLE

TRANSISTOR COMPONENTS

Midget I.F.'s—465 kc/s ⅞" diam.	5/6
Osc. Coil—⅞" diam. M/W.	5/3
Osc. coil M. & L.W.	5/9
Midget Driver Trans. 3.5:1	6/9
Ditto O/Put Push-pull 3 ohms	6/9

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

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

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

Tuning Condensers. J.B. "00" 208+176pF, **8/6.** Ditto with trimmers, **9/6.** 365pF single, **7/6.** Sub-min. ¼" DILEMIN 100pF, 300pF, 500pF, **7/–.**

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

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

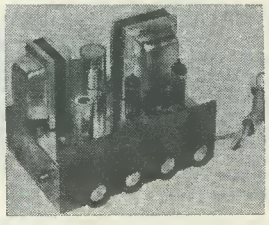
Ear Plug Phones—Min. Continental type, 3ft. lead, jack plug and socket. High Imp. **8/–.** Low Imp., **7/6.** High sensitivity M/coil 8–10 ohms, **12/6.**

JASON FM TUNER UNITS

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

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

3 OHM AND 15 OHM OUTPUT



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

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

MULLARD "5-10" AMPLIFIER—5 valves 10W, 3 and 15 ohms output.

Mullard's famous circuit with heavy duty ultra-linear quality output tfr. **Basic amplifier kit price £9.19.6.** Carr. 7/6. **Ready built 11½ gns.**

CONTROL PANEL KIT

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

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

2-VALVE PRE-AMP. UNIT

Based on Mullard's famous 2-valve (2 x EF86) circuit with full equalisation with volume, bass, treble, and 5-position selector switch. Size 9" x 6" x 2½". **Complete Kit £5.19.6.** Carr. 3/6. **Ready built £7.19.6.**

TRS Est. 1946

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

RADIO COMPONENT SPECIALISTS

70 Brigstock Road, Thornton Heath, Surrey
THO 2188. *Hours; 9 a.m.–6.m., 1 p.m. Wed. Terms C.W.O. or C.O.D. Post and Packing up to ¼ lb. 9d., 1 lb. 1/3, 3 lb. 2/3, 5 lb. 2/9, 8 lb. 3/6.*

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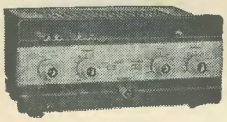
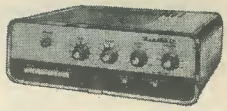
HI-FI AMPLIFIERS — RECORD PLAYERS — RADIO TUNERS

S-33 

AT-6

MA-12

S-99 

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

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

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

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

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

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

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

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

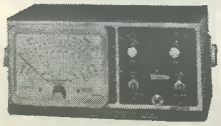
POWER SUPPLY UNIT. Model MGP-1. Input 100/120V, 200/250V. 40–60 c/s. Output 6.3V, 2.5A A.C. 200, 250, 270V, 120mA max. D.C. Kit **£5.2.6** Assembled **£6.12.6**

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

Heathkit DAYSTROM — The Symbol of Extra Quality, Service,

INSTRUMENTS

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



IM-13U

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

V-7A

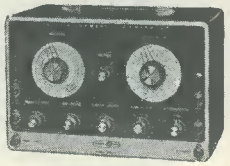
VALVE VOLTMETER. Model V-7A. 7 voltage ranges d.c. volts to 1,500. A.c. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0.1Ω to 1,000MΩ with internal battery. D.c. input impedance 11MΩ. dB measurement, has centre-zero scale. Complete with test prods, lead and standardising battery. Kit **£13.18.6**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

RF-1U

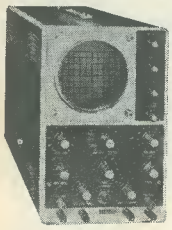
MULTIMETER. Model MM-1U. Ranges 0–1.5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0.2Ω to 20MΩ. 4½" 50μA meter. Kit **£12.18.0** Assembled **£18.11.6**

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

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



HFW-I



1O-12U

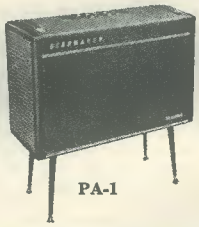
5" GENERAL-PURPOSE LABORATORY OSCILLOSCOPE. Model IO-12U. This outstanding oscilloscope, with its professional specification and styling, fulfils most laboratory and service requirements. Vertical frequency response 3 c/s to over 4.5 Mc/s, sensitivity 10mV r.m.s. per cm. at 1 kc/s. T/B covers 10 c/s–500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

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

S-3U

ELECTRONIC SWITCH. Model S-3U (Oscilloscope Trace Doubler). Enables a single beam oscilloscope to give simultaneous traces of two separate and independent signals. Switching rates approx. 150, 500, 1,500, 5,000 and 15,000 c/s. Sig. freq. response 0–100 kc/s. ±1dB. Separate gain controls and sync. output. Sig. input range 0.1–1.8V r.m.s. Kit **£12.18.0** Assembled **£18.10.0**

FOR THE MUSIC MAKER



PA-1

PA AMPLIFIER PA-1. The ideal compact unit for VOCALISTS, INSTRUMENTALISTS, RECORDS, with 50 Watt output, 2 Heavy Duty Speakers. Variable TREMOLO. Elegant modern cabinet. Kit **£54.15.0** Assembled **£74.0.0** Legs optional extra **17/6** set of 4

POWER AMPLIFIER MA-50 50W output. Kit **£19.18.0** Assembled **£27.18.0**

ELECTRONIC ORGAN

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UJR-1

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of hi-fi equipment, at the Grand Hotel, Southampton Row, W.C.1, 21-25 April, 1965 (concurrent with the Audio Festival). Our technical advisory staff will be available to answer questions, etc.

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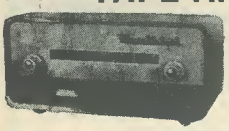
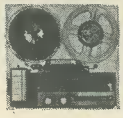
TAPE AMPLIFIERS — TAPE DECKS — CONTROL UNITS

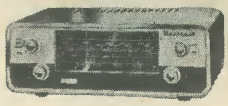


FM-4U

MAGNAVOX



TRUVOX



AM/FM

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

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HI-FI SPEAKER SYSTEM. Model SSU-1. Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical or horizontal models with legs, Kit **£11.12.0,** without legs, Kit **£10.17.6** incl. P.T.

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

THE "COTSWOLD". This is an acoustically designed enclosure 26" x 23" x 15¼" 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.
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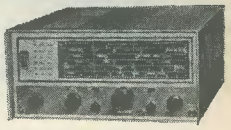

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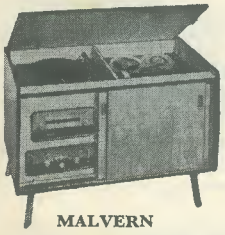
HI-FI CABINETS



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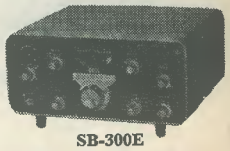

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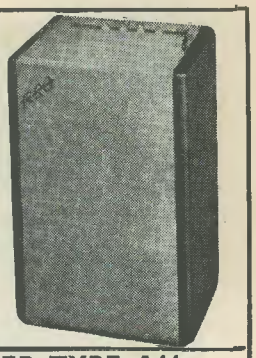

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39½ Gns.

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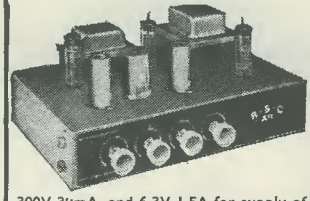
HIGH FIDELITY 12–14 WATT AMPLIFIER TYPE A11

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



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

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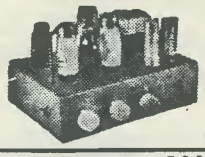

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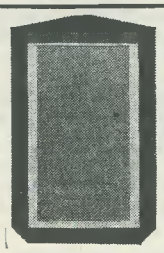

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350-0-350V 80mA, 6.3V 2A, 0-5-6.3V 2A	19/9
250-0-250V 100mA, 6.3V 2A, 6.3V 1A	21/9
250-0-250V 100mA, 6.3V 3.5A, C.T.	19/9
250-0-250V 100mA, 6.3V 4A, 0-5-6.3V 3A	27/9
300-0-300V 130mA, 6.3V 4A, 6.3V 1A, for Mullard 510 Amplifier	33/9
300-0-300V 100mA, 6.3V 4A, 0-5-6.3V 3A	27/9
350-0-350V 100mA, 6.3V 4A, 0-5-6.3V 3A	27/9
350-0-350V 150mA, 6.3V 4A, 0-5-6.3V 3A	35/9

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250-0-250V 60mA, 6.3V 2A, 0-5-6.3V 2A, midget type 2½" x 3" x 3"	17/11
250-0-250V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
300-0-300V 100mA, 6.3V 4A, 5V 3A	28/9
300-0-300V 130mA, 6.3V 4A, C.T. 6.3V 1A, for Mullard Amplifier	35/9
350-0-350V 100mA, 6.3V 4A, 0-5-6.3V 3A	28/9
350-0-350V 150mA, 6.3V 4A, 0-5-6.3V 3A	37/9
425-0-425V 200mA, 6.3V 4A, C.T. 5V 3A	57/9
425-0-425V 200mA, 6.3V 4A, C.T., 6.3V 4A, C.T. 5V 3A	59/9
450-0-450V 250mA, 6.3V 4A, C.T. 5V 3A	69/9

OUTPUT TRANSFORMERS

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

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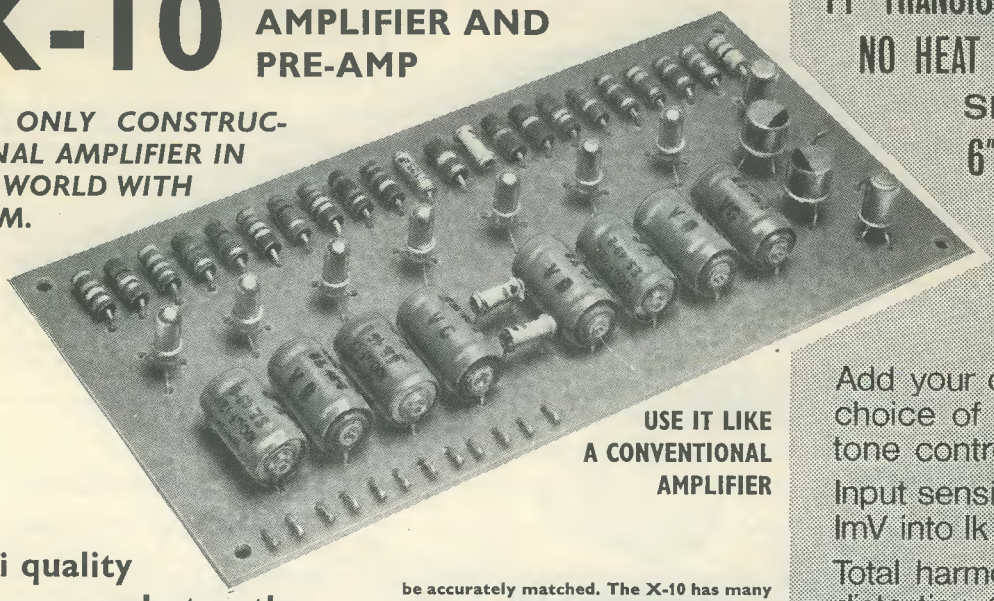

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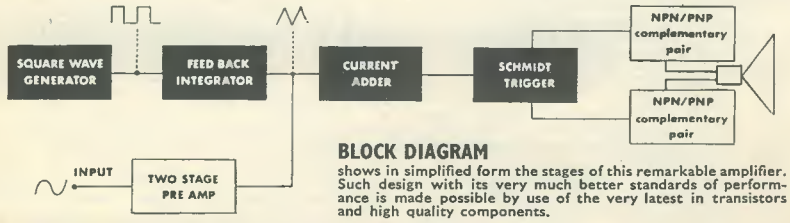

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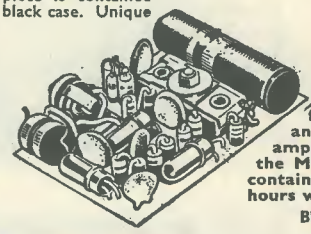

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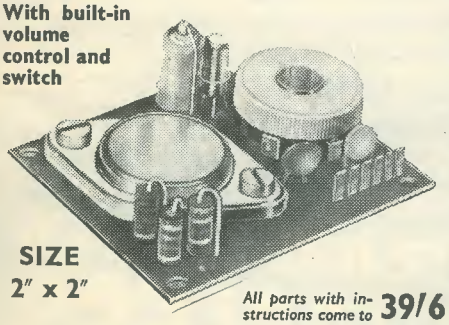

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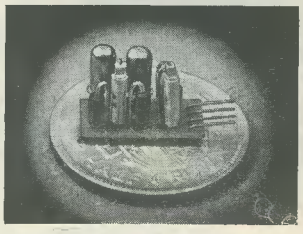

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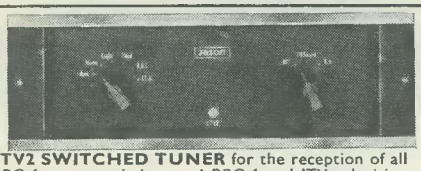

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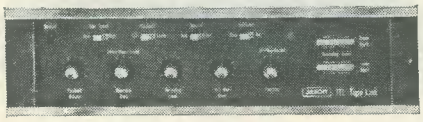

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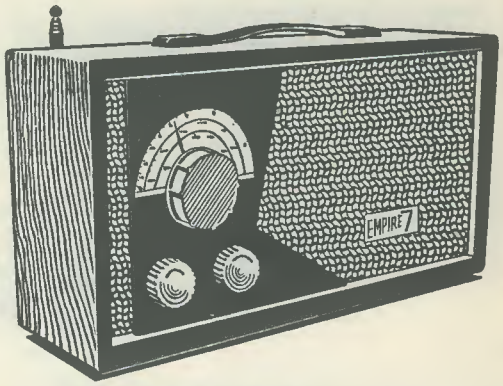

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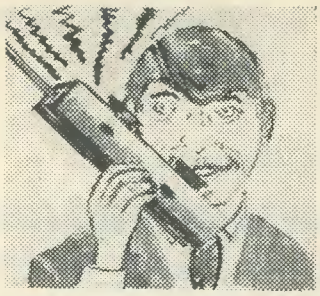

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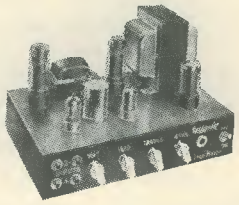

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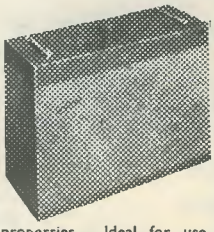

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Vol. 18, No. 9
Published Monthly
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Published in Great Britain by the Proprietors and Publishers Data Publications Ltd. 57 Maida Vale London W9
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Checking Bias Conditions

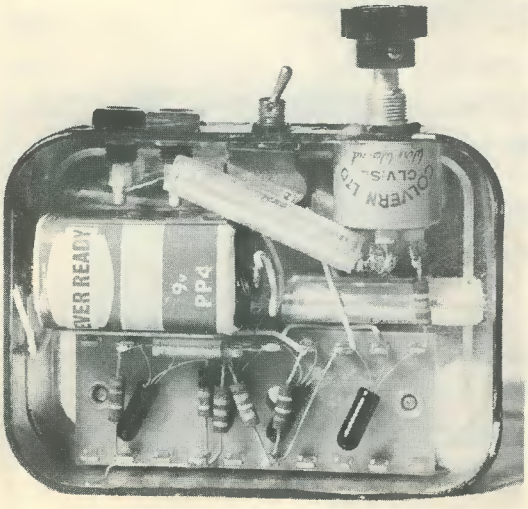
To determine the required bias conditions the most satisfactory method is to feed a signal into the amplifier, monitor the output on an oscilloscope, and adjust the bias components accordingly.

Although it would be possible to use a sinusoidal signal for this, small amounts of crossover distortion are easier to see if the signal used has a straight, or linear, portion. The writer required an inexpensive generator whose output waveform contained a linear section and which could be made up from readily available components. The unit described in this article was the result.

The overall testing arrangement is shown in Fig. 1. If the amplifier is correctly biased then the output waveform will be identical in form to the input. If crossover distortion occurs, the waveform will be distorted. Fig. 2 shows severe crossover distortion. When checking for crossover distortion, care must be taken not to overdrive the amplifier by applying too large a signal. Overdriving the amplifier results in a flat top on the waveform.

The Circuit

The circuit used for the writer's generator is shown in Fig. 3. It consists of an emitter-coupled multivibrator employing the components TR_2, TR_4, C_2, C_1, R_2, R_3, R_4 and R_6; these being used in conjunction with TR_3 and R_5 which cause the "space" part of the waveform to become a linear sweep. A sawtooth waveform appears at the emitter of TR_2. TR_1 is an emitter follower, and gives a low impedance output without loading TR_2.



Internal view of the writer's sawtooth generator

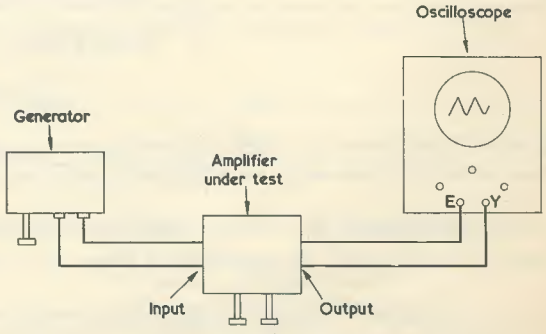


Fig. 1. The arrangement used for amplifier testing

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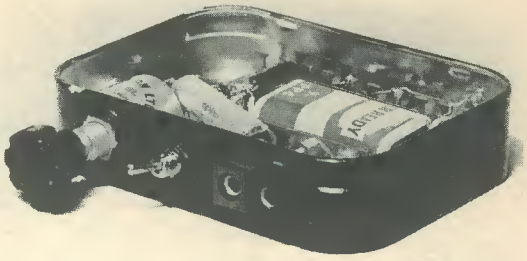
Fig. 2. The effect of crossover distortion on a linear waveform

Construction

The writer's unit was constructed in a 2 oz. tobacco tin, and the layout employed is shown in Fig. 4. This layout may be used as a guide by constructors. If necessary, R_3 may need to be adjusted around the value specified, until the unit oscillates.



Side view of the generator, showing the controls and output sockets

Components List

Resistors
(All fixed values 10% ¼ watt)

R_1	2.2kΩ
R_2	15kΩ
R_3	12kΩ*
R_4	1.2kΩ
R_5	1kΩ
R_6	820Ω
VR_1	500Ω linear pot.

Capacitors

C_1	200μF, electrolytic, 6V wkg.
C_2	0.02μF paper
C_3	25μF, electrolytic, 25V wkg.

*May need adjustment—see text.

Transistors
$TR_{1,2,3,4}$ OC71

Switch
S_1 s.p.s.t.

Battery
9V (EverReady type PP4)

Miscellaneous
Groupboard, 10 pairs (Bulgin type C.125)
Battery clips
Output sockets
Knob

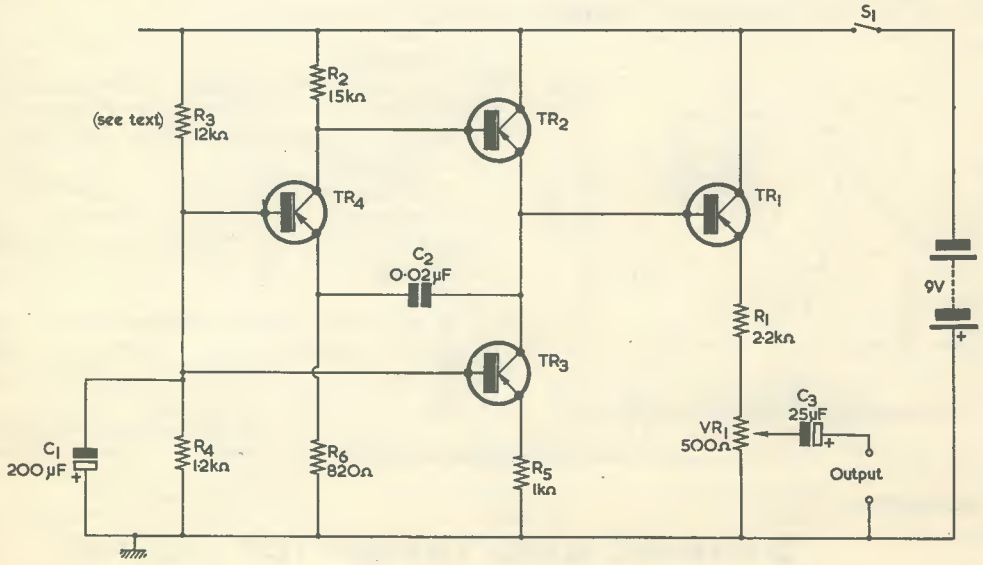


Fig. 3. The circuit of the generator

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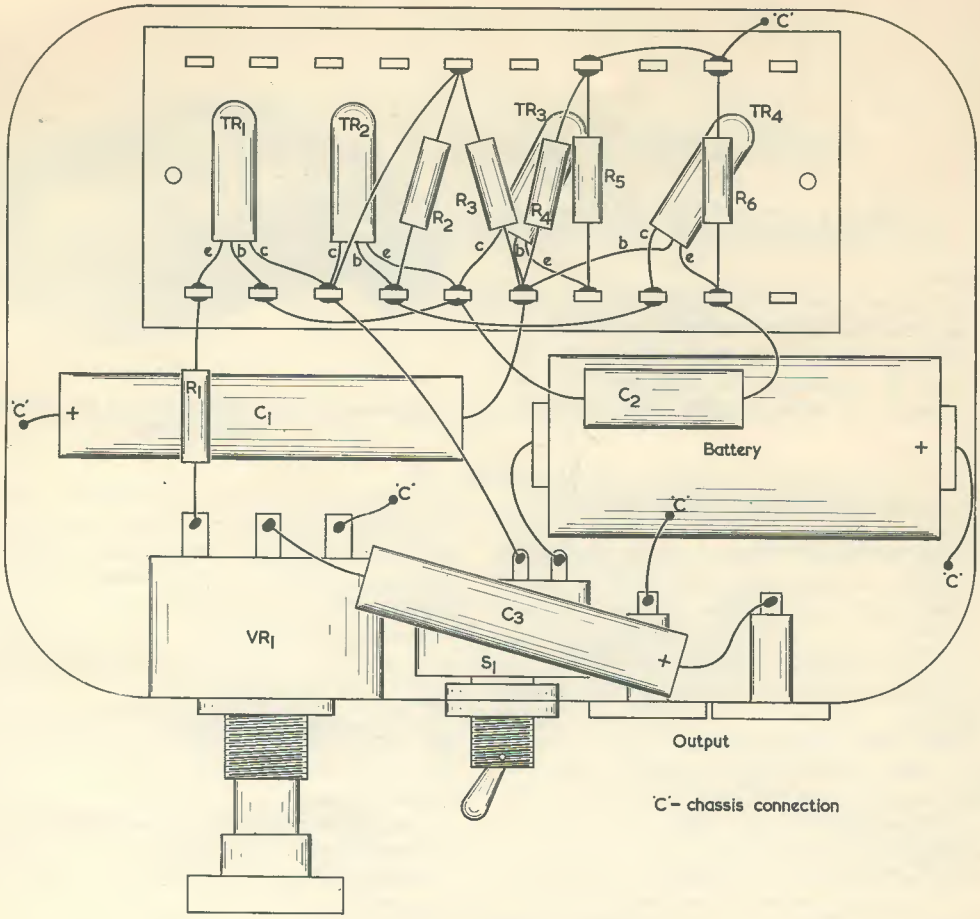

Fig. 4. The layout of the unit built by the writer

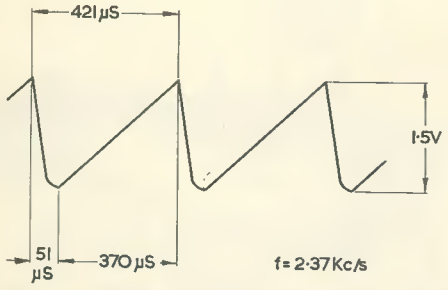

Fig. 5. The waveform generated by the writer's unit

Performance

The prototype oscillated with supply voltage down to 1.5 volts. Current consumption was 3.5mA at 9 volts, and the results given apply to the 9 volt supply.

The frequency of oscillation is nominally 2 kc/s. The maximum open circuit voltage is 1.5 volts. The actual waveform obtained with the writer's unit is shown in Fig. 5. This had a frequency of 2.37 kc/s.

It should be added in conclusion that, although the unit admirably fulfilled its required function, it can also be used wherever a spot frequency audio signal is required.

NEXT MONTH . . .

DYNAMIC GAIN TRANSISTOR TESTER, IMPROVING THE AR88 RECEIVER.

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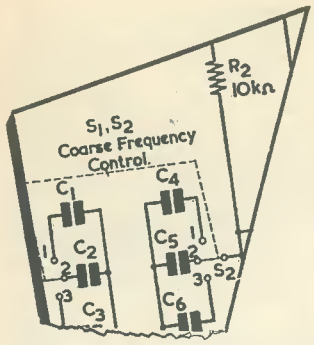

Adding Tuning Meters to Transistor A.M. Receivers

SUGGESTED CIRCUIT No. 173

By G. A. FRENCH

IN THE SUGGESTED CIRCUIT published two months ago in the February issue ("An 'Economy' Capacitance Bridge") the writer described a capacitance bridge which employed, as null indicating device, any standard medium wave receiver fitted with a tuning indicator. The writer also stated that if a medium wave receiver did not have a tuning indicator it could still be pressed into service by temporarily connecting a voltmeter to it to give indications of signal strength. In the case of a transistor receiver, such a voltmeter could be connected across the emitter resistor of any a.g.c. controlled transistor or between the positive supply rail and the a.g.c. line itself.

A tuning indicator is a very useful accessory in any a.m. receiver, this being largely due to the fact that it enables tuning adjustments to be made which result in the provision of maximum a.g.c. voltage and, in consequence, maximum protection against fading. Tuning adjustments of similar accuracy may not be as readily achieved by merely listening to the audio signal provided by the loudspeaker. Since commercially produced transistor receivers rarely have tuning indicators the writer felt that it would be of advantage to devote a little time to this particular subject, and to provide, in this series, some details of the problems involved.

As a result, the present article discusses the techniques involved in fitting a meter as tuning indicator to any standard medium and long wave transistor superhet. The writer has also developed an experimental circuit which allows signal strength to be indicated by the brightness of a small m.e.s. bulb, but space considerations necessitate that this be discussed separately in next month's issue.

Basic Receiver Circuits

Before describing the tuning indicator circuits, it is first of all desirable to examine the basic a.g.c. arrangements employed in conventional medium and long wave transistor receivers. This is necessary because, following standard practice in valve receivers, any add-on tuning indicator will need to operate from a.g.c. potential.

The basic detector and a.g.c. circuit used in conventional a.m. transistor superhets is shown in Fig. 1. This arrangement is common to all of a large number of commercial receivers whose circuits were checked by the writer for the purposes of this article, there being only slight variations which will be discussed shortly. Many currently available receivers have a damping diode circuit between the collectors of the first i.f. transistor and the oscillator/mixer transistor whose function is to damp the primary of the first i.f. transformer under conditions of excessively high signal strength, but such a circuit does not concern the present discussion and is not shown in Fig. 1.

In Fig. 1 the diode detects the i.f. signal passed to it by the last i.f. transformer, the resultant a.f. being then applied to the following a.f. stages. The signal carrier also causes a positive a.g.c. potential to appear at the upper end of the diode load, R_4, this being applied to the stabilising potentiometer R_2, R_1. The base of the first i.f. transistor couples to the junction of R_2 and R_1 by way of the secondary of the first i.f. transformer and its bypass capacitor, C_1. Thus, an increase in signal strength results in the upper end of

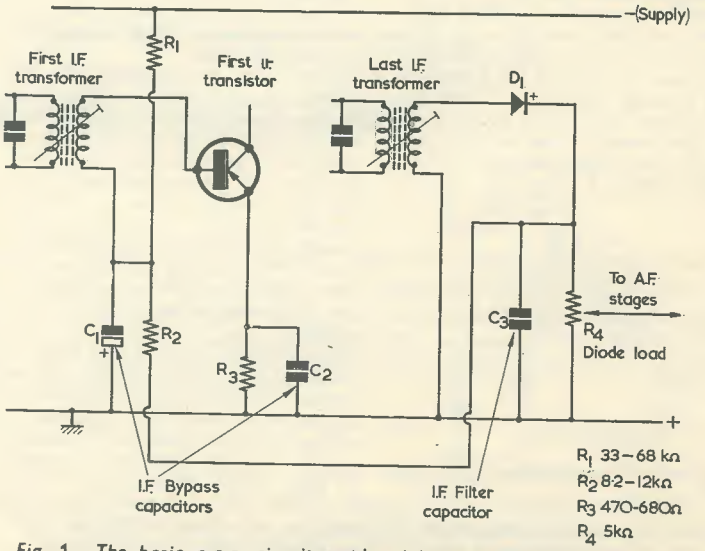

Fig. 1. The basic a.g.c. circuit employed in conventional a.m. transistor superhets. Single-tuned i.f. transformers are assumed

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the diode load resistor going positive. The base of the i.f. transistor then also goes positive, whereupon it exhibits reduced gain and the requirements of an a.g.c. loop are achieved.

It is important to note that, in the absence of signal, the diode in Fig. 1 passes a continual small current in the forward direction, this flowing from the positive supply rail through the diode and R_2R_1 to the negative supply rail. In the absence of signal, therefore, the upper end of the diode load is slightly *negative* of chassis, and it only swings positive of chassis on reception of a signal of sufficient strength. The values in R_2 and R_1 are such that the base of the i.f. transistor receives a standing negative bias which allows it to offer full gain to the i.f. signal under no-signal conditions. R_2 and R_1 also ensure that the base falls to around chassis potential on reception of the most powerful signals likely to be encountered in normal service. The fact that the diode passes a small continual forward bias results in an apparent delay in a.g.c. performance. Due to the forward bias, very weak signals can be detected and reproduced at acceptable loudspeaker strength, but they may not cause the development of any appreciable positive-going a.g.c. voltage on the upper end of the diode load. Because of this, a tuning indicator working from the a.g.c. line of a transistor a.m. receiver may not give useful indications when very weak signals are being received. This slight shortcoming, which will vary in degree between receivers of different design and manufacture, has to be accepted if tuning indicators operating from the a.g.c. line are to be employed, and could only be avoided by the use of a second diode intended purely for operating the indicator itself. The writer feels that this disadvantage is far too small to merit the added complications incurred by fitting a second diode. Nevertheless, it does mean that any tuning indicator fitted does not have *quite* the same range of sensitivity as would be offered by a similar indicator in a valve a.m. receiver having an undelayed a.g.c. circuit.

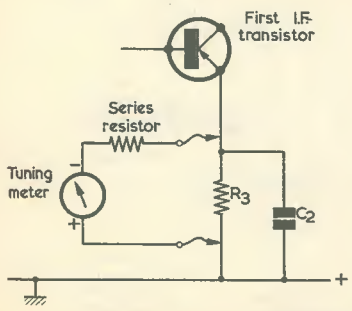

Fig. 2. A very simple method of adding a tuning meter to the circuit of Fig. 1

As was just mentioned, Fig. 1 represents the basic a.g.c. circuit found in conventional a.m. transistor superhets. One or two variations may, however, be encountered. For instance, Fig. 1 shows that the diode load functions as the volume control as well, but a few receivers may be encountered in which the diode load is a fixed resistor, this being coupled by a capacitor to a separate volume control. Another variation likely to be met is the provision, in some receivers, of a low-value i.f. filter resistor between the diode and the upper end of R_4, together with an additional i.f. filter capacitor. Resistor values tend to vary from design to design, and those most frequently employed are listed in the diagram.

Meter Indicator

The simplest type of tuning indicator which may be added to the circuit of Fig. 1 consists, as was suggested in the previous article, of a voltmeter connected across the emitter resistor of the first i.f. transistor. Such a voltmeter is shown in Fig. 2, and it consists of a current-reading meter, which may be mounted on the front panel of the receiver, and a series resistor. As we have seen, an increase in signal strength causes the base of the transistor to go positive. So also, by emitter-follower action, does the emitter, with the result that the meter reading decreases.

The only requirements of the added voltmeter circuit of Fig. 2 are that the meter should show full-scale deflection under no-signal conditions, and that, to prevent upsetting circuit conditions in the receiver, the overall resistance added across the emitter resistor is high. This latter point should be adequately catered for in practice by ensuring that the overall voltmeter resistance is no less than ten times the value of the emitter resistor.

A practical example will help to illustrate these requirements. Let us assume that the emitter resistor, R_3, has a value of 680Ω, and that a voltage of approximately 0.8 appears across it in the absence of signal. To give an f.s.d. reading of 0.8 volts, a 100μA meter requires a series resistor of 8kΩ (assuming zero resistance in the meter) which is, of course, greater than ten times the value of the existing emitter resistor. Thus, in this case, the tuning indicator could employ a 100μA movement and present an overall resistance of around 8kΩ. On switching on the receiver, the meter needle would then rise from zero to f.s.d. under no-signal conditions, the reading falling according to the strength of any signal tuned in.

With almost all receivers, it will probably be found that the use of a 100μA meter adequately meets the two requirements just detailed. Initially, a variable resistor could be temporarily connected up to provide the series resistor. This resistor may then be set up to give an f.s.d. reading under no-signal conditions, after which its value may be measured and a suitable fixed component fitted in its place.

The emitter resistor to which the voltmeter of Fig. 2 connects is normally bypassed by a large-value capacitor. In consequence, there are no significant i.f. voltages across the resistor, and the leads to the meter may have any length and should be capable of passing through any part of the receiver without introducing instability. Additional protection against instability may be given by mounting the meter series resistor close to R_3.

In some receivers the first i.f. transistor may be completely cut off by very strong signals, with the result that the meter of Fig. 2 cannot give accurate incremental tuning indications under these conditions. If this effect is considered important an alternative approach consists of connecting a voltmeter across the diode load itself as in Fig. 3 (*a*), since this meter will respond to all positive excursions at the upper end of the diode load. A 50μA movement should function adequately here and this, with its series resistor, should not add too low a parallel resistance across the diode load. (For those who wish to calculate a suitable meter sensitivity, the writer would suggest that an overall voltmeter resistance which is no less than four times the resistance of the diode load should not normally upset receiver circuit operation.) The voltmeter series resistor is initially set up to give an f.s.d. reading with the strongest signal likely to be received. The meter then gives a zero reading in the absence of signal, this rising in sympathy with the strength of received signals.

As there is a continuous forward bias across the diode when the receiver is switched on, the negative terminal of the meter in Fig. 3 (*a*) is returned to a fixed potentiometer, R_5R_6, across the supply rails, this

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offering the same voltage to the meter as is offered by the diode load under no-signal conditions. Such a potentiometer is desirable because, if the negative terminal of the meter were returned direct to chassis, its needle would suffer a reverse displacement in the absence of signal. The potentiometer draws somewhat less than 1mA from a 9 volt supply, the value of the lower resistor, R_6, being found experimentally to suit the particular receiver concerned.

An alternative idea for overcoming the reverse deflection problem consists of balancing it out with the meter zero-set adjustment. In this instance, the negative terminal of the meter is returned to chassis as in Fig. 3 (*b*), the meter zero-set being adjusted such that it indicates zero under no-signal conditions when the receiver is switched on. The only disadvantages to this approach are that the zero-set adjustment may not offer sufficient range to take up the standing voltage across the diode load, and that the meter will have a permanent positive deflection when the receiver is switched off.

In Figs. 3 (*a*) and (*b*), the series resistor should be mounted close to the diode load, and it will then decouple any i.f. and a.f. voltages which may be present from the meter leads. These leads can, in consequence, be routed through any part of the receiver without undue risk of instability.

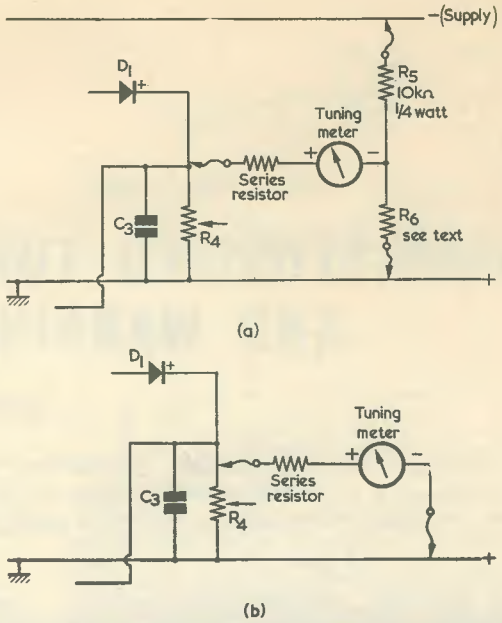

Fig. 3 (a). An alternative method of adding a tuning meter (b). If the standing voltage across diode D_1 is balanced out with the meter zero-set adjustment, the negative terminal of the meter may be connected directly to the positive supply line

Performance

The writer has checked the three circuits discussed this month in conjunction with a standard 6-transistor medium and long wave superhet, and the results described were obtained with no trouble or difficulties at all.

These meter tuning indicators offer considerable ease of reading and only incur the addition of simple circuitry to the receiver. Some of the smaller meter movements currently available have attractively presented scales, and they could impart an impressive outside appearance to the cabinet of a transistor radio.

Unfortunately, it is not possible to mount a tuning meter on the smaller transistor radio cabinets and, to meet this instance, the author has developed an alternative type of indicator which requires panel space for an m.e.s. bulb and a small press-switch only. The circuit employed is more complicated than those discussed here, and will be described separately in next month's article in the Suggested Circuit series.

NEW PORTABLE PROFESSIONAL TAPE RECORDER

A new portable professional tape-recorder, which weighs only 10¾lb, inclusive of batteries, is announced by EMI Electronics Ltd. It provides five additional facilities over the company's previous portable models at no extra cost.

These facilities—incorporated after a detailed market research survey—give the type L4 tape-recorder a versatility far beyond its predecessors, the L2 and RE321, which were specifically designed for use in the broadcasting field. For example, film studios will find the provision of a position for a fourth magnetic head for sound sync to be an invaluable asset, previously only available on specialised film recording equipment.

Other additional facilities include a choice of two speeds—7½ or 3¾ i.p.s.—remote control, press-button operation and mixing of two microphone inputs.

L4's portability and simple operation make it ideally suitable for industrial noise measurement, checking aircrafts' blind landing systems, medical research and a wide variety of other uses in science, industry and entertainment.

Powered by a 14V rechargeable battery, L4 is fully tropicalised and is available in half and full track versions. It is housed in a smartly-styled lightweight alloy case, measuring only 11⅝ x 7 x 6¼in, which has a transparent acrylic lid.

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TRANSISTORISED TURNING INDICATOR AND WARNING DEVICE

By J. G. RANSOME

Our contributor describes a simple multivibrator "winker" circuit for installation in a car. Also discussed is an experimental oscillator which gives audible warning that the flashing indicator is switched on. A 12 volt supply with a positive earth is assumed

ONE OF THE HARD LESSONS LEARNED DURING A recent cold spell was the rather variable performance of the electrical system of the average motor car. A particular problem encountered by the author was the slow warm-up time of the car "winking" indicator which, being essentially a thermal device, took up to three seconds on occasions to reach sufficient temperature to produce the first flash. This rather long delay produced somewhat embarrassing situations and so a cheap unit with a faster cold switch-on rate was investigated.

The Circuit

The circuit of the "winking" switching unit is shown in Fig. 1. As can be seen, the unit is merely a multivibrator coupled to a power amplifier, TR_3, which drives the switching relay. It is felt that this circuit is the simplest that could be devised, and it offers one "blink" per second.

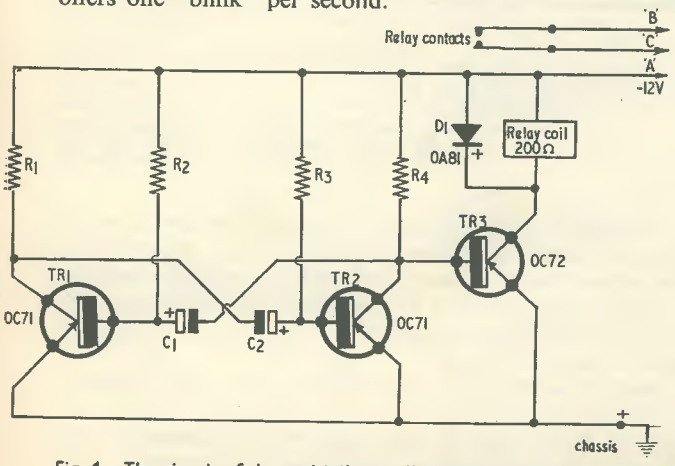

Fig. 1. The circuit of the multivibrator "winker" unit. The points indicated by the letters "A", "B" and "C" couple to similarly identified points in Fig. 3. The relay contacts close when the relay energises

The multivibrator may be assembled in any convenient manner. However, the prototype was built on a printed circuit for both convenience and ruggedness, a suitable arrangement for the layout being shown in Fig. 2. The wiring is straightforward and, with just a little care, a small and strong unit can be made. It is recommended that the relay should be as small as possible since it was found that the weight of a Post Office type unit was such that the relay tended to pull away from the circuit board.

There should be no difficulty in the construction of the multivibrator unit. The connections to the circuit board should be made quickly with a good quality cored solder using a hot iron. There should then be little trouble due to the copper conductor pulling away from the board.

Car Wiring

The wiring of the auxiliary circuit in the car is

Components List
(Fig. 1)

Resistors
R_1 4.7kΩ ¼ watt 10%
$R_{2,3}$ 10kΩ ¼ watt 10%
R_4 1.8kΩ ¼ watt 10%

Capacitors
$C_{1,2}$ 50μF electrolytic 15V wkg.

Semiconductors
$TR_{1,2}$ OC71
TR_3 OC72
D_1 OA81 or similar

Relay
Relay with 200Ω coil and make contacts (see text)

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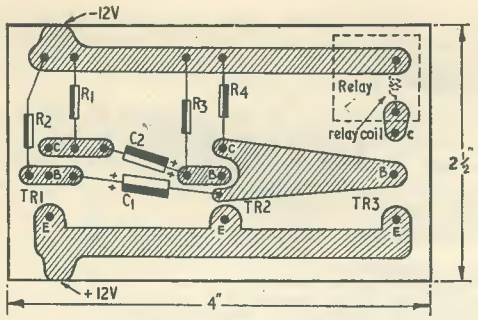

Fig. 2. The prototype printed circuit pattern employed for Fig. 1. Final dimensions may vary according to the type of relay employed

shown in Fig. 3. Most of this circuit will be already wired in place if the unit is used to replace the more conventional flasher. If, on the other hand, the unit is to be fitted to the older type of vehicle, then the auxiliary wiring will have to be put in according to the diagram. The only non-standard item is the 3-way switch. In the original this switch was a Post Office type key-switch which locked in either the right or left hand positions with a centre "rest" position (these switches are readily available from many surplus stores for a few shillings). However, any switch which satisfies the circuit requirements and has suitable mechanical properties may be employed.

The relay and switch contacts must be capable of switching 3 to 4 amps and this means that heavy duty contacts will have to be used in these components.[1]

The full circuit of Figs. 1 and 3 has been functioning, at the time of writing, quite satisfactorily for several months and has well fulfilled the design requirements.

[1] The relay employed in the prototype has, as shown in Fig. 1, a 200Ω coil and one pair of make contacts. Such a relay may be available through surplus suppliers, and coil resistances higher than 200Ω should be satisfactory if the relay is capable of energising at around 8 volts. A suitable 3-way switch (Fig. 3) is the Bulgin rocker-contact component, List No. S.780, which is rated 6–10 amps at 200–250 volts a.c.—EDITOR.

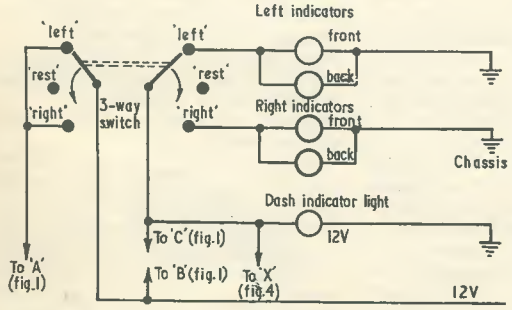

Fig. 3. The switching circuit installed in the car. The switch is a 2-pole, 3-way component. The connection at point "X" is only required if the audible warning device is used

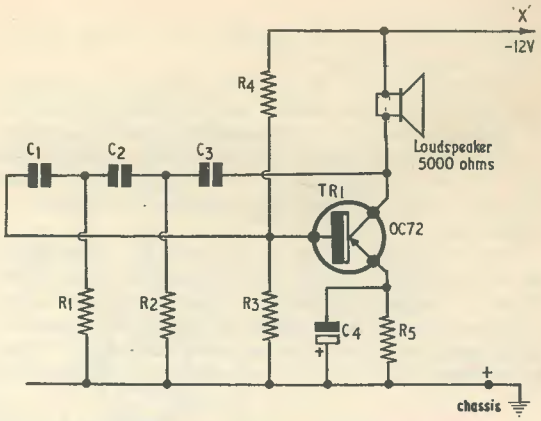

Fig. 4. The experimental audible warning device

Audible Warning System

The other addition which has been made to the turning indicator is an audible warning system to supplement the warning light on the dashboard. It has been found that there is a tendency to ignore the conventional flashing light on the dash—especially in broad daylight—and this means that the flashers are left on giving a false impression of one's direction!

The circuit has been designed around a simple phase-shift oscillator which is used to drive the

Components List
(Fig. 4)

Resistors
$R_{1,2,3}$ 6.2kΩ ¼ watt 10%
R_4 22kΩ ¼ watt 10%
R_5 3.9kΩ ¼ watt 10%

Capacitors
$C_{1,2,3}$ 0.01μF
C_4 25μF electrolytic 6V wkg.

Transistor
TR_1 OC72

Loudspeaker
High impedance unit (see text)

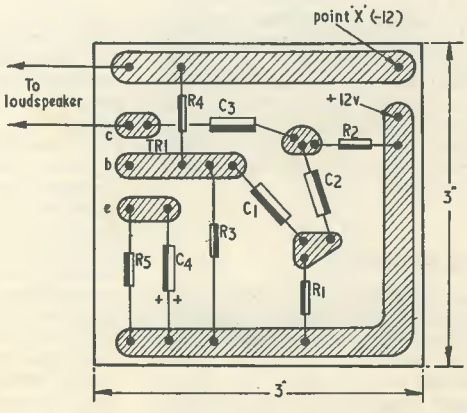

Fig. 5. A printed circuit layout for Fig. 4

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small warning device directly. The circuit of the unit is shown in Fig. 4.

Basically it can be shown that the minimum current gain required for the successful operation of the transistor in a phase-shift oscillator circuit is in the order of 30 and this is readily obtained with the circuit configuration used here. The values shown in Fig. 4 give an operating frequency of 1,000 c/s.

The only item likely to give rise to difficulty is the loudspeaker which, in the original, was made from a balanced armature headphone unit and provided more than ample volume. Any suitable *high impedance* unit may be used here but it must be stressed that a high impedance is required in order that the current gain may be obtained.[2] Other than this, there should be no other difficulty in the construction, and a suitable printed circuit layout is shown in Fig. 5.

The connection to the main circuit is made at point "X" in Fig. 3 but if the unit is to be built into an existing installation then the unit power supply is best taken by wiring across the warning light on the dashboard.

[2] Due to the limitation offered by the choice of speaker, it would be preferable to bring the circuit of Fig. 4 into working order on an experimental basis before preparing it for permanent installation in the car. It should be possible to obtain a reasonable sound output with a 3Ω speaker coupled into the collector circuit via a step-down transformer. The latter could be chosen experimentally, and could be a valve or transistor output transformer.—EDITOR.

3-Stage Pre-Selector for the Beginner Part 2

E. GOVIER

In the first article of this two-part series, written specifically for the beginner, the writer introduced the subject of r.f. amplification and described a simple 1-valve preselector. This concluding instalment deals with a 2-valve r.f. pre-amplifier based on the 1-valve design, together with the final addition of a cathode follower stage

IN PART 1 OF THIS SERIES, PUBLISHED in the last issue, a 1-valve (EF183) pre-selector was described together with references to 2 and 3-valve designs which would be based on it. Advice was also tendered on the obtaining of a 2-gang 500pF variable capacitor and two sets of identical coils (3 in each set) for those who required to construct the unit with more than one valve. It is assumed by the writer that the first design has been built and that two sets of coils have been mounted on the central metal screen contained under the chassis and, in addition, that the 2-gang variable capacitor referred to above has also been included.

2-Valve Pre-selector

The circuit for the 2-valve pre-selector is shown in Fig. 8. It should be noted that all the components used in the circuit of Fig. 1 (published last month) have been given the same designations (e.g. R_4 is the gain control in both versions). This has been done in order to avoid confusion and to facilitate the constructional description.

A careful study of Fig. 8 will reveal that the circuit around V_1 is nearly (but not quite) identical to that in Fig. 1, that both V_1 and V_2 have nearly similar circuits, and that the gain control R_4 is common to both stages.

Major differences between the two circuits are that the r.f. choke has been removed from the anode of V_1 and inserted into the anode supply to V_2; also, that the anode h.t. supply to V_1 is now obtained via the added coil primary winding (L_3), this being bypassed to chassis via an added capacitor C_6. Again, a further switch ($S_{2(a)}$ (b)) has been added; S_1 now has four sections ($S_{1(a)}$ (b) (c) (d)); and a panel aerial trimmer (C_5) has been included. Finally, a connection direct from the aerial input to the receiver (via $S_{2(a)}$ and C_{10}) has been provided.

Having assimilated these points, the beginner will now realise that the r.f. signal is selected and further amplified by V_2, thereby giving even greater selectivity and gain than was provided by V_1 on its own.

Circuit

The circuit for V_1 was described last month but the necessary modifications require some discussion at this point.

The switch $S_{1(a)}$ (b)—see Fig. 9—has been added as a panel control for the reason that the pre-selector may not always be required. It is inconvenient to switch off the unit and to rearrange the aerial connections, and so the added switch offers a very useful and labour-saving device. When receiving strong local amateur signals (as on "Top Band") or powerful broadcast stations, switch $S_{2(a)}$ (b) may be operated to feed the aerial direct into the receiver. It also becomes useful should a 100 kc/s crystal oscillator frequency standard be in use as less confusion with respect to the recognition of the 100 kc/s beat notes will arise if the pre-selector is switched out of service. Coaxial cable, with the metal braiding connected to chassis, should be used for the aerial lead from $S_{2(b)}$ to the capacitor C_{10}.

The panel trimmer C_5 (see Components List) has been added so that the signal may be "peaked" and the tuned circuit of V_1 brought into resonance with that of V_2—assisted by the trimmer capacitor C_8 of that stage—at any point in the frequency coverage of the unit.

The signal from the anode of V_1 is fed, via $S_{1(c)}$, to the primary winding (L_3) of the second coil, and thence to the secondary winding (L_4). L_4 connects, via $S_{1(d)}$, to the grid of V_2, being tuned by the parallel combination $C_{1(b)}$ and C_8. $C_{1(b)}$ is the second section (that to the rear of the chassis) of the 500pF variable tuning capacitor. The resistor R_5 supplies h.t. potential to grid 2 of V_1 (pin 8) this being bypassed to chassis via C_7. The anode supply is

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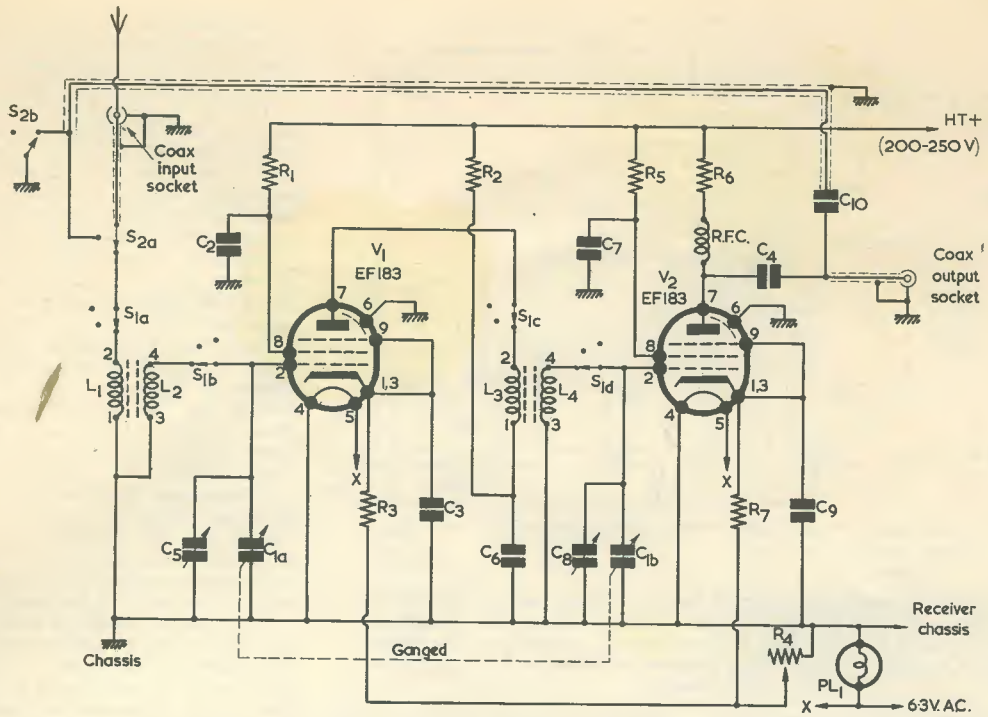

Fig. 8. Circuit of the 2-valve pre-selector

via R_6 and the r.f.c. (removed from the anode of V_1). The output is taken from the anode of V_2 (pin 7) via the coupling capacitor C_4 (again removed from the old V_1 circuit).

The potentiometer R_4 is common to both stages in order that the gain may be variable with respect to both V_1 and V_2. The two stages operate in cascade.

Construction

As with V_1, the second stage should have a small metal screen soldered across the valveholder as shown in Fig. 5, published last month. The soldered connections for this screen are exactly the same as for V_1.

An earthed soldering tag should be mounted under one of the nuts securing V_2 valveholder to the chassis and the valveholder oriented such that pin 2 is nearest the coils. A small hole fitted with a grommet is needed in the chassis near this pin to take the non-earthed lead from $C_{1(b)}$ and C_8.

Fig. 10 shows the connections to the coils (L_3 and L_4 in Fig. 8) and it will be noted that these are somewhat different from those needed for L_1 and L_2. In the present instance, the primary winding (L_3) carries the h.t. potential to the anode of V_1 and the bottom end of this winding is bypassed to chassis via C_6. The secondary winding (L_4) is connected in the same manner as was L_2. Connections to the switch are also shown.

The r.f.c. and C_{10} should be removed from the anode of V_1 and inserted, where shown, in the anode circuit of V_2.

Fig. 9 shows the wiring to the added switch $S_{2(a)\ (b)}$.

Fig. 11 gives details of the panel and chassis for the 2-valve version and is very similar to Fig. 3 published in the last issue. Also shown in Fig. 11 is the position of the third valve—the addition of which is discussed later.

When dealing with the front panel, it should be noted that hole (i) now takes the panel lamp assembly; this previously occupying hole (a) in the 1-valve version. Hole (a) is now utilised for switch $S_{2(a)\ (b)}$, and hole (h) for the aerial trimmer control C_5.

Components List (Fig. 8)
(Additional components for V_2 only are listed)

Resistors (all 20%)
- R_5 33kΩ 1 watt
- R_6 5kΩ ½ watt
- R_7 200Ω ½ watt

Capacitors
- C_5 100pF variable (Jackson Bros. type C804)
- C_6 0.01μF tubular (Mullard)
- C_7 0.01μF tubular (Mullard)
- C_8 3–30pF concentric trimmer (Philips)
- C_9 0.01μF tubular (Mullard)
- C_{10} 100pF ceramic

Valve
- V_2 EF183 (Mullard)

Valveholder
- B9A with centre spigot

Coils
- Osmor type QA1, QA3, QA4

Switch
- $S_{1(a)\ (b)}$ 2-pole, 2-way

Miscellaneous
- 4-way tagstrip, nuts, bolts, coaxial cable, etc.

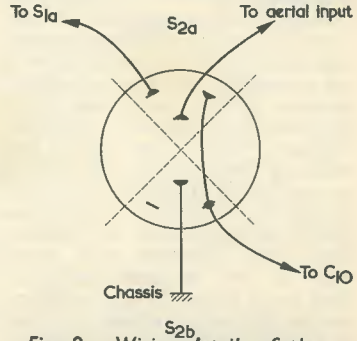

Fig. 9. Wiring details of the switch $S_{2(a)\ (b)}$. The connection to C_{10} is via screened wire

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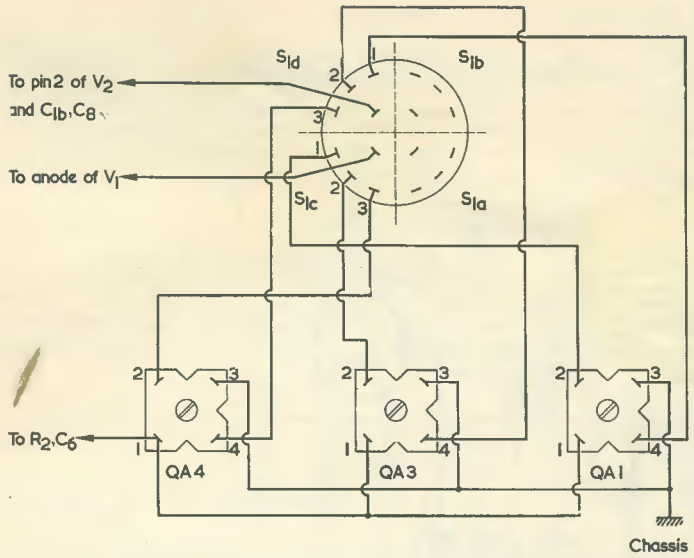

Fig. 10. Wiring details of the switch $S_{1(c)\,(d)}$. A part from the lead to the anode of V_1 all wiring should be on the V_2 side of the screen. The lead to V_1 anode must be kept well clear of the wiring to $S_{1(a)}$ and $S_{1(b)}$. The chassis connection is made to the earth tag fitted to the screen in Fig. 6 (published last month)

Having drilled the hole for C_5, mount this component to the panel and connect a lead from its stator plates to the tag of the main tuning capacitor section nearer the panel, i.e. the section tuning L_2.

Mount under the chassis, at a point between the positions shown for V_2 and V_3 in Fig. 11, a further 4-way tagstrip and wire-up this tagstrip as shown in Fig. 12, also wiring-up the associated circuitry for V_2.

When the construction of the 2-valve unit has been completed, it should be connected to the aerial and receiver and switched on, the alignment of the two tuned circuits now being carried out.

Alignment

Alignment is a simple process and one that need not deter the beginner. The gain control R_4 should be set in the maximum gain position and the receiver should have the a.g.c. (automatic gain control)—sometimes labelled "a.v.c." on older type receivers—switched on. The S-meter (where fitted) should now operate. Should no S-meter or other tuning device be installed in the receiver, then the constructor will simply have to rely on aural indication. This is not as satisfactory a method, but is the only manner in which alignment can be carried out until such time as a tuning device is fitted to the receiver.

Alignment should start with the lowest frequency band and continue from there to the highest frequency band. The aerial tuned circuit is fitted with the parallel variable capacitor C_5 and therefore it will only be necessary for the trimmer in the tuned circuit of V_2 (C_8) to be adjusted for optimum signal strength at a position in the approximate centre of each of the three bands. The "swing" of C_5 will adjust the two circuits at any point either side of this central position.

The most selective tuned circuit is that in the grid of V_2 and the method for aligning each coil here is to adjust their iron-dust cores to provide the frequency required at the low frequency end (rotor vanes of $C_{1(a)\,(b)}$ fully meshed) of each range, and then adjust the cores of the V_1 coils in order to provide the maximum sensitivity (strongest signal). Following this procedure, ascertain that the optimum aerial trimming is being obtained on each band, at various points in the frequency coverage, by adjusting the panel trimmer C_5.

Adding the Third Stage

The third stage, shown in Fig. 13, is a cathode follower, and its function is to provide an improved impedance match between the output of the pre-selector of Fig. 8 and the aerial terminals of the receiver at all frequencies covered by the unit. A cathode follower stage provides no additional gain, but it does ensure that an optimum transference of r.f. energy is achieved at all times.

The valve used is an EF80 r.f. pentode, and it has the same base connections as the EF183 in the V_1 and V_2 positions. This stage is comparatively simple to wire-up and requires very few additional components other than the valve and valveholder. The position of V_3 is shown in Fig. 11, and an earth tag should be mounted under one of its securing nuts.

To introduce the cathode follower stage, capacitor C_4 should be disconnected from the coaxial output socket (see Fig. 8) and connected direct to the grid of V_3 (pin 2), R_8 being taken from this pin to chassis (the earth tag at V_3 valveholder).

The cathode circuit should now be wired-up. Pins 1, 3 and 9 of the valveholder are connected, via R_{10}, to chassis and, via C_{13}, to the coaxial output socket. The connection with C_{10} is made at the same point.

Note that the output is taken from the cathode of V_3 and that the output impedance has been so arranged that it will correctly match into 75Ω. This is the impedance of ordinary TV coaxial cable, which is most commonly used for linkage purposes; most communication receivers having an input impedance of around this figure.

Power Supply

With receivers that do not have a power outlet socket, or which cannot provide the h.t. and heater current required by the pre-selector, a separate power supply will be needed.* Fig. 14 shows a simple circuit which will provide all the necessary supplies required.

The 5Y3GT rectifier is an octal based valve and is available cheaply on the surplus market. All components are specified in the Components List and the mains transformer is supplied complete with connection details—these also being shown on the circuit diagram. It will be noted that the rectifier has a 5 volt heater supply whilst a 6.3 volt winding supplies the remainder of the valves in the pre-selector circuit. The two smoothing capacitors C_{14} and C_{15} are contained within a single metal can and the chassis connection is made by the metal chassis mounting clip which should be purchased with this capacitor. Note that the

*The 2-valve version requires some 20 to 30mA h.t. current and 6.3 volts at 0.6A for the heaters, whilst the 3-valve circuit requires about 25 to 40mA h.t. current and 6.3 volts at 0.9A. These heater currents do not include the current drawn by the pilot lamp.

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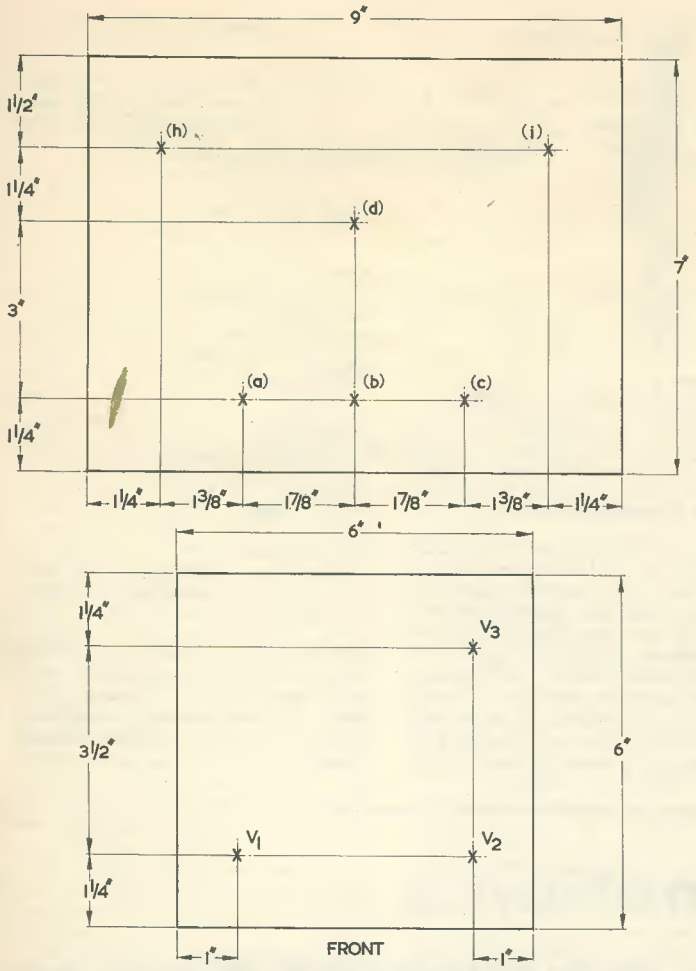

Fig. 11. Details of the panel and chassis. The panel holes (h) and (i) are for the aerial trimmer C_5 and the pilot lamp respectively

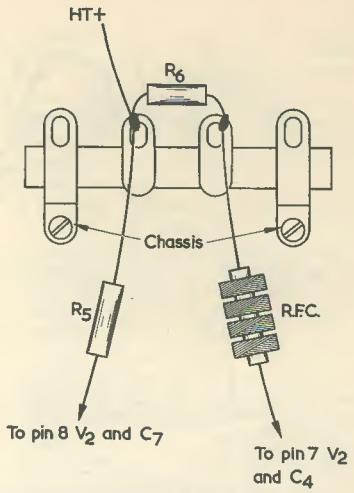

Fig. 12. Wiring details of the tagstrip mounted between V_2 and V_3

chassis point will be given by an earth tag mounted under one of the securing nuts for the rectifier valveholder. Before soldering, all heater leads should be scraped with a sharp knife so that the thin enamel covering is removed exposing the bright copper wire, which should then be tinned thoroughly.

A small chassis is needed for this power supply and requires to be only some 5 x 7 x 2in.

Finally, the beginner is reminded that all leads from the mains transformer and the l.f. choke will have to be fed from the top of the chassis to the underside, and that all holes drilled in the chassis to take these leads must be fitted with rubber grommets. The output from the yellow wire (h.t. centre tap) of the mains transformer, together with one of the green 6.3 volt heater connections and the white wire should all be connected to chassis. It is immaterial which of the 6.3 volt heater leads is so connected. A suitable

Components List (Fig. 13)

Resistors (all 20%)
- R_8 100kΩ
- R_9 1kΩ
- R_{10} 180Ω

Capacitors
- C_{11} 0.01μF tubular (Mullard)
- C_{12} 0.01μF tubular (Mullard)
- C_{13} 0.005μF mica

Valve
- V_3 EF80 (Mullard)

Valveholder
- B9A

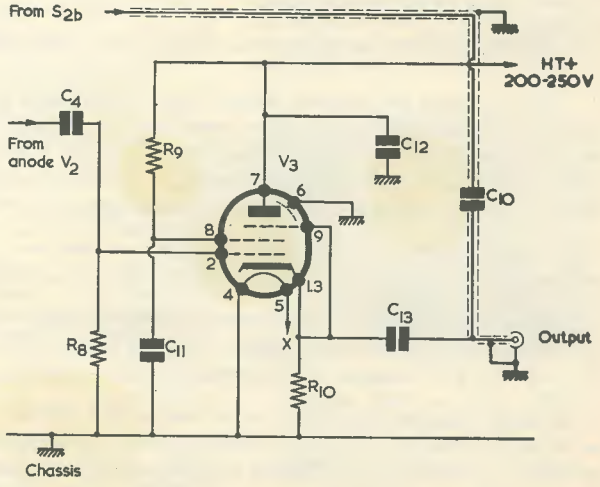

Fig. 13. Circuit of the added cathode follower stage

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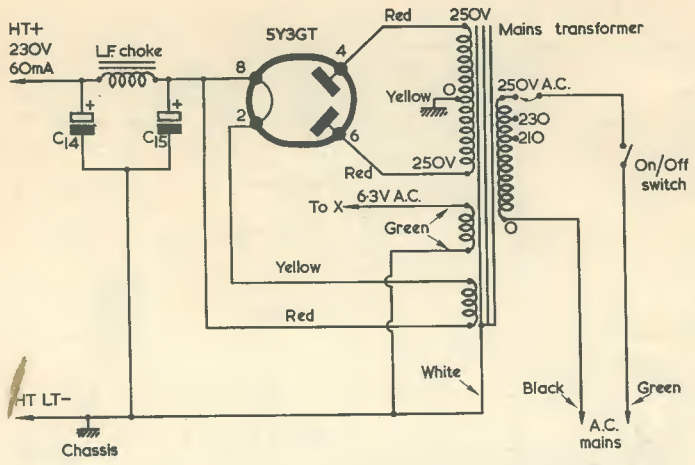

Fig. 14. A suitable power supply for the 3-valve pre-selector

power supply should preferably be terminated in an octal socket mounted on one of the chassis walls, the pre-selector connecting via an octal plug and a 3-way cord. It is pointed out here that *no "lash-ups" are permissible with respect to the power pack*, all connections should be properly soldered and the unused mains input tapping wires from the transformer primary (there are three of these *in all*, only one being used according to the local mains supply) should be taped *separately*, such that the bare ends are adequately insulated. These may then be tucked away above the chassis and under the transformer itself. Additionally, on the secondary side of the mains transformer, there is a blue lead (6.3V, 2A) on the same winding as that supplying heater voltage to the rectifier; also a twin wire (green) which is a centre-tap to the main 6.3V heater supply. Both of these leads must be *separately* taped and tucked away in a corner of the chassis.

Components List (Fig. 14)

Capacitors
C_{14} 16μF, electrolytic, 350V wkg.
C_{15} 8μF, electrolytic, 350V wkg. (contained in single can)

Mains Transformer
Ellison type MT161

Plugs and Sockets
As required—see text

On/Off Switch
Toggle type s.p.s.t.

LF Choke
10H, 60mA

Valve
5Y3GT

Valveholder
International octal

Chassis
5 x 7 x 2in

Miscellaneous
Capacitor mounting clip, nuts, bolts, grommets, earthing tags, etc.

Elliott-Automation's Automatic Circuit Tester

COMPLEX ELECTRICAL CIRCUITS CHECKED AT TEN TIMES NORMAL SPEED

The Admiralty has recently placed further orders with Elliott-Automation for automatic circuit testers. These orders are the result of the highly successful performance of one of the first Elliott automatic circuit testers which the Admiralty bought early last year. This is now in regular production line use and is not only achieving large savings in time and improved accuracy in the checking of complex electrical circuits, but has made it possible to use unskilled labour in place of skilled workers who are in increasingly short supply.

On one job alone, the equipment enabled a production run of complex wiring systems to be checked in less than one-tenth of the normal time, using unskilled female labour instead of skilled male labour.

The Elliott Automatic Circuit Tester replaces the conventional, laborious and time-consuming method of point-to-point checks with buzzers and meggers. It checks automatically, rapidly and accurately circuits of from 100–1,000 lines for continuity and insulation within preset limits of acceptance.

It is able to cope with printed circuit boards, and circuits containing relays and similar devices. Checking is carried out at approximately 10 tests per second. Normally, a continuity test, followed by an insulation test, is applied consecutively to each circuit. A step-on pulse moves the equipment automatically to the next circuit if the results of the current pair of tests are satisfactory. When there is a fault, its location and type is clearly displayed.

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NEWS AND COMMENT . . .

Ideal Home

Visitors to the 1965 Ideal Home Exhibition could operate a colour TV set on the stand of the British Relay organisation (Empire Hall stand No. 212).

As most readers will know, basically a colour TV camera first analyses the scene into three main colours—red, green and blue—and produces electrical signals corresponding to these colours. These signals are fed into the receiver where each feeds a separate channel in the set and produces an image on the face of the screen in the appropriate colour. After undergoing a complicated system of transmission the three colours then combine into a single picture. In the display at the exhibition a normal black-and-white camera is used to produce a single electrical signal corresponding only to changes in brightness level. This signal is split three ways and fed into the red, green and blue channels in the receiver. The level of each of these colour signals is dependent on the setting of the three controls provided on the exhibition set on the company's stand.

In another display visitors operated four sets of push-button selector switches linked to four remote-control viewing units to select and watch four different TV programmes — B.B.C.1, B.B.C.2, I.T.V., and a special closed-circuit programme.

For Your Diary

The Eleventh International V.H.F./U.H.F. Convention, organised by the Radio Society of Great Britain, will be held at the Kingsley Hotel, Bloomsbury Way, London, W.C.1, on Saturday 10th April, 1965.

The Convention opens at 11 a.m. with a trade exhibition. A lecture programme on a variety of topics of general v.h.f. interest is arranged for the afternoon, and the proceedings will end with a dinner in the evening. Guests will include Dr. R. L. Smith-Rose and Mr. C. G. Phillips, Chief Telecommunications Engineer, Ministry of Aviation.

Tickets are available from the Convention Treasurer, Mr. F. E. A. Green, G3GMY, 48 Borough Way, Potters Bar, Middlesex, at a cost of 4s. 6d. (Convention only) or 30s. (Convention and Dinner).

Warning

A transistor set valued at 3,000 guineas was recently stolen from Whiteley's Ltd., the well-known London store. Readers are therefore advised to be careful before buying a transistor receiver with a mink case, etc., at a bargain price!

Taking for Granted

The editor of *Radial*, the monthly journal of the Radio Amateur Invalid and Bedfast Club, commented in a recent issue on the fact that she had been, without her knowledge, enrolled as an honorary member in a radio amateur society, with H.Q. in Florida.

It was not that she objected to the objects of the society which seemed worthy enough, but to be given an operational number and elected to membership without so much as a by your leave is rather breath taking. It seems to rather fall into the category of the pseudo personal letter one may receive from a commercial organisation stating that one has been especially selected as a person worthy to take part in a national survey, etc. At least in this case there is the option of doing nothing about it. However, we feel that the extension of this sort of thing into amateur radio is to be regretted.

Whitehall 1212

"Whitehall 1212"—probably the world's best known telephone number—is to be streamlined when Scotland Yard moves next year to its new building at No. 10 Broadway, Westminster.

Orders worth more than £200,000 have been placed with Standard Telephones and Cables Limited for a new 1800-extension telephone exchange and a 150-line automatic teleprinter exchange to form Scotland Yard's new communications centre.

The new system will provide vital communication links between divisional stations, fire and ambulance services and Scotland Yard, headquarters of London's Metropolitan Police.

New Tantalum Capacitors

Newly introduced by Plessey-UK Limited is a range of subminiature solid electrolyte tantalum capacitors, designated Type 'M'.

Their diminutive size—a typical example is 4mm long x 1.8mm diameter—makes them suitable for such applications as hearing aids, personal paging systems, rescue beacons, electronic wrist-watches and all solid state or thin film circuitry.

Capacitance range is 0.047μF to 10μF at d.c. working voltages of 50 to 1.5V. Other characteristics are: temperature range −55°C to +85°C; leakage current, not greater than 2 microamps at 20°C; power factor, 25% maximum at 120 c/s; surge voltage, rated working voltage plus 16%.

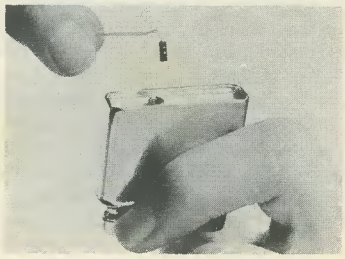
A three-dot marking system, based on the international colour code, gives the capacitance value in pF.

Operation

Type M capacitors are polarised units for operation with a d.c. bias. To prevent reverse polarity, the peak value of any a.c. component must not exceed the applied d.c. bias. Also, the sum of the d.c. bias voltage and the peak value of any a.c. component must not exceed the rated working voltage of the capacitor.

Construction

A porous tantalum anode of sintered high-purity tantalum powder is anodised and impregnated with manganese dioxide solid electrolyte. Tinned nickel contact leads of 0.01in diameter are welded to the anode and soldered to the cathode, the anode lead being gold "flashed" to indicate polarity. The unit is metallic coated and encapsulated in an epoxy case.



Smaller than a lighter flint. Type M for Microminiature—the latest "Castanet" tantalum capacitor developed by Plessey-UK Limited, Towcester, Northants.

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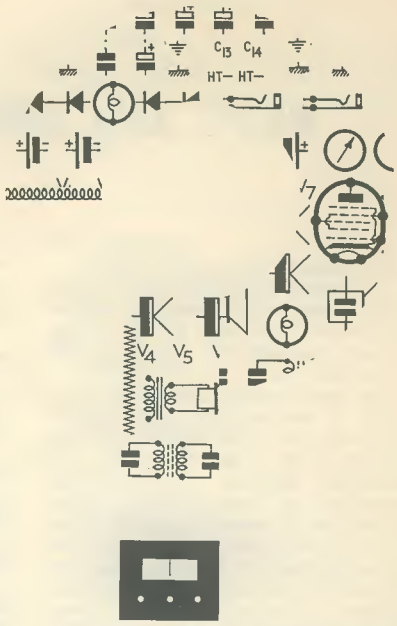
understanding radio



By W. G. MORLEY

THE CHOKE INPUT RECTIFIER FILTER

IN LAST MONTH'S ARTICLE WE CONTINUED OUR discussion on high tension rectifier circuits, dealing with the action of the reservoir capacitor in full-wave and bridge rectifier circuits. We also considered the smoothing circuits—choke and capacitor, and resistor and capacitor—which may be employed to obtain a final rectified direct voltage having a low ripple component. We shall now turn our attention to rectifier circuits which do not have a reservoir capacitor.

Choke Input

Fig. 269 (*a*) illustrates a full-wave rectifier, the cathodes of whose diodes connect directly to a choke, the latter being followed by a large-value capacitor. There is no reservoir capacitor. As we may expect from our previous discussions, positive half-cycles are applied to the left hand terminal of the choke, these having the appearance shown in Fig. 269 (*b*). The mean direct voltage of this waveform is also indicated in Fig. 269 (*b*). The choke offers a high reactance to the alternating component of the waveform, and the capacitor which follows it a low reactance, with the result that only a small proportion of the alternating component of the waveform appears across the load. At the same time, the choke offers a low resistance, and the capacitor a very high resistance, whereupon nearly all the mean direct voltage appears across the load.

It is important to note that (assuming negligible internal resistance in the transformer and diodes and sufficient inductance in the choke) the mean direct voltage in Fig. 269 bears a fixed relationship to the alternating voltage applied to the rectifier anodes. It is, in fact, 0.9 times the r.m.s. value of the alternating voltage appearing across each half of the transformer secondary (or 0.45 times the r.m.s. voltage across the entire secondary). This represents quite a different state of affairs to that which occurred when we had a reservoir capacitor. With the assumptions just made, the mean direct voltage at the rectifier cathodes of Fig. 269 (*a*) is fixed, regardless of changes in load current. With a reservoir capacitor immediately following the rectifier cathodes, the mean direct voltage is not fixed, and it falls with increase in load current. It may be seen, therefore, that the rectifier circuit without the reservoir capacitor offers much better *regulation* (i.e. it has a much greater ability to maintain the output voltage constant despite changes in load current) than has the rectifier circuit with the reservoir capacitor.

In practice, the mean direct voltage offered by the rectifier circuit without reservoir capacitor is not entirely constant. This is because there is a small fall in the output voltage at the diode cathodes with increase in load current due to the inevitable internal resistance in the transformer secondary and the rectifiers. These factors also, of course, similarly apply to the circuit with the reservoir capacitor.

The main advantage of the full-wave rectifier without reservoir capacitor is the high regulation it provides. There is, also, the point that the rectifier is not called upon to pass the high peak charging currents which flow when a reservoir capacitor is used. A disadvantage is that the rectified voltage is lower, for a given transformer secondary voltage, than is provided when a reservoir capacitor is employed.

A bridge circuit without reservoir capacitor is shown in Fig. 270. This causes half-cycles to appear across the load which are the same as those given

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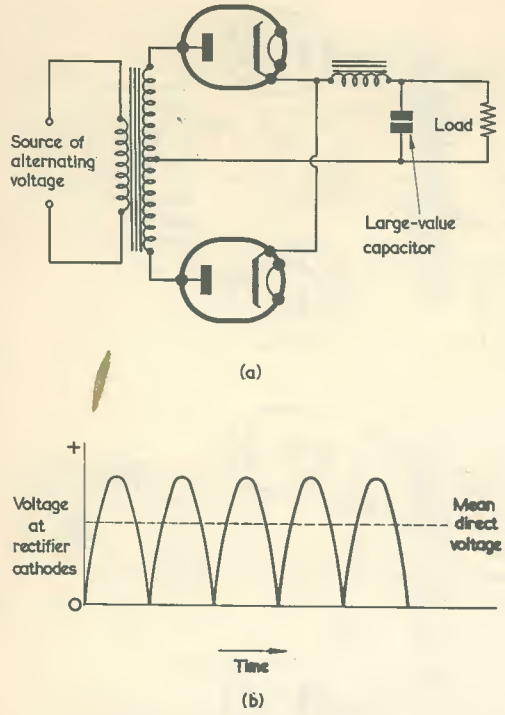

Fig. 269 (a). A full-wave rectifier circuit without a reservoir capacitor. The rectifier cathodes connect directly to the choke (b). The waveform appearing at the rectifier cathodes. The mean direct voltage is 0.9 times the r.m.s. value of the alternating voltage across each half of the transformer secondary

by the full-wave rectifier of Fig. 269. The mean direct voltage is, in consequence, 0.9 times the r.m.s. value of the applied alternating voltage.

Fig. 271 (*a*) shows a half-wave rectifier without reservoir capacitor. In this instance the half-cycles at the rectified cathode are spaced out with half-cycle intervals between them, as in Fig. 271 (*b*).

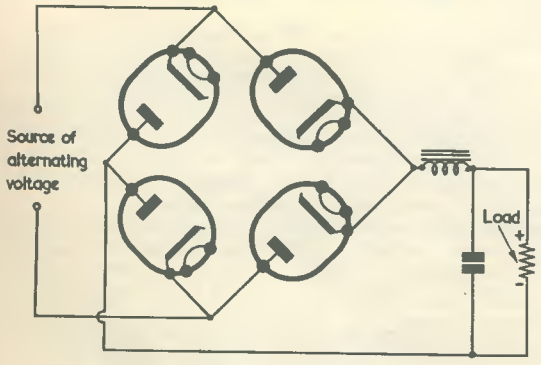

Fig. 270. A bridge rectifier circuit followed by a choke and capacitor, and without a reservoir capacitor

The mean direct voltage here is 0.45 times the r.m.s. value of the applied alternating voltage.

Choke and Capacitor Inputs

As we have just seen, the performance of the rectifier circuits of Figs. 269 to 271 is quite different from that of rectifier circuits having a reservoir capacitor. The two basic types of circuit may be differentiated in terms of the filter which follows the rectifier, whereupon we may say that the circuits in Figs. 269 to 271 represent rectifiers with a *choke input* filter, and that when a reservoir capacitor is employed we have rectifiers with a *capacitor input* filter.

We commenced our description of high tension rectifiers with the capacitor input version because this is far more frequently employed in common

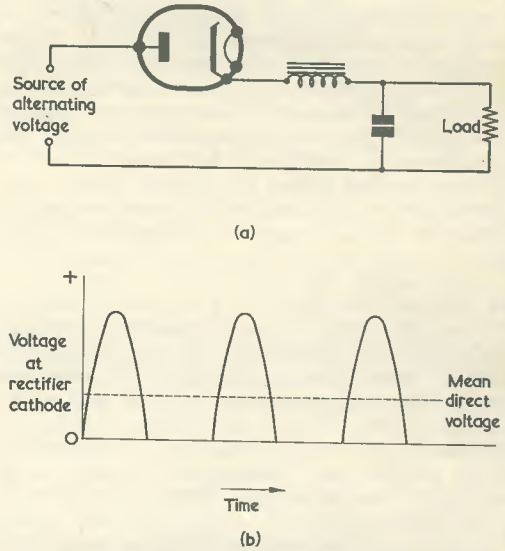

Fig. 271 (a). The half-wave rectifier followed by a choke and capacitor (b). The waveform at the rectifier cathode. The mean direct voltage is 0.45 times the r.m.s. value of the applied alternating voltage

radio applications. Also, the capacitor input circuit offers a somewhat easier introduction to h.t. rectifier and smoothing principles. Most radio circuits draw a reasonably steady current from the h.t. supply and do not, in any case, normally require an exceptionally well regulated h.t. voltage. The capacitor input rectifier circuit is much more attractive for such applications, because it allows a higher rectified voltage to become available, for the same alternating voltage input, than does the choke input circuit. Also, the reservoir capacitor provides a significant degree of smoothing itself, and can often be followed by relatively inexpensive resistor-capacitor smoothing circuits. The choke input filter is normally employed only when a high degree of h.t. voltage regulation is required. It is most commonly encountered in some classes of trans-

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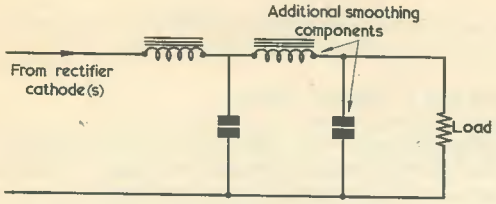

Fig. 272. To provide additional smoothing, a second choke and capacitor may follow the choke and capacitor of Figs. 269 to 271

mitter equipment whose current requirements vary widely in use, and in some pieces of test equipment. Normally, the choke input filter would be used with a full-wave or bridge rectifier circuit, as the half-wave circuit offers too low an output voltage and has a fundamental ripple frequency which is half that given by the full-wave and bridge versions. Nevertheless, the half-wave rectifier with choke input filter may occasionally be encountered when low rectified voltages at low currents are required. If the current requirement is sufficiently low, the input choke may be replaced by a resistor.

When a rectifier with a choke input filter is used, a second choke and large-value capacitor may be added, as in Fig. 272, to provide additional smoothing.

Peak Inverse Voltages

The subject of peak inverse voltages was previously introduced in the light of rectifier circuits having a capacitor input filter. This approach was used because, once again, it enabled a simple explanation to be presented. If we now briefly examine the question of peak inverse voltage with a choke input filter we will find that this remains the same for the full-wave and bridge rectifier circuits, but differs for the half-wave circuit.

Fig. 273 (*a*) illustrates a full-wave circuit with capacitor input filter at an instant when the applied alternating voltage is at peak level, and when the upper terminal of the transformer secondary is negative and the lower terminal positive. Following our discussion in last month's article (when we examined the peak inverse voltage in a circuit of this type) we can say that, assuming negligible load current, the reservoir capacitor becomes virtually fully charged and has peak voltage across its plates, the upper plate being positive, as shown. This voltage across the reservoir capacitor is in series with the peak voltage across the upper half of the transformer secondary, whereupon twice that peak voltage appears, with non-conducting polarity, across the upper diode. Thus, the peak inverse voltage applied to the upper diode is twice the peak voltage across half the transformer secondary; and corresponds to 2.828 times the r.m.s. voltage across half the secondary or 1.414 times the r.m.s. voltage across the entire secondary.

In Fig. 273 (*b*), we have the same alternating voltage conditions, but we have now changed to a choke input filter. Despite the lack of reservoir

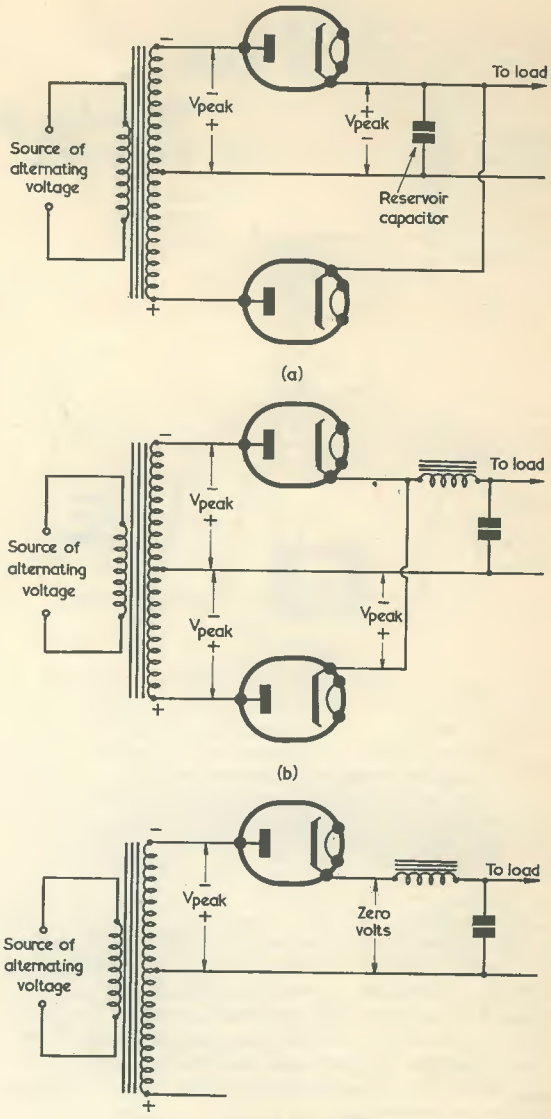

Fig. 273 (a). With a reservoir capacitor, the peak inverse voltage on each diode of the full-wave rectifier shown here is twice the peak value of the alternating voltage across half the transformer secondary. Here, and in (b) and (c), V_{peak} refers to the peak voltage across half the transformer secondary

(b). When a choke input filter is used the peak inverse voltage is not altered, since the conducting lower diode causes positive peak voltage to appear at the cathode of the upper diode

(c). Removing the lower diode results in the upper diode functioning as a half-wave rectifier. Peak inverse voltage (assuming sufficient inductance in the choke) is now equal to V_{peak}

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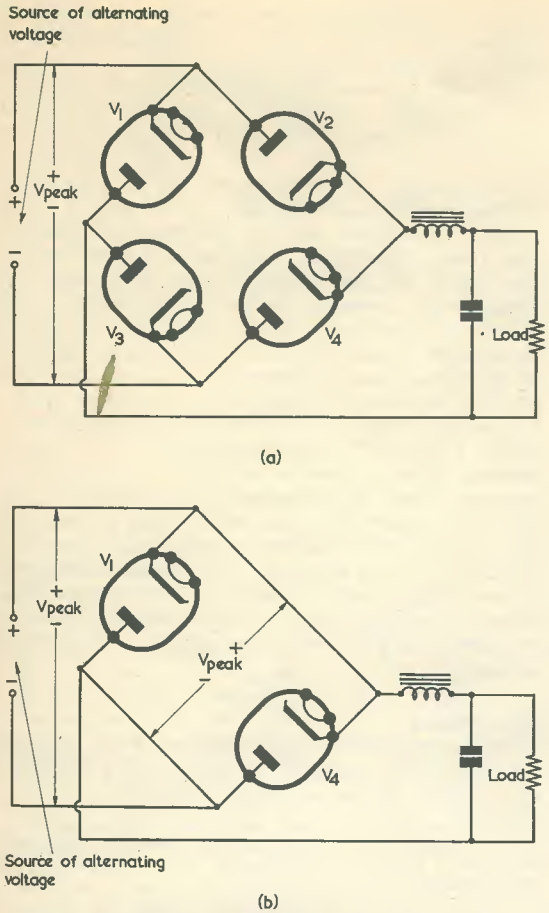

Fig. 274 (a). The bridge rectifier circuit with choke input filter, at an instant when the applied alternating voltage is at peak level with the polarity shown
(b). In (a) V_2 and V_3 are conducting and, assuming negligible voltage drop in these diodes, could be replaced by short-circuits. The peak voltage is then applied, with non-conducting polarity, to V_1 and V_4

capacitor, the cathode of the upper diode is still at peak positive potential because this potential is applied to it by the conducting lower diode. In consequence, the peak inverse potential applied to the upper diode is, once again, 2.828 times the r.m.s. voltage appearing across half the transformer secondary, or 1.414 times the r.m.s. voltage across the entire secondary. By reversing the polarity of the applied alternating voltage, this peak inverse voltage will be similarly applied to the lower diode.

Fig. 273 (*c*) repeats the peak alternating voltage conditions of Fig. 273 (*b*), but the lower diode is now removed, thereby causing the upper diode to operate, on its own, as a half-wave rectifier. Due to the absence of the lower diode, the cathode of the upper diode is now at the same potential as the negative end of the load or the centre-tap of the

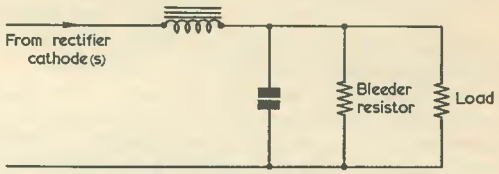

Fig. 275. Adding a bleeder resistor across the output from a choke input filter

transformer secondary. Thus, the peak inverse voltage across the diode is equal to the peak value of the voltage appearing across half the transformer secondary. The lower half of the transformer secondary now plays no part in circuit operation, so we may conclude that the peak inverse voltage for the half-wave rectifier with choke input filter is the peak value of the applied alternating voltage, or 1.414 times its r.m.s. value. It will be recalled that, with a reservoir capacitor, the peak inverse voltage of the half-wave rectifier is 2.828 times the r.m.s. value of the applied alternating voltage.

It should be added that this last explanation assumes that the choke has a sufficiently high inductance to meet the requirements of the circuit. If choke inductance is too low the filter circuit will tend to function as a capacitor input filter, and the peak inverse voltage across the diode may, in consequence, become greater than 1.414 times the r.m.s. value of the applied alternating voltage. Too low an inductance in the choke will, with the full-wave and bridge circuits, similarly cause the filter to function more as a capacitor input circuit. However, in these cases there is no alteration in peak inverse voltage (which is the same for both types of filter) but regulation may suffer. As we shall see shortly, the minimum amount of inductance required for true choke input operation varies according to rectified voltage and load current.

Reverting to the subject of peak inverse voltage, Fig. 274 (*a*) shows a bridge rectifier with a choke input filter. The applied alternating voltage is at peak level, its upper terminal being positive and its lower terminal negative. Under these conditions V_2 and V_3 are conducting whereupon, assuming negligible voltage drop in these diodes, we may replace them with short-circuits, as illustrated in Fig. 274 (*b*). As may now be seen, the peak voltage is applied, with non-conducting polarity, across diodes V_1 and V_4. Thus, the peak inverse voltage for these diodes is the peak value of the applied alternating voltage. Reversing the polarity of the applied alternating voltage will cause the same peak inverse voltage to be applied to diodes V_2 and V_3. Thus, the peak inverse voltage for the diodes in a bridge rectifier circuit with choke input filter is the peak value, or 1.414 times the r.m.s. value, of the applied alternating voltage. Interested readers may note that the circuit of Fig. 274 (*b*) is similar to that of Fig. 264 (*b*) in last month's article, which demonstrated that the same peak inverse voltage was given with a capacitor input filter.

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Choke Inductance

For true choke input operation, the inductance of the choke must be greater than a certain *critical inductance*, which varies directly as rectified voltage, and inversely as the load current.[1] Thus, as load current decreases, the critical inductance increases. Because of this effect, manufacturers of rectifiers which may be used with choke input filters normally specify minimum inductance requirements at various load currents and voltages.

Due to its inverse relationship with load current, the critical inductance required for true choke input operation may be exceptionally high at low load currents. At zero load current it is, indeed, infinite! In consequence, it is a common practice to connect a *bleeder resistor* across the load, this resistor ensuring that, despite variations in load current, the output current from the rectifier is never less than a value which permits the use of a choke having a reasonable practicable inductance. Such a bleeder resistor is shown in Fig. 275. The power dissipated in the bleeder resistor is, of course, wasted, but the use of this component is well justified if it gives a saving of cost in the choke.[2]

An alternative manner of looking at the function of the bleeder resistor is to state that it can prevent the rectified current falling below a level which causes critical inductance to be higher than that offered by a practicable choke. At low load currents, it therefore prevents the filter tending to function as a capacitor input circuit, and the consequent appearance of undesirably high voltages across the load.

To meet the requirements of the circuit the inductance of the choke has to be greater than critical inductance at the lowest load current anticipated. However, this means that the choke may have an unnecessarily high inductance for higher load currents. When load currents vary widely, the result could be that a needlessly expensive component is used, its cost being warranted only at the lower load currents. A solution to this problem consists of employing a *swinging choke*. A swinging choke is a relatively low-cost component which exhibits a high inductance at low direct currents and a low inductance at high direct currents. Such a performance is achieved by the use of a smaller iron core than would be required in a choke which offered a reasonably constant inductance at all currents. The falling inductance of the swinging choke is due to its core approaching saturation as the direct current through its windings increases, and this effect is permissible in the present application.[3]

Next Month

This completes our consideration of the diode as a power supply rectifier. In next month's article we shall discuss its use as a signal detector.

[1] An approximate value for critical inductance, in henrys, with a full-wave or bridge rectifier operating from a 50 c/s supply is $\frac{V}{I \times 940}$, where V is voltage across the load, and I is current in amps flowing through the load. (F. Langford-Smith, *Radio Designer's Handbook*, Iliffe, fourth edition, page 1182.)

[2] A resistor connected across a high tension power supply is normally described as a bleeder resistor even when its function is not that of maintaining favourable critical inductance conditions in a choke input filter, as occurs here. Frequently, such resistors are added to high voltage rectifier circuits (both capacitor input and choke input) to ensure that the capacitors following the rectifier discharge quickly after the a.c. supply is switched off, and do not therefore present a shock hazard to people working on the equipment.

[3] See "Understanding Radio" in the June, July and August, 1963, issues, which give a detailed explanation of the operation of iron-cored components.

B.B.C.2 PRE-AMPLIFIER

By J. D. BENSON

Considerable interest was aroused by our contributor's "B.B.C.2 U.H.F. Amplifier", which appeared in our September 1964 issue. The present article describes another TV u.h.f. pre-amplifier, this being based on a British transistor and having a significantly improved performance. Of particular importance is the fact that optimum noise performance is automatically obtained by the normal process of tuning up the aerial circuit

IN THE SEPTEMBER, 1964, ISSUE THE AUTHOR described a B.B.C.2 amplifier using a transistor of foreign origin.[1] The amplifier aroused great interest, but supplies of the transistors recommended have not, apparently, been as readily available as had been hoped. There is, however, a transistor of British manufacture now available at lower cost. This transistor, the AF186, is manufactured by Mullard Limited, who have kindly given the author permission to incorporate data regarding this transistor into an article on the construction of a v.h.f. pre-amplifier. The pre-amplifier has been fully tested at the Mullard Central Applications Laboratory, and gives results superior in some respects to that described in the September issue.

[1] John D. Benson, "B.B.C.2 U.H.F. Amplifier", *The Radio Constructor*, September, 1964.

Strict Adherence To Design

Before proceeding to the constructional details,

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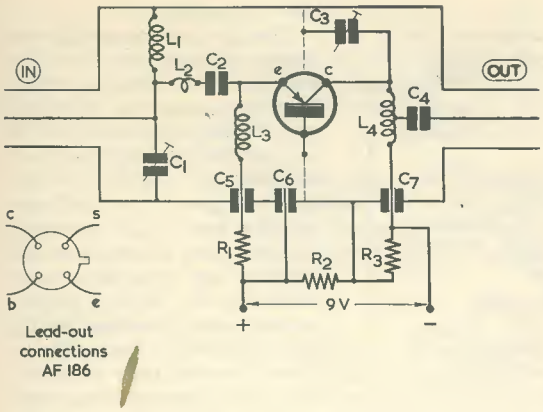
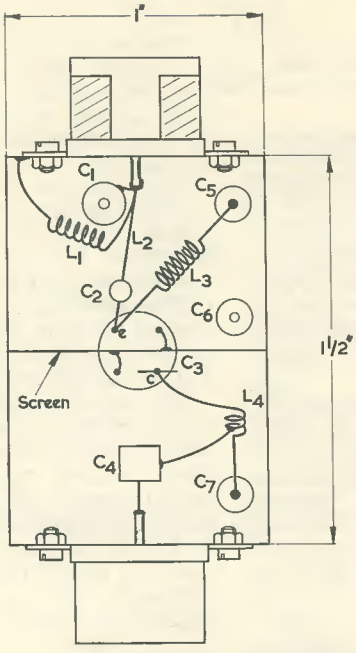


Fig. 1. The circuit of the pre-amplifier when this is mounted near the receiver. Resistors R_1, R_2 and R_3 are mounted outside the chassis. Coil L_2 consists, in practice, of the lead-out wire of C_2

it must be pointed out that, if maximum results are to be obtained, it is imperative that the design be strictly adhered to. There are two important points which must be accurately observed, these being the total length of the lead which forms L_2 and the length of lead between the transistor base and C_6 in the mast-head version. The reason for this is that, at u.h.f., a length of wire exhibits inductive characteristics, and these can introduce instability or otherwise generally impair the performance of the amplifier if the design is not carefully followed.

The amplifier described in this article is designed around a centre frequency of 570 Mc/s, (Channel



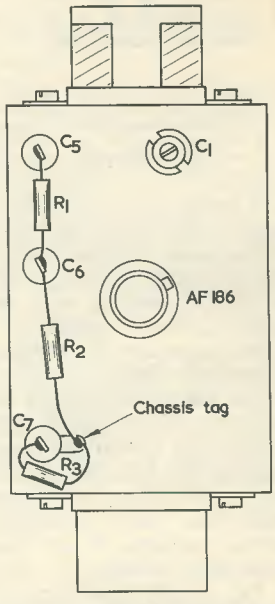
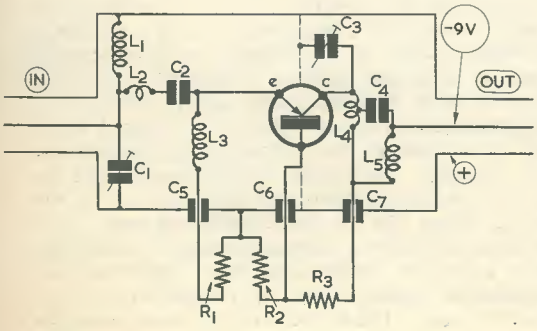


Fig. 3. Underside and top views of the chassis when the circuit of Fig. 1 is employed. Chassis depth is 1in. The chassis must be made of a solderable material in order that both the centre screen and the feed-through capacitors may be soldered to it. When used, the transistor holder is fixed to the chassis surface, the transistor body then being above the chassis. The base and shield of the transistor connect directly to the centre screen



33, as currently used by B.B.C.2, London) and has a bandwidth of 80–100 Mc/s in order to cover the four possible channels in any one area. It is intended to operate from a 75Ω source and into a 75Ω load. For optimum noise matching the transistor should be presented with a 50Ω source resistance, the required impedance transformation being given by the wide-band input circuit, C_1, L_2. (See Fig. 1.) Capacitance C_1 is provided by a concentric trimmer, whilst L_2 consists, in practice, of the lead-out wire from coupling capacitor C_2. This lead-out has a total length of ¾in, and presents the required inductance in its "straight" condition (i.e. not coiled). Adjusting C_1 for maximum

Fig. 2. The mast-head version. With this, the 9 volt supply is applied via the coaxial downlead

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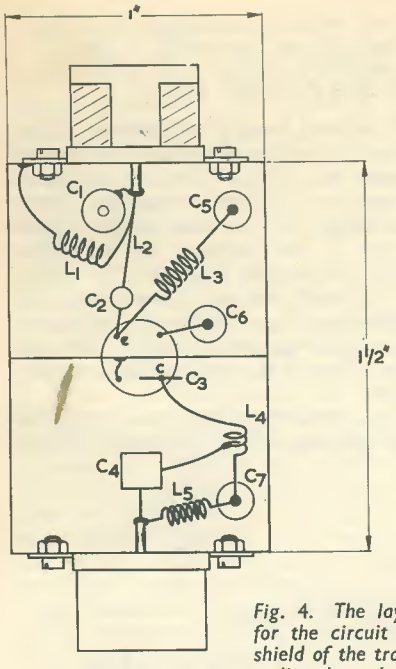

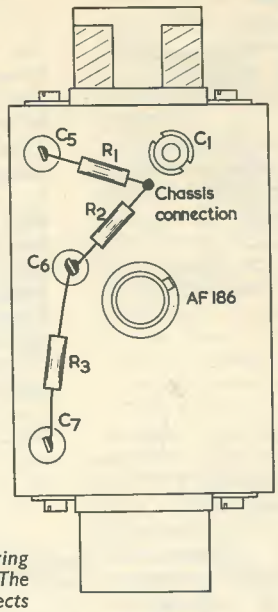

Fig. 4. The layout and wiring for the circuit of Fig. 2. The shield of the transistor connects directly to the centre screen

gain automatically ensures that a close approximation to the required match for optimum noise performance is obtained. The coil L_1 protects the transistor against high voltage surges, such as from lightning, and also bypasses unwanted signals of lower frequency.

The transistor is a Mullard AF186 and, in the prototype (where a number of transistors were tested for performance), a Mullard u.h.f. T018 transistor holder was incorporated for convenience. In the Fig. 1 circuit, which shows the version intended for use near the TV receiver, the base of the transistor connects directly to chassis, with the result that the 9 volt supply is "floating" (i.e. neither terminal is at chassis potential). In the mast-head version, the circuit of which is shown in Fig. 2, the base cannot be at chassis potential because the supply voltage is fed along the coaxial down-lead. The base is, in consequence, bypassed by the low-inductance feed-through capacitor, C_6, and it is most important that the lead from the base to this capacitor be as short as possible, and definitely less than 3mm, to avoid instability. The base lead to chassis in the Fig. 1 circuit must also be as short as possible for the same reason.

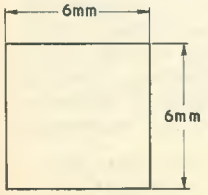

Fig. 5. Capacitor C_3 employs a thin copper sheet of the dimensions shown here. The thickness should be of the order of 26 s.w.g.

The Output Circuit

The output bandwidth is largely determined by the position of the tapping on L_4. Higher gain can be obtained by altering the position of the tap, but at the expense of bandwidth. Details of the coil are given in the Components List. L_4 is tuned by adjusting its length and by varying the capacitance offered by C_3. C_3 is not a conventional trimmer but is provided by a thin copper sheet, 6mm square, which in the prototype was soldered to the collector pin of the transistor holder, variations in capacitance being obtained by bending this closer to, or further away from, the centre screen. Adjusting C_3 has less effect on bandwidth than has varying the length of L_4. The tapping point as designed, allows for a bandwidth of 80–100 Mc/s.

The amplifier is designed to operate from a 9 volt supply, and the current consumption is of the order of 2.5mA.

The power gain and bandwidth taken from a number of tests with different transistors ranged from 11 to 15dB, and the bandwidth from 90 to 110 Mc/s. The average noise figure was 7.1dB.

Two versions may be constructed, one for fitting to an existing installation of the receiver and where access to the aerial is not practical. This circuit, as was mentioned earlier, has a floating battery supply. The other version is for mast-head fitting, the battery power being fed via the aerial feeder. When fitted at the mast-head, the amplifier will give better results as the signal/noise ratio is improved. The amplifier gives a greater overall improvement than can be achieved by increasing the aerial size.

Construction

It will be seen from the dimensions given in the drawings that the chassis on which the amplifier is built is quite small, being only 1 x 1½ x 1in deep. The construction of the chassis will be greatly simplified if all the drilling is carried out whilst the metal is in the flat state. After drilling has been completed, the chassis can be formed on a block of hardwood cut to the inside dimensions of the chassis. The screen should be soldered in, with a good fillet of solder on each side and at the bottom. When the transistor holder is used, there is no danger of damage to the transistor by soldering. Check carefully, when inserting the transistor into such a holder, that the positioning of the leads is correct. The construction is quite straight-

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forward, but particular attention must be paid to ensuring that the lead from C_2 to the transistor emitter is very short and that its other lead, to C_1, is ¾in long. In constructing the mast-head version, great care must be paid to the positioning of C_6, so that the connecting lead to the transistor base is as short as possible.[2]

For outdoor mast-head fitting, the amplifier can be contained in a wooden box fitted with grommets, through which pass the input and output cables. A lid can be screwed on to make the amplifier water-tight.

It is best if the chokes are doped to prevent alterations due to vibration.

Setting up and tuning requires a little patience to obtain the best results. Initially L_4 should be wound with double wire diameter spacing. C_1 should be first adjusted for best results and then further improvement made by adjusting C_3. If adjustment of C_3 is insufficient to tune through signal leak then the coil should be slightly compressed or opened out as required, after which re-tuning is carried out by adjustment of C_3. Finally, C_1 should be adjusted for optimum results, this ensuring that the best noise match is obtained.

The battery panel connector shown in Fig. 6 is used when the amplifier is fitted at the mast-head. An on/off switch could also be fitted to this to eliminate the removal of the power supply when not in use.

Acknowledgements

Grateful acknowledgements are due to Mullard Limited for the information used in this article.

[2] The desirability of introducing as little base inductance as possible into a common-base u.h.f. amplifier is most important. C_6 is a feed-through capacitor, and its skirt should be reliably soldered, all round, to the chassis. It would be preferable to make the base connection to the capacitor spill fairly close to its ceramic sleeve, but care must be taken here not to use undue heat when soldering, as this may have injurious results on the internal solder joint in the capacitor itself.—EDITOR.

EDITOR'S NOTE.—Where applicable in the Components List, components are specified, in brackets, by the make and type number employed in the prototype. Constructors may have difficulty in obtaining some of these particular components through the normal retail channels, but the more experienced should be able to fit alternatives quite successfully.

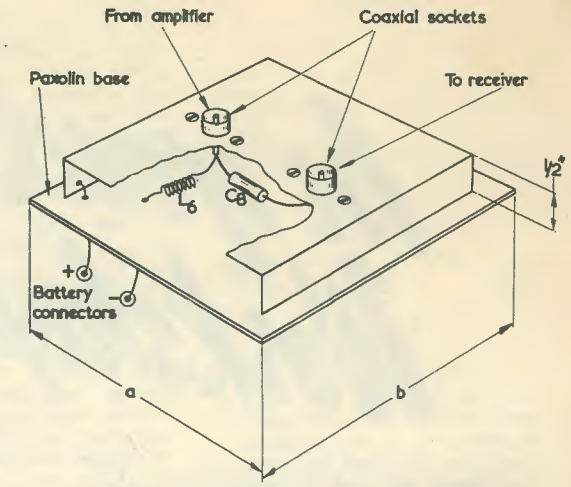

Fig. 6. The socket panel needed at the receiver when the mast-head version of the pre-amplifier is used. Dimensions (a) and (b) may be chosen to suit a PP9 battery

The ceramic trimmer, C_1, is of the concentric type fitted to television tuner units in which the earthy member is an adjustable screw passing down a ceramic tube. The non-earthy member is provided by a conductive sleeve, or silvering, on the outside of the ceramic tube. Soldering (or otherwise mounting) the trimmer to the chassis automatically makes the earth connection to the screw.

C_2 and C_4 are ceramic "bead" capacitors, and it would be preferable to use "bead" components here, if available. Nevertheless, approximately equivalent results should be given by small disc types.

The Erie capacitor type CFT 2500 (C_5, C_6, C_7) is a miniature ceramic feed-through component having a circular skirt for soldering to the chassis. The dimensions of its ceramic body are ⅜in long by 0.194 in maximum diameter. Any small feed-through capacitor could be used here. A proviso, with C_6 in the Fig. 2 version, is that the overall conductor length to the transistor base must be kept short.

The constructor may have considerable difficulty in obtaining a transistor holder suitable for the TO18 lead spacing. In place of such a holder, a small panel of Paxolin, or preferably nylon, sheet can be screwed down over the hole where the holder would mount, and have four holes drilled to the correct TO18 spacing. The transistor wires may then be passed through these holes and soldered into circuit. The transistor should not be mounted without such an anchorage if a holder is not available. Since L_4 is a fairly robust winding, it should be possible to solder the trimmer plate of C_3 at its connection with the transistor lead.

The AF186 transistor may be obtained from Home Radio (Mitcham) Ltd., or any Mullard dealer on special order.

Components List

Resistors

(All resistors 10% ¼ watt)

R_1 1kΩ
R_2 4.7kΩ
R_3 12kΩ

Capacitors

C_1 0.7 to 3.7pF, tubular ceramic trimmer (Philips type C004CA/3E)
C_2 22pF, ceramic Hi-k bead capacitor (Philips type C322BD/P22E)
C_3 See text
C_4 5pF, ceramic Hi-k bead capacitor (Philips type C322BD/M5E)
$C_{5,6,7}$ 1,000pF feed-through (Erie type CFT 2500)
C_8 70pF ceramic. (Required for mast-head version only)

Inductors

L_1 10 turns 30 s.w.g. enamelled copper, 3mm diameter, turns spaced by wire diameter
L_2 Formed by lead on C_2—length ¾in
L_3 As for L_1
L_4 2 turns 22 s.w.g. enamelled copper, 5mm diameter, spacing to be adjusted for tuning (see text), tapped at ½ turn from earthy end (nearest C_7)
$L_{5,6}$ 15 turns 30 s.w.g. enamelled copper, ⅛in diameter, ⅜in long. (Required for mast-head version only)

Transistor

Mullard type AF186

Plugs and Sockets

2 coaxial plugs and sockets (4 for mast-head version)
Transistor holder. See Editor's Note

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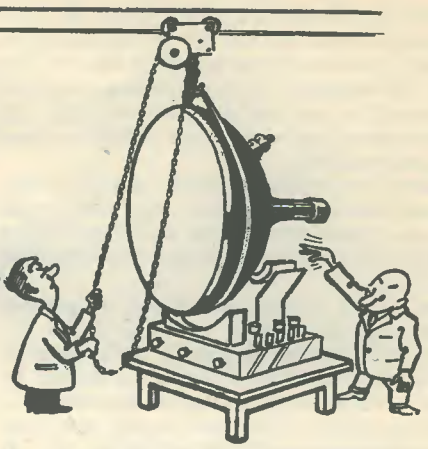
In your Workshop



This month Smithy the Serviceman, aided as always by his able assistant, Dick, takes a look at capacitors, dust cores and CR circuits. We, in turn, take a look at Smithy, to discover a completely unsuspected facet of his personality

"*Now, children, you must never let your angry passions rise.*"

Open-mouthed, Dick placed his cup of tea on the bench and looked incredulously at the preoccupied Smithy.

"*Your little fists were never meant to black each others' eyes!*"

"What on *earth*," enquired Dick, "are you on about?"

The Serviceman blinked, and slowly brought his eyes into focus on his assistant.

"Pardon?" he asked bemusedly. "I was miles away just then."

"I'll say you were," agreed Dick. "You were spouting some verse about angry passions and blacking people's eyes!"

"So I was," replied Smithy, now almost fully restored to his normal self. "Funnily enough, that little jingle has been at the back of my mind for ages, and I've been racking my brains trying to remember exactly how it went. Then, just now, it suddenly came back to me."

"Who," asked Dick idly, "wrote those lines, anyway?"

"They were spoken rather than written," replied Smithy. "Harry Wharton used to say them when he bumped into some of the other boys having a scrap. Or was it Tom Merry?"

Measuring Capacitance

"Don't ask me," replied Dick dispassionately. "I haven't the faintest idea what you're talking about. Besides, now that we've just started our tea-break, I was hoping you could clear up a few odd technical queries I've bumped into recently."

"What, again?" snorted Smithy. "Dash it all, it seems impossible for me to have even a few minutes clear of technical matters these days. What are these queries of yours about, anyway?"

"All sorts of things," replied Dick promptly. "To start off with, how do you measure low value fixed capacitors?"

"With a capacitance bridge," replied Smithy, "or a similar type of instrument."

"I *know* that," said Dick impatiently. "What I mean is, how do you get really accurate measurements without conflicting results due to the way in which the test connections are made? If, for instance, you connect to the capacitor by means of crocodile clips, you're liable to get a higher reading if the clips happen to be close together than if you keep them well apart."

"That's bound to happen," replied Smithy. "So far as general service work is concerned, though, it's quite a simple matter to avoid serious errors. Significant errors in measurement are only liable to occur with fixed capacitors lower than 10pF or so, and the errors start to become really important if the capacitor value is of the order of 2pF. It's normally safe to assume that the capacitance value marked on the component is that given by the *body* of the capacitor on its own, whereupon measurements should be carried out with as little additional capacitance given by the test leads as possible. Or, indeed, by the lead-out wires of the capacitor itself."

"Blimey," remarked Dick, "that's going it a bit, isn't it? Don't tell me that the capacitance between the lead-out wires is liable to mess up your readings."

"It can do," said Smithy. "The self-capacitance between the two lead-out wires of, say, a small tubular ceramic would be of the order of 0.1pF if they were uncut and ran parallel to each other (Fig. 1). That doesn't sound much, I know, but it's still 5% of the value of a 2pF component. If you want reasonably accurate measurements with these very low value capacitors the best thing to do is to splay the leads out before connecting up to the measuring equipment" (Fig. 2).

Dick digested this information, then returned to the attack.

"What happens," he resumed, "at the capacitor factory? Don't tell me that they splay out the leads of every capacitor they check there."

"Oh no," said Smithy. "If the leads of low value capacitors protrude in the same direction they're usually checked at the factory with lead-out wires screened."

"Screened?"

"In a jig," added Smithy helpfully.

"I can see," commented Dick, "that this isn't going to be one of my days. *How* are the lead-outs screened in a jig?"

"In a very simple manner," replied Smithy, reaching over to pick up a note-pad and pencil from his bench, "which I shall now describe to you. I'll sketch out a suitable jig first (Fig. 3 (*a*)). As you can see, all this consists of is a pair of long contact assemblies poking up from a piece

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of insulating material, these being spaced apart such that they comfortably accept the leads of the capacitor which is to be tested (Fig. 3 (*b*)). The capacitance measuring gear then connects to the two contacts."

"I still don't get it," said Dick. "Surely there must be a whacking great capacitance between those contact assemblies on their own!"

"There is," agreed Smithy. "But I haven't finished my explanation yet. You start off by measuring the capacitance offered by the jig with no capacitor inserted. You then pop the capacitor under test into the jig, and measure the new capacitance. The true value of the capacitor is then the *difference* between these two readings."

"Well, I'm blowed," exclaimed Dick, "that *is* a neat approach! With that jig idea, you can't help but find the value of the capacitor minus its lead-outs because these are screened from each other by the jig contacts."

"Exactly," said Smithy. "And I should add that if you ever do any experimenting with very low value capacitors it's not a bad idea to knock up a little jig of this type yourself. It doesn't have to be all that elaborate, and you can easily use narrow diameter brass or copper tubing or something like that instead of the contact assemblies (Fig. 4). You'll get quite adequate contact for measurement purposes if you just pass the capacitor lead-out wires down such tubing."

Dust Cores

"Smithy," said Dick enthusiastically, "you're a genius! I'm going to knock up one of those little measuring jigs as soon as I get the chance."

"Fair enough," said Smithy equably. "More tea please!"

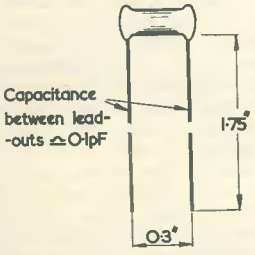

Fig. 1. A typical tubular ceramic capacitor, showing approximate dimensions for the lead-outs when these are uncut and run parallel to each other. The capacitance between the leads on their own may be of the order of 0.1pF

Obediently, Dick rose, picked up Smithy's empty cup, and trod the well-worn path towards the variegated collection of utensils which took pride of place alongside the Workshop sink. As he busied himself with the teapot, a thought occurred to him.

"Who was that chap you were talking about just now?" he asked over his shoulder. "What was his name—Tom Wharton?"

Smithy winced.

"*Harry* Wharton," he protested. "I was talking about Harry Wharton and Tom Merry."

"All right then," persisted Dick. "Who were *they*?"

"They were schoolboys," replied Smithy. "For many years before the war, Harry Wharton appeared in the *Magnet* and Tom Merry in the *Gem*."

"Oh," said Dick doubtfully. "Were these comic papers or something? Like the *Beano*, or *Superman*?"

A look of intense anguish crossed Smithy's face.

"The *Magnet* and the *Gem*," he pronounced, "were properly written magazines which came out once a week. I used to like the *Magnet* myself, but a lot of my friends preferred the *Gem*. You used to get a full-length story in each issue."

"Sounds interesting," commented Dick. "What were the stories about?"

"Well," said Smithy, "they were mainly about life at the boys' schools. Harry Wharton went to a large

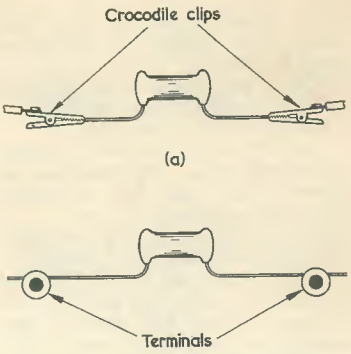

Fig. 2. For reasonably accurate measurements of very low value capacitors it is advisable to splay the leads out as shown here. Where test connections are made to the capacitor by crocodile clips, as in (a), these should not be allowed to approach each other too closely. In (b) the low value capacitor is shown connected to test equipment terminals

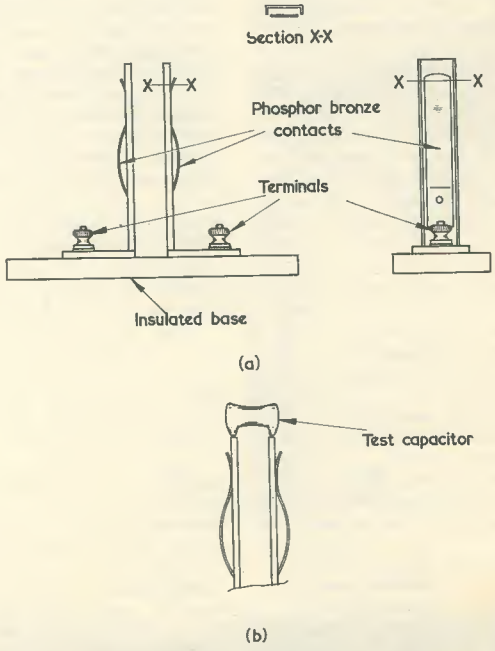

Fig. 3 (a). A testing jig for measuring low value fixed capacitors (b). A capacitor fitted to the jig. The lead-out wires pass down the contact assemblies

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school called Greyfriars, and Tom Merry to a similar sort of school called St. Jim's."

"Oh I see," said Dick brightly. "Sort of comprehensive schools."

Smithy blenched violently.

"Let us," he said weakly, "change the conversation. I've never known anyone like you for trampling memories underfoot."

"I'm sorry," said Dick contritely. "Were those tales really good?"

"They were the best," replied Smithy, a dreamy look coming into his eyes. "There will never be any stories like those again, ever."

Dick passed Smithy his cup of tea and decided that he had better divert the serviceman's mind from its present nostalgic channels.

"I bumped into rather a queer little phenomenon the other day," he remarked at random.

Reluctantly, Smithy dragged his thoughts away from his lost Arcadia of the *Magnet* and returned to the present world of electronics, of television, and of the enquiring visage of his assistant in search of knowledge.

"Oh yes," sighed Smithy, "and what was that?"

"Dust cores," replied Dick. "I found an iron-dust core which didn't seem to have as much permeability as the ones we normally handle."

"That seems reasonable enough," commented Smithy, dismissing his memories for the moment. "What happened?"

"I had a broken core in an internally threaded coil former," said Dick. "So, after I'd taken the pieces out, I fitted another one of the same size which I found in my spares box. And it just wouldn't tune the coil at all! Whilst the previous core brought the coil up to its correct inductance when it was about two-thirds of the way in, the new one couldn't do this even when it was right in the middle of the winding. And yet both cores had identical dimensions, and they both looked exactly the same."

"What probably occurred," said Smithy, "was that the broken core was an ordinary type intended for working at the lower radio frequencies, whilst the replacement core was a v.h.f. type."

"Come again?"

"The replacement core," repeated Smithy patiently, "was intended to work at a higher frequency than the one it replaced."

"I don't get it," commented Dick. "Surely an iron-dust core is an iron-dust core, and that's an end to it!"

"Life," replied Smithy dolefully, "is rarely as simple and clear-cut as that. In practice there are quite a few different grades of iron-dust core material which are used for r.f. coils. As you know, the main function of an iron-dust core in an r.f. coil is to increase its inductance and thereby allow a greater Q to be obtained in a small space. At the same time, however, the dust core introduces losses of its own, these being due to eddy currents. The eddy currents are held at a low level by making up the core with small particles of iron suspended in an insulating plastic binding material, with the result that each particle of iron is insulated from its neighbours and eddy current losses are kept down. Unfortunately, the eddy current losses tend to increase with frequency, whereupon an iron-dust core mixture which is satisfactory for use up to some 30 Mc/s or so may introduce excessive losses if it is used in a coil working at 100 Mc/s. The losses at the higher frequency may only be reduced to acceptable proportions by employing a different core material which incorporates smaller iron particles dispersed more sparsely through the mixture. The result is that the permeability of a dust core extended for high frequency working is less than that of its low frequency brother."

"Well, that's a fine thing, I must say," exclaimed Dick indignantly. "Up till now, I thought that all dust cores were of the same type. Now you tell me that they're made with different types of material!"

"There's no need," protested Smithy mildly, "to get all aereated about it."

"Of course there is," snorted Dick. "What happens if you're fixing a set and you're replacing an iron-dust core?"

"You just," replied Smithy, "put in a new. one"

"But how do you know," continued Dick, "whether the new one is the right type? Dash it all, it's happened to *me*! It was the fact that I put an incorrect core in a coil that started me asking you about dust cores in the first place."

"Your experience," said Smithy soothingly, "was a little exceptional. To start off with, it's only occasionally that dust cores have to be changed during practical servicing work, anyway. Even then, they usually get broken by ham-handed geysers who don't use the proper trimming tools for adjusting them. The next point is that almost all r.f. coils up to 30 Mc/s, and practically all f.m., a.m. and television i.f. transformers, use a standard low frequency grade of dust core. Provided that the dimensions are the same, these dust cores can be considered as being interchangeable. The only places you're normally likely to encounter the lower permeability high frequency cores are in television tuner units and f.m. receiver front ends. However, the cores employed here are quite often of different physical size and shape to those used in the lower frequency coils, and so the risk of muddling up the two is not all that great. It can still happen, of course, as you've found out yourself, but the chances against it are pretty high."

"I see," said Dick, doubtfully. "Well, that seems to clear up *that* little problem."

"Not entirely, I'm afraid," said Smithy, "because some of the adjustable cores fitted to internally threaded coil formers aren't iron dust at all. They're ferrite."

"Oh no," groaned Dick. "I had

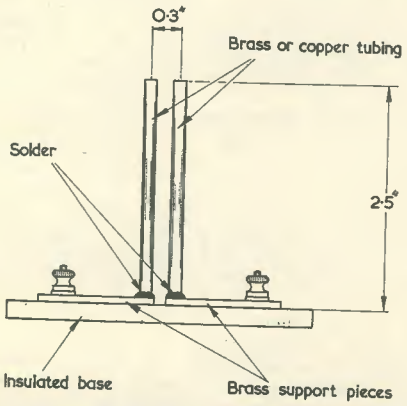

Fig. 4. For occasional experimental work, a simple version of the jig of Fig. 3 may be made up, a suggested example being shown here. The two pieces of tubing may be sweated into holes in the brass support pieces. The lead-out wires of the capacitor under test are passed down the central holes of the tubing

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an idea that your remarks about interchangeability were going to be a bit too good to be true."

"The situation is still," remarked Smithy, "not as bad as all that. What happens occasionally is that a TV i.f. strip may have, in one of its coils, a single ferrite core of the same dimensions as the remaining iron-dust cores. Normally, though, the coil in which the ferrite core is fitted will not be resonant at the intermediate frequency. A typical example would be given by a coil employed in a vision interference limiter circuit; and so you want to watch out for ferrite cores in coils of that nature. You may find, also, that some manufacturers use ferrite cores in their tuned circuits as well, but in this case they usually employ their own particular design of threaded former and the cores are not interchangeable with those from other makes of set."

"Can you", asked Dick, "distinguish a ferrite core from an iron-dust core?"

"Not very reliably," replied Smithy, "if you're just working from appearance. Iron-dust cores are a lightish grey, whilst ferrite cores are a darkish grey. Which is, I would agreee, not a particularly helpful bit of information. Fortunately, their performances differ quite a bit when they are inserted in a coil, since a ferrite core offers a significantly higher permeability than does an iron-dust core. If you accidentally put a ferrite core where an iron-dust core should go, or vice versa, the difference in electrical performance, or in the amount of core insertion needed to achieve resonance, is usually obvious enough to warn you straightaway that you've selected the wrong type of core."

Transistor Multivibrators

"Fair enough," said Dick. "That's something I must remember to look out for. There's another thing that's puzzling me, too."

"About dust cores?"

"Oh no," said Dick. "It's nothing technical. My mind keeps going back to those school stories you mentioned just now. What baffles me is how a bloke like you should have been so interested in stories about schoolboys."

"I read them," replied Smithy, "because at that time I was going to school myself."

Dick's jaw dropped open.

"You went to school?" he gasped, unbelievingly. "As a *schoolboy*?"

"Naturally I went to school as a schoolboy," snapped Smithy. "What on earth do you think I went as?"

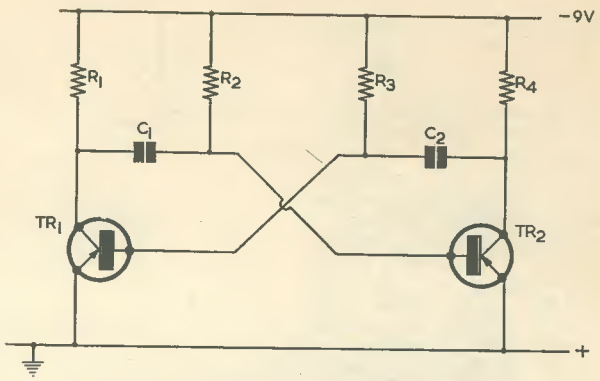

Fig. 5. A standard transistor multivibrator circuit

"In short grey flannel trousers and a school blazer? And with a school cap on top?"

"Of course," replied Smithy testily. "We did *have* schools in those days, you know."

Dick studied the greying Serviceman carefully, then shook his head.

"It's no good," he remarked dispassionately. "I just cannot visualise you as a schoolboy in any way whatsoever. I'm trying to raise up a picture in my mind of your racing about after school, or forming up in the queue outside the Head's study, but it simply will not come. Blimey, Smithy, if you ever *were* a schoolboy, you must have been the weirdest one going!"

"For the love of goodness," shouted the exasperated Smithy, "stop carrying on as though I'm a Peter Pan in reverse. Of course I went to school!"

"All right then," asked Dick. "How many 'O' levels did you get?"

"I didn't get any."

"There you are then," said Dick triumphantly, "that proves it!"

"We didn't have 'O' levels in those days," snarled Smithy furiously. "We had matriculations. The way you carry on anyone would think I entered the world in the form of a doddering old man."

"Now, *that*," commented the unyielding Dick, "I can just about accept. But you as a schoolboy? Never!"

Smithy threw out his hands resignedly.

"I'm starting to wonder," he said hopelessly, "whether I ever *was* a schoolboy myself. Well, will you accept the fact that I used to read those Harry Wharton school stories?"

"Not", replied Dick cautiously, "necessarily."

"Have you ever," queried Smithy despairingly, "heard of Billy Bunter, the Owl of the Remove?"

This time it was Dick's turn to look into the past.

"Billy Bunter?" he repeated. "Yes, I've heard of him. I seem to remember there being some Billy Bunter plays on the telly when *I* was a schoolboy."

"Billy Bunter," said Smithy, "was a character in the Harry Wharton stories I used to read. So also were other boys such as Bob Cherry, Lord Mauleverer and Hurree Jamsett Ram Singh."

"Who?"

"Hurree Jamsett Ram Singh," repeated Smithy. "I think I've got that right!"

The magic of those almost forgotten names was once more drawing the cloak of Greyfriars about the Serviceman. He succumbed, happily.

"Then," he continued dreamily, "there was Herbert Vernon-Smith, the Bounder, who was always caught smoking, and Fisher T. Fish, the show-off American boy with his horn-rimmed glasses. Coker was the Bully of the Fifth, and old Billy Bunter was always waiting for a Postal Order which never arrived."

Smithy chuckled.

"Then there were the masters," he said. "Mr. Quelch was the Master of the Remove—very strict but a decent old bloke really. And there was a pompous old bloke called Prout. Who else was there? Oh yes, Sir Hilton Popper, Joe Banks—he was a rotten type, he was—and the jeweller, Mr. Lazarus. Dear oh dear me, what a rich bunch of characters they were!"

Smithy stopped and glanced at the Workshop clock.

"My goodness," he said, draining his tea cup, "we're well past the end of our tea-break."

"Are we?" asked Dick, startled at the sudden transition from Smithy nostalgic to Smithy authoritative.

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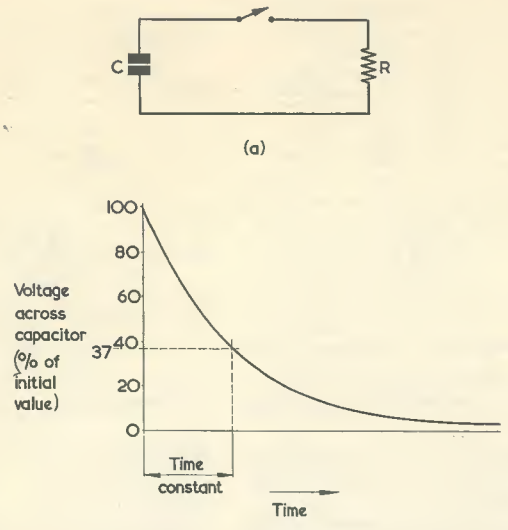

Fig. 6 (a). A charged capacitor connecting to a resistor (b). The voltage discharge curve given by the capacitor of (a)

"Yes we are," replied Smithy briskly. "We should have been at work at least five minutes ago."

"I don't think you're being fair," protested Dick. "I was hoping you'd have a go at another query of mine during the tea-break."

"It's working time now."

"It would," Dick pointed out gently, "still have been tea-break if you hadn't kept on all the time about those school stories of yours."

"Is your question a quick one?"

"A very quick one."

"Fair enough," replied Smithy. "I'll have a bash at it, then."

"It's about these transistor multivibrators," said Dick, reaching over for Smithy's pad and scribbling out a circuit on it. (Fig. 5.) "The circuits are quite straightforward, but what puzzles me is that a number of recent magazine articles have referred to the period when either transistor is conducting as being 0.7 times the CR of the associated capacitor and resistor."

"That's right," agreed Smithy.

"But where", asked Dick, "does the 0.7 come from? I thought that the time constant *was* CR."

"So it is," agreed Smithy. "As it happens, I've heard that this 0.7 CR business is puzzling quite a few other people as well, so it wouldn't be a bad idea to clear it all up now."

Smithy reclaimed possession of his pad and drew a further circuit on it. (Fig. 6 (*a*).)

"Now, here we have," he remarked, "the normal circuit arrangement which we use for demonstrating time constant. We assume that the capacitor has been previously charged so that a potential, which we'll call V, appears across its plates. We then close the switch, whereupon the capacitor discharges into the resistor, giving us the familiar exponential discharge curve. (Fig. 6 (*b*).) The term 'time constant' is the product of the value of the capacitor and the value of the resistor, and it is, theoretically, the time taken to fully discharge the capacitor if the discharge current remains constant at its initial value. This doesn't, of course, occur with the parallel resistor and capacitor circuit because the discharge current reduces as the potential across the capacitor plates goes down. With this circuit, it so happens that, after a period equal to the time constant, the voltage across the capacitor drops to 37% of its initial value."

"I know all that," said Dick, a little impatiently. "But what about the transistor multivib?"

"I'll be coming to that in a minute," said Smithy, scribbling once more on his pad. "Now, if the capacitor was initially discharged, and was then connected to a battery via a resistor (Fig. 7 (*a*)) the voltage across the capacitor increases, following a mirror-image of the discharge curve we've just discussed. (Fig. 7 (*b*). In this case the time constant would correspond to the time taken for the voltage across the capacitor to reach 63% of that across the battery. To complete the picture, I should add that the time constant is in seconds, and that R is in ohms and C in farads. Or, you can have R in megohms and C in microfardas, whereupon you still get time constant in seconds."

"But I *know* all this," repeated Dick. "What about this 0.7 CR business?"

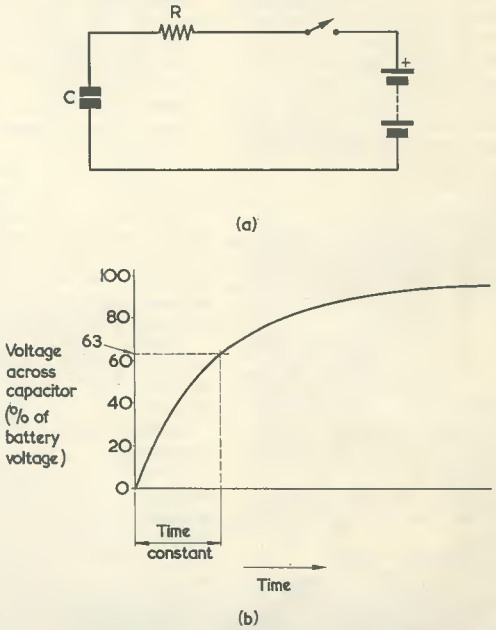

Fig. 7 (a). Connecting a discharged capacitor to a battery via a resistor (b). The voltage across the capacitor as it charges

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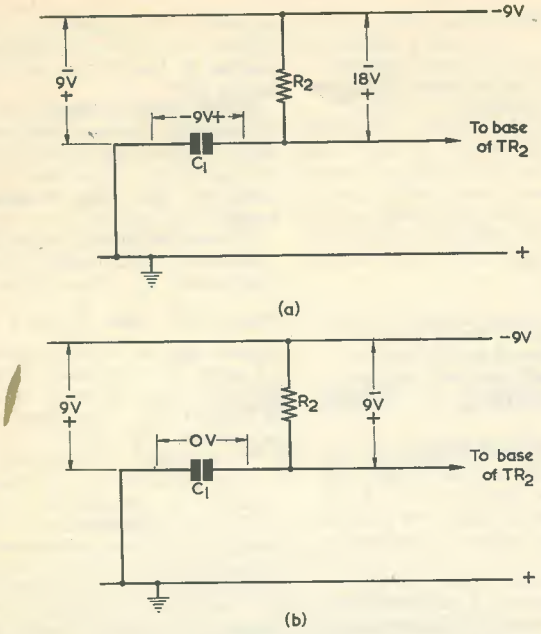

Fig. 8 (a). The circuit conditions existing in Fig. 5 immediately after TR_1 becomes conductive
(b). The potentials in Fig. 5 at the instant where TR_2 starts to conduct

Discharge Curve Law

"There's just one final point," continued Smithy, imperturbably ignoring his assistant's protest. "Returning to the capacitor discharge curve, this follows the law $t = CR \log_e \frac{V}{V_1}$, where V is the initial voltage at the instant of closing the switch and V_1 the voltage across the resistor after time t."

"Your discharge curve", commented Dick suspiciously, "showed the voltage across the capacitor, not the voltage across the resistor."

"It didn't take you long to spot that one!" chuckled Smithy. "I was rather hoping I could pop it in without your noticing it! I said 'resistor' for two reasons. The first is that the voltage across the resistor decays both for the discharge *and* the charge curve, and so you've got a nice ready-made general formula for both occasions. As you'll shortly see, we're more interested at the moment in the discharge curve with the resistor and capacitor in parallel, and where the voltage across the resistor is *obviously* the same as the voltage across the capacitor. The second reason for referring to the voltage across the resistor is that this makes the transistor multivib explanation easier. Incidentally, I don't want to labour that equation too much, because working out logs to the base 'e' is by no means everybody's cup of tea."

"You can say that again," grinned Dick. "It's as much as I can do to work out logs to the base 10!"

"Nevertheless," continued Smithy, "I should just briefly mention for the record that if you check out $t = CR \log_e \frac{V}{V_1}$ for the case where t and CR are equal, you'll find that V_1 is 37% of V. Indeed, 37% is $\frac{1}{e}$."

"I'll take your word for it!"

"Fair enough," replied Smithy. "And now to that multivib."

"Blimey," said Dick. "I thought we'd never get there!"

"In the multivib," continued Smithy, once more brushing aside Dick's comments, "we'll assume that, when a transistor is off, or non-conducting, it represents an open-circuit and that when it is on, or conducting, it represents a short-circuit. All right?"

"You mean an open or short-circuit between emitter and collector?"

"That's right," confirmed Smithy. "We'll assume also that, if a transistor is off, it comes on again as soon as the potential on its base reaches the potential on its emitter."

"I think", said Dick doubtfully, "I see what you mean."

"If you don't," said Smithy cheerfully, "you'll soon get the idea when we start digging into your circuit. Which we shall now commence to do, starting off at a time when TR_2 is on and TR_1 is off. At this time, the left hand plate of C_1 is at the same potential as the −9 volt supply line, whilst the right hand plate is at the same potential as the earth line. Right?"

"Sure," said Dick enthusiastically. "There are no problems there!"

"Good," replied Smithy. "So we now have C_1 charged up to 9 volts, with its left hand plate negative and the right hand plate positive. After

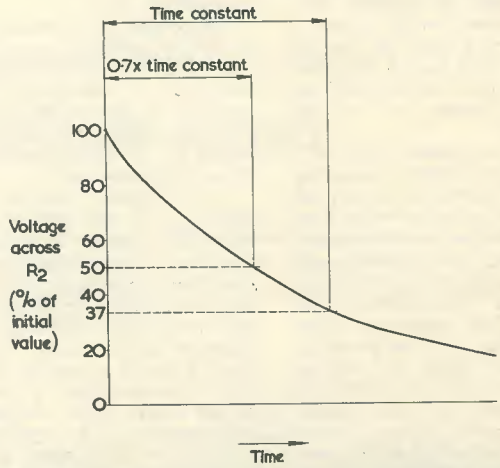

Fig. 9. An expanded view of the left hand side of the discharge curve of Fig. 6 (b), as applied to R_2 in the multivibrator. This demonstrates that the time taken for the initial voltage to drop to 50% is 0.7 times the time constant

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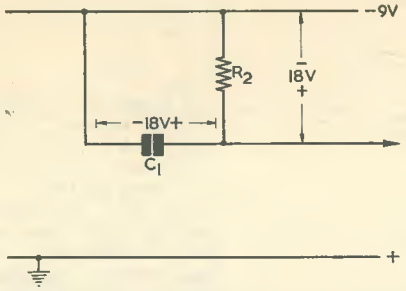

Fig. 10. The discharge voltages appearing across R_2 would similarly occur if the left hand plate of C_1 were connected to the negative supply line, as shown here. The initial voltage of 18 volts across R_2 will drop to 9 volts in the same period as occurs in Figs. 8 (a) and (b)

a time the transistors change over in the regulation multivibrator manner, whereupon TR_2 goes off and TR_1 comes on. Immediately after the changeover we have the case where the left hand plate of C_1 is at earth potential because TR_1 is on."

"Wait a minute, though," interrupted Dick, "isn't C_1 charged?"

"It is," confirmed Smithy. "As we have just noted, it's charged up to 9 volts. The result is that immediately after the changeover its right hand plate goes 9 volts positive of the earth line, causing a grand total of 18 volts to appear across R_2. (Fig. 8 (*a*).) Capacitor C_1 now commences to discharge into R_2 and the voltage across this resistor will follow the discharge curve we saw earlier. At the start of this discharge, the right hand plate of C_1 is positive of the earth line, thereby keeping TR_2 cut off. However, the discharge causes the voltage on the right hand plate to proceed northwards in a negative direction until, after a period, it becomes equal to that on the earth line. (Fig. 8 (*b*).) TR_2 now commences to pass current and the multivibrator changes back to its previous state."

"I see what you meant just now," commented Dick, "about assuming that a cut-off transistor comes on again when the potential on its base reaches the potential on its emitter."

"Good show," said Smithy. "I was certain you'd see what I was driving at once I got down to the explanation. The important thing about the moment of changeover is that this occurs when the voltage across R_2 is 9 volts. We have now, therefore, learned several things. Firstly, the period during which TR_1 is on is controlled by C_1 and R_2. Secondly, the period commences when the voltage across R_2 is 18. And, thirdly, the period stops when the voltage across R_2 is 9. The same reasoning we have used could be applied for any other supply potential, whereupon we may then say that the period during which TR_1 is on is governed by the time needed for the voltage across R_2 to drop to *half* its initial value."

"Blimey," said Dick impressed. "This *is* something. I still don't see, though, where the 0.7 RC business comes in."

"You will," said Smithy, "if you look at the exponential discharge curve we discussed just now. If the curve is accurately drawn and you mark off the time taken to reach 50% or half-voltage (Fig. 9), you'll see that this is just about 0.7 of the time needed to reach the time-constant point. Which means in other words that the associated transistor in the multivibrator is on for a period equal to 0.7 times the time constant."

"Well, I'm dashed," exclaimed Dick. "So it is! That explains everything, then."

He paused for a moment.

"No, it doesn't," he said suddenly. "In your original discharge circuit the capacitor was directly across the resistor. In the multivibrator circuit its left hand plate is at earth potential, which is 9 volts positive of the negative supply rail."

"That doesn't matter," replied Smithy. "At the start of the period when TR_1 is on, C_1 is charged to 9 volts, but you'd have had exactly the same discharge curve if it had been initially charged to 18 volts with its left-hand plate connected to the negative supply line. (Fig. 10.) Such a circuit is exactly the same as the original discharge circuit we talked about. Don't forget that the performance of a capacitor, when charging or discharging, is governed by its *capacitance*, and is not altered by having fixed d.c. voltages in the circuit. This point is brought out very clearly in any practical example you can think of. A 1,000pF bypass capacitor always acts as a 1,000pF bypass capacitor regardless of whether it has 2 volts or 200 volts across it!"

"I see your point," said Dick. "Now that you've shown me how the 0.7 CR figure is obtained from the discharge curve, why did you bring in that $\log_e$ formula just now?"

"I brought it in," said Smithy, "so that I could finally tidy everything neatly up. The equation states that $t = CR \log_e \frac{V}{V_1}$, and in the present case we want to know what t is when V_1 is half of V. This gives us $t = CR \log_e 2$, which works out to $t = 0.69$ CR. And that, as near as dammit, is 0.7 CR."

"You seem", commented Dick, "to be treating this 0.7 figure as though it's a wee bit approximate."

"It *is* approximate," replied Smithy. "And that's because of the assumptions we made when we started examining the multivibrator. In practice, a transistor is not a short-circuit when it's on, since a small voltage appears across it. Also, there can be a small leakage current which prevents it being a true open-circuit when it's off. Again, our assumption that a transistor would start to pass current when its base potential became equivalent to emitter potential wasn't *entirely* accurate. Since we introduced approximations at the beginning, our final result must similarly be approximate."

Session Over

With these words, Smithy placed his notepad on his bench, rose from his stool and resolutely switched on his soldering iron. It was obvious that the session was over.

"Haven't you", enquired Dick, who, having become comfortably settled, didn't feel in the mood to return to work immediately, "anything further to say about this CR business?"

"Nothing at all," said Smithy firmly. "And it's now quite definitely time to get back to our labours."

"Nor even", persevered Dick, "anything about those Greyfriars stories?"

"You won't catch me out on that one," replied Smithy, picking up his soldering iron. "I leave my reminiscing for break periods only!"

"I was digging around in the attic at home the other day," offered Dick desperately. "And I found quite a pile of issues of an old magazine. The *Union Jack*, I think it was called."

Smithy's soldering iron became motionless in mid-air.

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"Are you telling me", asked Smithy with a tremor in his voice, "that you have a collection of *Union Jacks*?"

"That's right," replied Dick, delighted at the result of his news. "There must have been about fifty or sixty of them."

"I can see myself", said Smithy, "calling on you in the very near future! Do you know, Dick, the old *Union Jack* ceased publication way back in 1933, and I haven't seen one for donkey's years now."

"Is there", asked Dick innocently, "anything special about it?"

"Special?" queried Smithy. "Special? Don't you realise, boy, that it was the *Union Jack* which first introduced Sexton Blake and Tinker to me. Now, those *were* detective stories. Apart from Blake and Tinker there were the Robin Hood League and the Onion Men, not to mention George Marsden Plummer and Mrs. Bardell, his landlady. Now, who else was there? Oh yes, Pedro the bloodhound, and . . ."

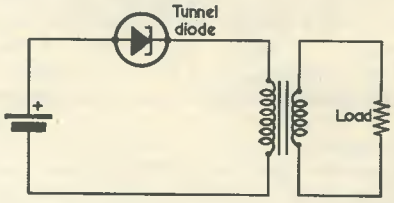
Smithy sat down on his stool again, absent-mindedly returning his soldering iron to its rest. Quietly, Dick got up and wandered over towards the sink. So far as he could see, it would be perfectly safe to put the kettle on for at least another pot of tea.

220 AMP TUNNEL DIODES

by J. B. DANCE, M.Sc.

THE TUNNEL DIODE IS NORMALLY THOUGHT OF AS a device which operates at a current of about 1 to 50mA (see "The Tunnel Diode in Theory and Experiment", *The Radio Constructor*, November and December 1960 and January 1961). Tunnel diodes are now available which have peak current values as high as 220 amps.[1] Whilst these diodes are mainly employed as low voltage inverters,[2] they are also used as overload detectors, as oscillators, and as high speed current switches. The diodes are similar to conventional tunnel diodes, but have a larger junction area and must be mounted on heatsinks.

A simple type of relaxation oscillator which can be used for converting a low voltage into a higher voltage is shown in the accompanying diagram. Such circuits can operate from power sources such as fuel cells, solar cells or thermionic converters at input voltages below those required by transistors. Efficiencies of the order of 50% can be obtained when a push-pull tunnel diode circuit is used.



[1] R.C.A. Technical Manual TD-30.
[2] F. M. Carlson and P. D. Gardner: I.R.E. Electron Devices Conference.

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.

P104 (1392) 62H Receiver.—K. E. LeMasurier, "Aqir", Feugre, Cobo, Guernsey, manual or any other data.

* * *

460 kc/s Variable I.F. Filter.—K. Snell, 9 Armitage Gardens, Allerton, Liverpool, 18, requires a circuit using two i.f. transformers. Also loan or purchase of *Practical Wireless* October 1954 to March 1955.

Canadian Receiver No. 9 MKI.—T. Lonergan, 33 Burnham Gardens, Cranford, Middlesex, circuit diagram or any other information.

* * *

No. 1986 Transmitter.—M. O'Brien, 5 Butts Walk, The Reddings, Cheltenham, Glos., information on using the i.f. strip for f.m. operation.

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NOVEL SIGNAL TRACER

By I. M. WILSON

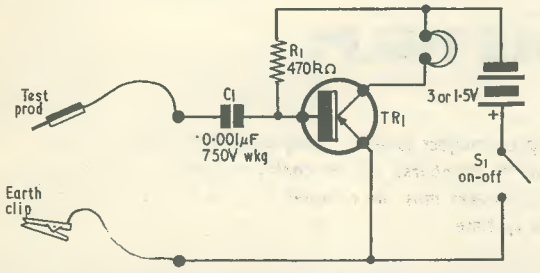
A simple testing device for servicing valve and transistor radio receivers

SOME TIME AGO, THE AUTHOR REQUIRED A SIGNAL tracer in order to repair an old superhet radio. It was decided to construct the instrument described in this article, and it has since been used for a number of further applications of the same type. The instrument has the advantages of low cost, small size and simplicity of construction.

Design Approach

Whilst most signal tracers employ a diode detector followed by an a.f. amplifier, this course was not adopted in the present case since it was decided to aim for maximum simplicity. In consequence, the circuit shown in the accompanying diagram was used. Despite its very few components, the circuit offers a number of facilities which may not at first sight be obvious.

In use, the earth clip of the device is connected to the chassis of the receiver under test, the prod being applied to the various stages in the receiver. The transistor base-emitter junction functions as a diode when r.f. is applied to the test prod, whereupon an amplified version of the detected a.f. is available at the collector. If the prod is applied to an a.f. point, the transistor functions as an a.f. amplifier.



The value of series capacitor C_1 has an important bearing on circuit operation. This is a 0.001μF component, and it has a relatively low reactance at aerial and intermediate frequencies, and a relatively high reactance at audio frequencies. Thus, as testing proceeds from the r.f. and i.f. stages of a receiver to the a.f. stages, the signal level applied to the transistor base automatically reduces. If this were not the case, high level a.f. signals could overload the transistor and cause an excessively high output in the phones.

As the test prod may be applied to high voltage points in mains-operated receivers, capacitor C_1 should, preferably, have a working voltage of 750.

Components

In the prototype, the transistor employed was a GT11. This is, however, an obsolete type, and an OC71 could be employed in its place. Whatever transistor is employed should offer a low noise level, and it may be found that surplus transistors of the "red spot" variety are unsuitable because of this.

The function of resistor R_1 is to provide forward bias for the transistor base, and it has a value of 470kΩ. It may be found that better performance with low-level r.f. signals is given by alternative values for R_1, and this point could be made the subject of experiment, if desired. The final value should, in this case, lie between some 100kΩ and 1MΩ.

The phones should offer an impedance of 1 to 10kΩ. A pair of series-connected headphones with a resistance of 2kΩ each would be satisfactory. If low impedance phones are used, a step-down transformer of the appropriate ratio will be necessary.

The battery may offer a voltage of 1.5 or 3, as desired.

Operation

The instrument is employed for signal tracing in the normal manner, working from the aerial to the loudspeaker.

The tracer may also be used to find faults in circuits other than those at which signal voltages appear. If, for instance, the prod is applied to the heater pins of mains-operated valves, the presence of alternating voltage is indicated by a low-pitched low-volume buzz. Oscillator circuits usually produce a loud hiss. If signal is heard when the prod is applied to an a.g.c. line, a.g.c. decoupling is probably faulty. The same applies if a signal is heard with the prod on an h.t. line.

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Cover Feature

The "Athenian" 4-Band Superhet Receiver

Part 1 — A Design for the Beginner, 16—2,000 Metres

By **James S. Kent**

This receiver has been designed, and this series of articles specifically written, for the beginner to superhet construction. The coverage is long wave, medium wave and two short wave bands, and a special feature of the design is that one valve is used both as an i.f. amplifier and b.f.o. stage

SOONER OR LATER, THE BEGINNER WHO HAS constructed one or more "straight" or t.r.f. mains-operated designs will find that such receivers have their limitations, whereupon the wish to continue the hobby further by building a superhet becomes one of natural evolution. It should be pointed out here, however, that the design about to be described is not for the *absolute* beginner and that some previous experience in more simple receiver construction should be obtained before embarking on the project dealt with in this series.

The design offered here is that of a semi-communications type receiver covering the long, medium and two short wave bands and incorporating four valves and one diode. The receiver is mains-operated and an experimental part of the circuit is that one valve performs the functions of both an i.f. amplifier and a b.f.o. stage.

All the components specified are currently obtainable and are of the best quality. The use of surplus parts, or components long stored in the spares box, is not recommended with this design if maximum results are to be achieved.

The specified coverage of the coilpack, when used with a 500pF two-gang variable capacitor, is from 16 to 2,000 metres but this will be slightly altered somewhat by the inclusion of the bandspread capacitors. The ranges are: long wave, 800 to 2,000 metres (375 to 150 kc/s); medium wave, 194 to 550 metres (1.546 to 545 kc/s); short wave 1, 50 to 160 metres (6 to 1.85 Mc/s); and short wave 2, 16 to 50 metres (18.75 to 6 Mc/s). The ranges actually obtained will be slightly lower in frequency than those quoted, due mainly to an additional 27pF bandspread circuit and its stray capacitance. This loss (whose practical effect occurs at the 18.75 Mc/s end) is not, however, of any great consequence for, at frequencies around this figure, a converter becomes more attractive for optimum performance.

A power supply socket is fitted at the rear of the chassis in order to provide supplies for such a converter (if required at a later date) or for other ancillary apparatus, some 26mA of current at a voltage of 280 being available. It should be added that bandspread tuning, with its ease of station selection, confers a great advantage on a design of this nature.

Before discussing the circuit in greater detail, some other features of the design will be dealt with here.

In the aerial input circuit, an i.f. filter unit (see Components List) has been inserted in order to eliminate i.f. breakthrough (i.e. the reception of signals on the intermediate frequency of 465 kc/s, with consequent whistling noises on each station received). The filter consists of a parallel tuned rejector circuit having a fixed capacitor and a variable iron-dust core for tuning purposes. As received, the filter unit is correctly adjusted to the 465 kc/s intermediate frequency. When the aerial is fed direct to this unit (i.e. not via a pre-selector or converter) a little insertion loss may be apparent at some frequencies. Some constructors may, therefore, prefer to either (*a*) omit the filter unit or (*b*) arrange a switch on the rear of the chassis which effectively bridges it when not required.

A further filter unit is given by L_6, this being inserted in the a.c. input to the mains transformer primary winding. The inclusion of this unit is well worthwhile, as it effectively protects the receiver from the mains-borne "hash" and interference which is so common in these days of a multiplicity of surrounding unsuppressed electrical gadgets.

The total power consumption of the receiver, under no-signal conditions (aerial disconnected and the function switch set at a.m.) is 47mA at 280 volts, this being measured at the smoothing capacitor C_{28}. Both this and all subsequent voltage

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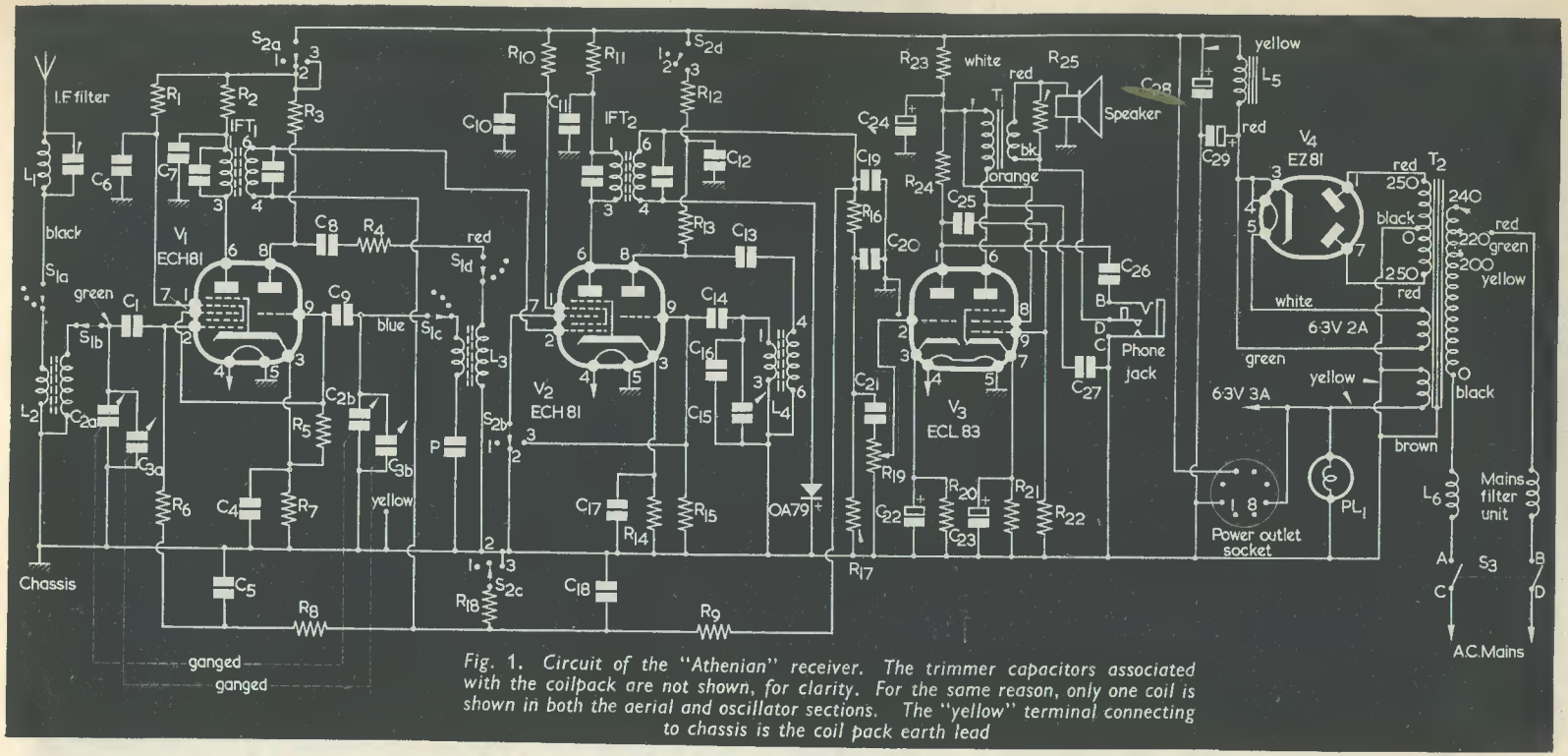

Fig. 1. Circuit of the "Athenian" receiver. The trimmer capacitors associated with the coilpack are not shown, for clarity. For the same reason, only one coil is shown in both the aerial and oscillator sections. The "yellow" terminal connecting to chassis is the coil pack earth lead

Components List

Resistors

(All ½ watt 10% unless otherwise stated)

R_1	33kΩ
R_2	10kΩ
R_3	33kΩ
R_4	150Ω
R_5	47kΩ
R_6	1MΩ
R_7	220Ω
R_8	220kΩ
R_9	2.2MΩ
R_{10}	100kΩ
R_{11}	10kΩ
R_{12}	150kΩ
R_{13}	22kΩ
R_{14}	220Ω
R_{15}	47kΩ
R_{16}	22kΩ
R_{17}	270kΩ
R_{18}	100Ω
R_{19}	1MΩ pot. log track (with S_3)
R_{20}	1.8kΩ
R_{21}	470Ω
R_{22}	220kΩ
R_{23}	1.5kΩ 5 watt
R_{24}	100kΩ
R_{25}	10Ω

Capacitors

C_1	100pF silver mica
$C_{2a, b}$	500pF variable, two-gang (type ME, Jackson Bros. Ltd.)
$C_{3a, b}$	27pF variable, two-gang (type U102, Jackson Bros. Ltd.)
C_4	0.01μF tubular (Mullard)
C_5	0.01μF tubular (Mullard)
C_6	0.1μF tubular (Mullard)
C_7	0.1μF tubular (Mullard)
C_8	200pF silver mica
C_9	50pF silver mica
C_{10}	0.1μF tubular (Mullard)
C_{11}	0.1μF tubular (Mullard)

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and current measurements were taken with a 20,000Ω per volt meter. The total rated output of the power supply is 75mA. On c.w., however, the total consumption of the receiver is 49mA, this leaving 26mA available at the power outlet socket.[1]

Complete voltage and current tables will be published in Part 3 of this short series. Part 2 (to be published next month) will include full constructional details including point-to-point wiring diagrams of each stage.

[1] Constructors are advised to limit the external current requirements to around 20–25mA in order not to overrun the rated output of the mains transformer. For guidance, a single valve pre-selector (EF92)—see page 48 August 1964 issue—will require some 10.5mA; a single valve (EF183) pre-selector would require some 16.5mA —see page 752, May 1963 issue (omitting the cathode follower). A two-valve converter (ECH42/EF41) would consume approximately 14mA

C_{12} 0.1μF tubular (Mullard)
C_{13} 50pF silver mica
C_{14} 100pF silver mica
C_{15} 25pF variable (type C804 Jackson Bros. Ltd.)
C_{16} 140pF silver mica
C_{17} 0.01μF tubular (Mullard)
C_{18} 0.01μF tubular (Mullard)
C_{19} 100pF silver mica
C_{20} 100pF silver mica
C_{21} 0.01μF tubular (Mullard)
C_{22} 10μF electrolytic, 12V wkg.
C_{23} 25μF electrolytic, 25V wkg.
C_{24} 8μF electrolytic, 350V wkg.
C_{25} 0.01μF tubular (Mullard)
*C_{26} 0.1μF tubular (Mullard)
C_{27} 0.01μF tubular (Mullard)
†C_{28} 32μF electrolytic, 450V wkg.
†C_{29} 16μF electrolytic, 450V wkg.

* See Text.
† Contained in single can, complete with clip.

Valves
V_1 ECH81 (Mullard)
V_2 ECH81 (Mullard)
V_3 ECL83 (Mullard)
V_4 EZ81 (Mullard)

Diode
OA79 (Mullard)

Valveholders
4 B9A with centre spigots (2 with skirt and screening can)
1 International Octal

Inductors
IFT_1 465 kc/s (Denco type IFT11/465)
IFT_2 465 kc/s (Denco type IFT11/465)
L_1 I.F. Filter (Denco type IFF1)
L_2 L_3 Coilpack type CP3F (Denco)
L_4 465 kc/s (Denco type BFO 2/465)
L_6 Mains filter, type MFU1 (Denco)

Transformers
T_1 Type 117E (H. L. Smith & Co. Ltd.)
T_2 Pri: 0–200–220–240V; Secs: 250–0–250V, 75mA; 6.3V (centre-tapped) 3A; 0–5–6.3V, 2A. Type 3104A (H. L. Smith & Co. Ltd.)

Switches
S_1(a), (b), (c), (d) Integral with coilpack
S_2(a), (b), (c), (d) 4-pole, 3-way
S_3 Integral with R_{19}

Speaker
3Ω impedance

LF Choke
10H, 120mA, 200Ω, type M101 (H. L. Smith & Co. Ltd.)

Phone Jack and Plug
Igranic

PL_1 and Assembly
6.3V, 0.3A (red) (H. L. Smith & Co. Ltd.)

Chassis and Panel, etc.
(H. L. Smith & Co. Ltd.)

Dials
2 Scale Ball Drive, type 4489 (Jackson Bros. Ltd.)

Knobs
4 (H. L. Smith & Co. Ltd.)

Tagstrips
*9-way
*4-way

Aerial Socket
1 Coaxial socket

Miscellaneous
4 ¼in grommets
6 ⅜-in grommets

* The 9-way tagstrip is of the type that has tags 2 and 8 fixing to the chassis. The 4-way strip should have tag 3 fixing to the chassis. Should these types not be available locally, a "chain" of tagstrips may be obtained and the unwanted earth tags removed with tinsnips.

Circuit

The circuit is shown in Fig. 1, from which it will be seen that it consists of an ECH81 frequency changer, ECH81 i.f. amplifier and b.f.o., OA79 detector, ECL83 audio amplifier and power output and EZ81 full-wave rectifier.

The circuit diagram has been reproduced here in "reversed" form, i.e. black as white, and this has been done so that the constructor may fill in the various connections with a ball-point pen as each is made. In this manner, the beginner (to superhet construction) may then relate the instructions in the text, and the point-to-point diagrams, to actual circuit wiring.

A large part of the circuit conforms to standard practice but that relating to V_2 most certainly does

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not. This was undertaken by the writer as an experimental project in order (*a*) to save the cost of a further valve in a b.f.o. (beat frequency oscillator) stage and (*b*) to try and make the resolving of s.s.b. (single-sideband) signals a much easier matter than occurs when the more conventional separate b.f.o. stage is employed.

The lead colours shown around V_1 refer to the coilpack connections.

Switch $S_{1(a)}$, (b), (c), (d) is that fitted in the coilpack. Only one coil is shown in the aerial and oscillator positions for reasons of clarity, although there are, in fact, four coils in each position.

The signal arriving from the i.f. filter unit is fed, via $S_{1(a)}$, into the selected primary winding of L_2 and then coupled into its secondary winding. The secondary winding is tuned by the bandset and parallel bandspread capacitor ($C_{2(a)}$, $C_{3(a)}$), the selected signal being passed to the grid of V_1 via the a.g.c. blocking capacitor C_1. An automatic gain control voltage is fed to this stage via the resistor R_6 from the a.g.c. line. Positive potential is supplied to grids 2 and 4 (pin 1) via resistor R_1, the grids being bypassed to chassis via C_6. The anode of the heptode (pin 6) receives h.t. via the decoupling resistor R_2 and the primary winding of IFT_1, C_7 being the bypass component to chassis. Grid 3 (pin 7) of the heptode is connected, externally, direct to the triode grid (pin 9).

The triode anode (pin 8) is connected to the h.t. positive line via the resistor R_3, and to the oscillator coil secondary via C_8, R_4 and switch $S_{1(d)}$. The function of switch $S_{2(a)}$ will be described when dealing with the next stage. The triode grid receives leaky-grid bias via R_5, this component being connected between the grid and the cathode (pin 3). Cathode bias is supplied by the components C_4, R_7. The triode grid is tuned by the combination $C_{2(b)}$ and $C_{3(b)}$, these being the bandset and bandspread capacitors respectively, and the padder capacitor P; the grid being coupled to these via the capacitor C_9. Padder capacitor P is fitted in the coil-pack. The inclusion of resistor R_4 in the triode anode circuit ensures that conversion takes place without "squegging" over the entire coverage.

The resulting i.f. signal is now passed to grid 1 (pin 2) of V_2 via IFT_1. A.G.C. is supplied to V_2 via the secondary winding of IFT_1.

The V_2 circuit incorporates (as does V_1) an ECH81 triode-heptode frequency changer, and the circuit finally derived allows this to be employed (*a*) for a.m. (amplitude modulation or telephony) reception as an i.f. stage, and (*b*) for c.w. (continuous wave or morse) reception as a triode oscillator and i.f. stage. To further explain this, we must now look into the function of the 4-pole, 3-way switch $S_{2(a)}$, (b), (c), (d).

This switch is the function control and its positions offer the following circuit conditions: (1) standby; (2) a.m. on/a.g.c. on/b.f.o. off; (3) a.m. off/a.g.c. off/b.f.o. on.

In position 1, $S_{2(a)}$ switches off the h.t. supply to V_1, whilst $S_{2(b)}$, (c), (d) are, in effect, inoperative. In this position therefore the receiver is muted whilst the heaters of all valves are kept in operation and the h.t. potential is retained on the other stages, except, of course, the b.f.o. triode anode. This is the standby position.[2]

In position 2, $S_{2(a)}$ switches on the h.t. to V_1, causing it to become operative; $S_{2(b)}$ connects grid 3 of V_2 heptode (pin 7) to chassis thereby causing this portion of the valve to operate as a straightforward i.f. amplifier; $S_{2(c)}$ remains inoperative, allowing an a.g.c. voltage to be passed to V_1 and V_2; $S_{2(d)}$ remains inoperative. This is the a.m. position.

In position 3, $S_{2(a)}$ still applies h.t. to the circuit of V_1; $S_{2(b)}$ connects grid 3 of V_2 heptode to the grid of V_2 triode, thereby allowing the injection of a b.f.o. voltage; $S_{2(c)}$ switches off the a.g.c. by short-circuiting the a.g.c. line to chassis; and $S_{2(d)}$ switches on the h.t. supply to V_2 triode anode. This is the c.w. position. The resistor R_{18} is included in the circuit of switch section $S_{2(c)}$ in order to prevent switch wear due to sparking when C_{18} is short-circuited.

With switch $S_{2(a)}$, (b), (c), (d) set to a.m. (position 2), the first section of V_2 acts as an i.f. amplifier, bias being supplied by the cathode components C_{17}, R_{14}. Grids 2 and 4 (pin 1) are supplied with h.t. potential via the resistor R_{10}, and are bypassed to chassis by the capacitor C_{10}.

Resistor R_{10} is of some importance in this particular circuit, and its value should be that specified. When originally developing the circuit, the standard value (for a frequency changer of this type) of 22kΩ was inserted in the first instance. Subsequent measurements, however, revealed that, on a.m., V_2 heptode anode current was 8.9mA and that grids 2 and 4 consumed 6mA; whilst on c.w. the triode anode drew 4.6mA whilst the heptode anode drew 7.4mA. Apart from the amount quoted for the triode anode, these figures were disastrous!

In order to obtain stability, both as an i.f. amplifier and, more important still, as a b.f.o., the writer found that it was a better proposition to run the valve somewhat below its rated current consumption by increasing the value of R_{10}. The slight loss in gain is completely offset by the stability and docility of the circuit shown. The currents drawn with this circuit in the prototype are as follows: grids 2 and 4, 1.8mA; heptode anode (pin 6), 3.4mA on a.m. On c.w., the currents are heptode anode 2mA, and triode anode 4.6mA. It will be seen therefore that the value quoted for R_{10} in the Components List is of some importance.[3]

[2] The receiver should not be left switched at this position for very long lengths of time, as a condition known as cathode poisoning may occur with respect to the valves which are operated without an h.t. supply.

[3] It should be stressed here that the circuit of V_2 is experimental and, if the b.f.o. section is not required, then the ECH81 will be found to perform adequately as a straightforward i.f. amplifier. The writer has lowered the value of R_{10} from 100kΩ to 68kΩ and, while this provides greater gain whilst switched to the a.m. position, c.w. operation becomes unsatisfactory in that the oscillations tend to "block" the i.f. amplifier portion of the valve. For those who wish to experiment further, an effective reduction in the value of R_{10} for a.m. could be given by connecting an additional resistor between contact 2 of S_2 (*d*) and the junction of R_{10} and C_{10}. When S_2 is set to the a.m. position, this will result in the h.t. supply resistor for grids 2 and 4 consisting of R_{10} and the additional resistor in parallel.

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When operating in the a.m. position, the resultant amplified i.f. signal is fed, via the secondary winding of IFT_2, to the diode detector and the r.f. filter R_{16}, C_{19}, C_{20}, where any residual i.f. is bypassed to chassis. The resistor R_{17} is the diode load, whilst the a.g.c. line is decoupled by R_8, R_9, C_5 and C_{18}. The detected a.f. signal is passed to the volume control R_{19} via coupling capacitor C_{21}.

The ECL83 triode pentode serves firstly as an audio amplifier (triode section) and secondly as a power output stage (pentode section). Cathode bias for the triode portion is supplied by way of the components C_{22}, R_{20} and, for the pentode section, by C_{23}, R_{21}. Resistor R_{23} and capacitor C_{24} decouple the whole of this stage from the h.t. line. The output to the headphone jack is taken from the anode of the triode via C_{26} and this component must be rated at 350V at least. Insertion of the phones into the headphone jack automatically mutes the speaker. It is preferable to take the phone output from the triode rather than the following pentode section as the latter may offer excessively large bursts of audio.

The amplified audio signals from the triode is passed, via C_{25}, to the grid (pin 9) of the power output pentode section of the valve, R_{22} being the grid leak. The capacitor C_{27} is inserted between the pentode anode and chassis to provide tone correction. Resistor R_{25} is connected across the speaker transformer secondary winding to prevent high a.f. voltages appearing across the primary when the speaker is disconnected by the phone jack contacts.

The power supply section employs an EZ81 full-wave rectifier with a choke/capacitor filter. L_5 is the l.f. choke and the power supply provides an adequate supply to the receiver which is fully smoothed and ripple-free. On-off switch S_3 is an integral part of the volume control R_{19}. PL_1 is the red indicator light mounted on the front panel.

For those intending constructors who do not read c.w. signals, and have no wish to do so, the circuit could still be built as shown with the exception that the triode portion of V_2 would be left disconnected, i.e. the circuits associated with the triode anode and grid would not be required. In this manner, two of the valves (V_1 and V_2) would remain the same type, this being useful in that they are interchangeable should the need arise. Alternatively, of course, one might complete the receiver, less the b.f.o. stage, and add this at a later date whenever desired.

The receiver performs extremely well over the entire coverage and, as may be seen from the front cover illustration, has a pleasing appearance. The inclusion of a coilpack and pre-aligned i.f. transformers greatly assist in making the project a comparably easy matter to complete.

For those who already have a receiver, whether home-built or commercial, this receiver would serve admirably as a standby set to the main equipment.

Looking again at the front cover illustration, it will be seen that the controls are laid out in such a manner that ease of operation has been taken into account commensurate with "eye appeal". The controls are, bottom left to right, bandswitch, b.f.o. pitch, function control, audio gain/on/off and phones. The left hand dial is that of the bandset and the right hand dial that of the bandspread capacitors. Top right is the on/off indicator bulb whilst to the top left is the Athenian "medallion". This latter embellishment may be obtained by paying a visit to the local Woolworth store and inspecting the button counter where this, and many similar types, may be obtained for the sum of 1s. 3d!

Next month, in Part 2, the constructional details will be fully dealt with and this Part will also include individual point-to-point drawings for each stage, etc. Meanwhile, the intending constructor is urged to obtain the components listed herewith which, if the series is to be of any benefit to the beginner to superhet construction, must be those specified and not any other types or surplus components.

(To be continued)

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The New Dual-Standard TV Sets

PART 12

Gordon J. King
Assoc. Brit. I.R.E., M.T.S., M.I.P.R.E.

This article, the last but one in our present series on 405–625 line receivers, discusses power supply arrangements, then carries on to deal with circuits employing the new PFL200 Decal valve

TO DATE WE HAVE CONSIDERED the principal sections of the new dual-standard sets with the exception of the power supply circuits. It is proposed in this article to deal with those and thus conclude our discussion of a typical receiver. However, since this series was commenced some twelve months ago there have been several new developments with the emphasis on dual-standard models. These include the use of 10-pin valves, hybrid transistor/valve models and transistorised u.h.f. tuners. Thus, the final part of this article and the whole of next month's concluding article will deal with these things. First, the power supply section.

One can say that all dual-standard models adopt the so-called a.c./d.c. technique, where one side of the mains supply is connected to the metal chassis or h.t. negative line. With this technique there is no mains transformer. The heaters of the valves and the picture tube are all connected in series (or in a series-parallel arrangement) and applied across the mains supply, the current being limited by a mains dropping or ballast resistor.*

Unidirectional Heater Current

A very recent addition here is the elimination of the mains dropping resistor. Instead, one of the new silicon rectifiers is employed. This is in addition to the ordinary h.t. rectifier, and it rectifies the heater chain current so that it becomes unidirectional. This means that the heaters are energised by a current pulse every complete cycle instead, as with normal a.c., two pulses every cycle. The resulting loss in heater energising power balances the mains input current to that required to energise the heater chain correctly.

A silicon diode by itself is, of course, a highly efficient device, and since power is not burnt up in it, it operates quite merrily without getting hot! Thus, we have the complete solution to the hot mains dropper problem.

Such reduction in heat has shown the way towards smaller mains-operated sets, and this is also assisted by the use of transistor u.h.f. tuners and hybrid circuits, as we shall see later.

Quick Warm-up

Another idea related to the heater supply which may be adopted shortly is the "instantaneous warm-up" set. In such sets, the heater circuit would be so arranged that, as long as the set is plugged into an energised mains socket, the heaters light up even though the set may be switched off! Thus,

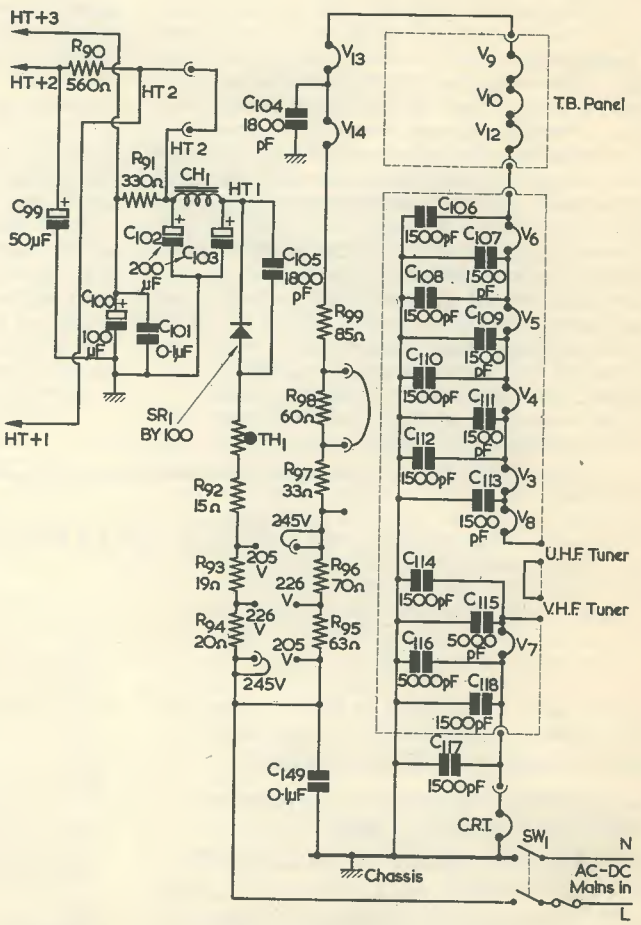

Fig. 37. The power supply circuits of a typical dual-standard receiver, as described in the text

* An exception here is the Thorn "900 Series" chassis. This employs a mains autotransformer having a 150 volt tap which feeds the heater chain.—EDITOR.

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as soon as the h.t. voltage is applied by switching the set on, the receiver immediately displays pictures and produces sound. The immediate appearance of the picture may be questioned, since usually the e.h.t. rectifier takes time to warm up after the line amplifier has been brought into action. This is taken care of with the instantaneous warm-up technique by the use of special high-voltage silicon rectifiers which have no warm-up time.

Fully transistorised television sets produce immediate sound on switching on, but with these the vision takes time to appear even when a solid-state e.h.t. rectifier is employed, for the heater of the picture tube has to warm up. The picture tube heater cannot be kept switched on all the time when batteries are used, of course. Quick warm-up tubes for such receivers are, however, under development.

The great majority of dual-standard models employ the fairly conventional power supply arrangement shown in Fig. 37. Here the on/off switch conveys mains power to the series-connected heaters through the heater ballast (i.e. mains dropper) comprising R_{95}, R_{96}, R_{97}, R_{98} and R_{99}. Taps and flying leads on this resistive network act as mains voltage adjustments, and the series resistance needed for the operating mains voltage is introduced by selecting the correct tapping.

It will be seen that the chassis is connected to the neutral side of the mains supply via one pole of the switch, and that the heater closest to the chassis is that of the picture tube. By having this heater as chassis potential, the a.c. stress between it and the tube cathode is minimised. The valves less affected by heater-to-cathode alternating voltages are connected towards the top end of the chain.

The heaters for both the v.h.f. and u.h.f. tuners are introduced towards the bottom of the chain, and the heaters of those valves dealing with r.f. and i.f. signals are decoupled to chassis by capacitors. Such heater decoupling also exists in the tuners.

Thermistor

In many receivers a thermistor (a resistor with a negative temperature co-efficient) is also included in the heater chain as a means of suppressing switch-on current surges. This component has a high resistive value when cold, but it speedily decreases to a low value as it warms up. It is connected so that the full heater chain current passes through it and, when the set is first switched on, its high initial value causes a rapid rise in its temperature and a consequent decrease in its resistance. Thus, the heater chain current is gradually increased in value, and the current surges which may occur without the thermistor are avoided.

Such a device may also be connected in series with the h.t. rectifier, as is TH_1 in Fig. 37. The live side of the mains is passed to another chain of resistors—R_{94},

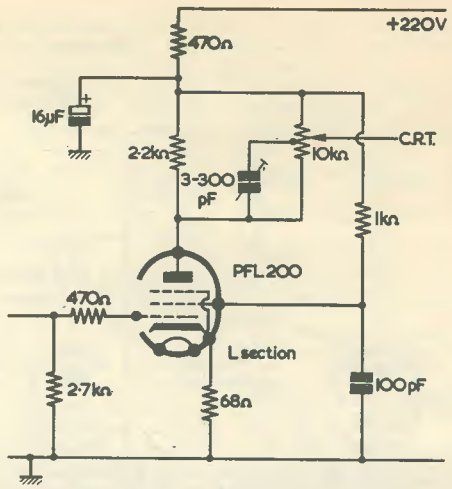

Fig. 38. A high-level contrast control circuit arranged in conjunction with the L section of the new PFL200 double-pentode valve. (Acknowledgements, Mullard Limited)

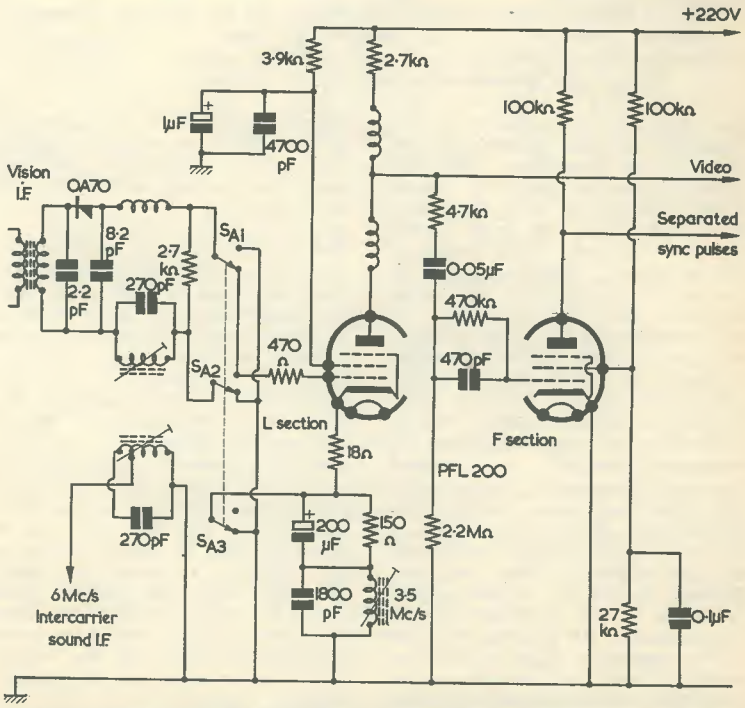

Fig. 39. Showing how the PFL200 is used in a dual-standard set with the L section as video amplifier and the F section as sync separator. The "standard change" switch is shown in the 625-line position. (Acknowledgements, Mullard Limited)

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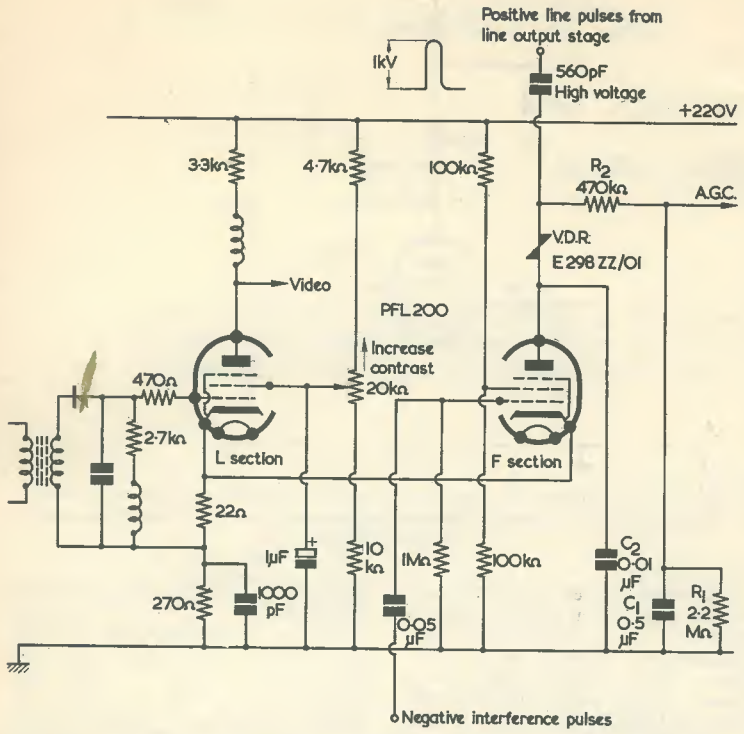

Fig. 40. This circuit shows how the PFL200 can be arranged as video amplifier (L section) and a.g.c. amplifier (F section). This circuit also provides noise cancelling and is suitable for negative modulation. (Acknowledgements, Mullard Limited)

R_{93} and R_{92}—and thence to the "anode" of the silicon rectifier SR_1 via the thermistor. The h.t. current over a range of mains input voltages is also controlled by a flying lead and taps on the resistive network. The resistors left in circuit, plus R_{92} which is always in circuit, act as surge limiters, and are necessary to prevent failure of the silicon rectifier, bearing in mind that the forward resistance of this is only a matter of a few ohms. Without such limiting the switch-on current flowing from the mains and, charging the reservoir electrolytic, C_{103}, could rise to a dangerously high value. The thermistor also assists with this action, and also neutralises the positive temperature coefficient of the series limiting resistors. Without it, the h.t. current would be likely to fall with increase in temperature of the limiting resistors.

The capacitor, C_{105}, across the rectifier tends to provide some protection against transient pulses, which are dangerous to all semi-conductor devices.

H.T. current is passed from the reservoir, C_{103}, through the smoothing choke CH_1 and filter networks to three h.t. lines, and these supply the various circuits that we have considered in past articles in this series.

The PFL200

A newcomer to dual-standard receivers is the PFL200 valve. This is a double-pentode, and in order to accommodate all the electrodes without resource to a top cap (which is undesirable in printed-circuit board configurations) the base employs 10 pins instead of the conventional 9 pins of the B9A base. It is given the name "Decal".

The Decal base has the same pitch circle diameter as the B9A 9-pin valves and the tenth pin is accommodated by slightly reducing the distance between the pins. The extra large gap between pins 1 and 10 is still retained, to allow the printing of a conductor from the outside circuit to the centre of the valve holder on the printed board.

The "L section" of the PFL200 has a very high slope of 21mA/V at 30mA, while the "F section" is of medium slope. The capacitances between the two sections are sufficiently low to avoid the possibility of interaction between two independent circuits.

The L section thus lends itself to high-gain video applications. The F section is suitable for voltage amplifying applications, for use as an i.f. or intercarrier amplifier or as an a.g.c. amplifier or sync separator.

Owing to the very high slope of the L section, this pentode is ideally suited to serve as video amplifier integrated with a high-level contrast control circuit. It will be recalled from past articles that a high-level contrast control circuit is one where the contrast control is connected to the video amplifier valve anode circuit, and that it adjusts the video drive to the picture tube. Such an arrangement using the L section is shown in Fig. 38.

Here the anode load resistor is of a low value so as to accommodate the relatively large shunt capacitances reflected back from the contrast control and associated connections. In spite of this low value load, the high slope of the valve permits a signal swing of 100 volts peak-to-peak at the anode (that is, a current swing of 50mA in 2kΩ).

It should be understood at this juncture that the effective video bandwidth is a function of the anode load resistor and the shunt capacitances. The smaller the value of the resistor and the value of the shunt capacitances, the wider the bandwidth. Thus, for a given bandwidth it is necessary to decrease the value of the load if the shunt capacitances are increased. With a normal valve, the use of a smaller load inhibits the voltage swing across it, and this puts a limit to the lowest value that can be employed. However, the high-slope L section of the PFL200 (achieved by a frame-grid control grid) allows the use of a low value load, as we have seen, while still providing adequate video drive.

The circuit in Fig. 38 is arranged for a negative-going video signal at the control grid. To avoid the valve dissipating too much current under zero signal conditions a little cathode resistance is introduced, and the screen-grid is fed through a 1kΩ resistor.

High Frequency Compensation

The slider of the contrast control feeds the tube cathode, while a tapping on the control element is connected to a trimmer capacitor to allow the circuit to be balanced for the best overall high frequency

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response over the range of the control. The h.f. response is also affected by the value of the screen-grid capacitor, and this is chosen in conjunction with the value of the cathode resistor for the best response.

Fig. 39 shows how the PFL200 may be used in dual-standard sets with the L section as the video amplifier and the F section as the sync separator. The vision detector switching is also shown here. This circuit is fairly straightforward and follows the basic principles expounded in previous articles dealing with the video amplifier, vision detector and sync separator.

The F section of the valve may be employed as an a.g.c. amplifier cathode-coupled to the video amplifier L section, as illustrated in Fig. 40. This circuit is arranged for negative modulation of the vision signal.

The circuit works as follows. The positive-going line pulses applied to the voltage-dependent resistor in the F section anode are clipped by the non-linear action of the VDR, and as a consequence a negative potential is developed across the capacitor C_1 and resistor R_1, these components forming, with R_2, a filter.

The presence of C_2 results in the negative potential "floating" about the chassis line. Now, since C_2 is effectively in parallel with the F section of the valve, the negative potential is varied by the conduction of this valve. Because the video signal level controls this conduction, it follows that the negative a.g.c. bias rises and falls with similar action of the picture signal.

The effect is rather like a d.c. controlled amplifier, the output of which is the a.g.c. bias and the control the video signal. The circuit has the advantage that the a.g.c. bias is independent of time base synchronising.

Next month we shall investigate the transistor u.h.f. tuner and dual-standard hybrid sets.

ACKNOWLEDGEMENTS

Acknowledgements are due to Mullard Limited for making available details of the PFL200 under "New Product Information".

NOTE

In "The New Dual-Standard TV Sets", Part 9, published in the January, 1965 issue, reference was made to the complete range of Decal valves. The author wishes to make it clear that the complete range of this type of valve is not yet available in Great Britain.

Mullard Limited have announced the availability of the PFL200 in this country, but point out that none of the other types is at present available.

Low Gain, Wide Band Oscilloscope Amplifier

P. Cairns G3ISP

Although this short article is primarily intended to discuss an alternative amplifier for an oscilloscope which has been previously described in these pages, it is still of general interest as the amplifier can be employed in any oscilloscope design. A particularly attractive feature is that the amplifier has a 3dB response up to 1.8 Mc/s and offers useful gain at over 3 Mc/s

SINCE THE ORIGINAL DESIGN OF THE C.R.O. described,* the writer has found that on frequent occasions a Y amplifier with a wider bandwidth was required. In the majority of cases a lower gain could also be tolerated. With these facts in mind a new design was evolved using the same two EF91 valves originally employed in the higher gain medium bandwidth amplifier. It was decided to keep these two valves together with the same number of components; thus, if the new circuit was required, only a minimum number of component changes would be necessary. There are in fact only five component changes, and the

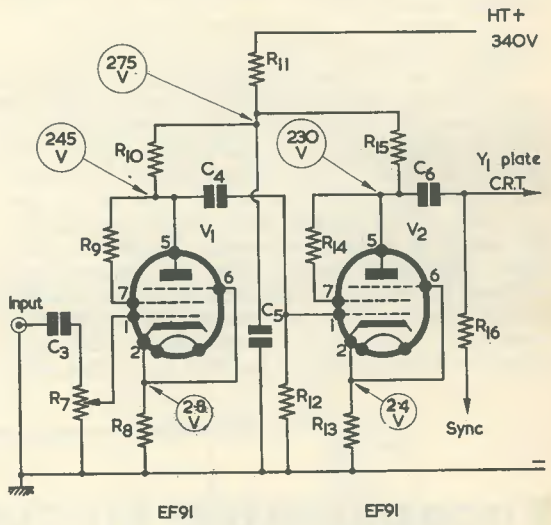

Fig. 1. Circuit of the Y amplifier

Components List

Resistors

(All fixed resistors 10% ½ watt unless otherwise specified)

R_7	1MΩ potentiometer, log
†R_8	470Ω 5%
R_9	100Ω
†R_{10}	5kΩ 2 watts 5% high stability
R_{11}	5kΩ 2 watts 5% high stability
R_{12}	1MΩ
†R_{13}	220Ω 5%
R_{14}	100Ω
†R_{15}	5kΩ 2 watts 5% high stability
R_{16}	330kΩ

Capacitors

C_3	0.25μF paper 750V wkg.
C_4	0.25μF paper 350V wkg.
†C_5	47pF silver mica 350V wkg.

Valves

$V_{1,2}$	EF91, Z77, 6AM6

* P. Cairns, "A Versatile Portable Oscilloscope", *The Radio Constructor*, July, August 1964.

† New values.

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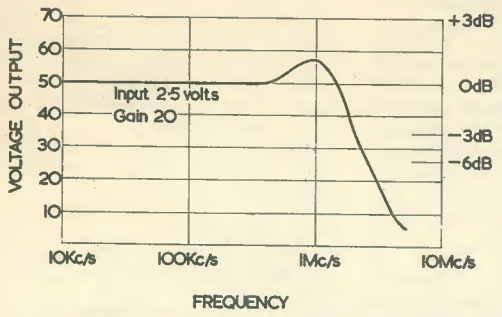

Fig. 2. The response curve of the amplifier

conversion can be carried out in a few moments. Having this choice of amplifiers considerably increases the versatility of the c.r.o., the user building the type of amplifier most suitable to the type of work being carried out. Should the alternate amplifier be required at any future date, a few moments work with a soldering iron will be sufficient to effect the change.

Amplifier Function

The actual function of the amplifier is in no way different from that described previously. In this version, the circuit of which is shown in Fig. 1, the anode loads R_{10}, R_{15}, have been considerably reduced in value. Since the common load resistor R_{11} is the same value as before, this means that not only is the overall gain much reduced but the feedback is also increased. Hence, a much higher bandwidth results. The two cathode bias resistors, R_8 and R_{13}, have been altered to give the correct bias level and so ensure that, even when overdriven, clipping is symmetrical. The high frequency compensation capacitor C_5 is the other component changed, this being very much reduced to meet the requirements of the new load resistors. While the h.t. drain is increased slightly, the 17mA taken by the amplifier is still well within the capabilities of the h.t. supply.

Voltage levels are shown in Fig. 1, these being measured with a 20kΩ/volt instrument.

Specification

The complete specification of the amplifier may be summarised as follows. Maximum overall gain is 20. Maximum undistorted output is 130 volts peak-to-peak. The response is flat between 5 c/s and 1.5 Mc/s, is −3dB at 1.8 Mc/s, and is −6dB at 2.5 Mc/s. There is useful gain up to over 3 Mc/s. Sensitivity is approximately 1.25 volts/cm.

A complete response curve is shown in Fig. 2. It will be noticed that a slight "hump" occurs at about 900 kc/s. This is due to slight h.f. over-compensation and was quite intentional, as the h.f. response would fall off lower down the frequency scale if an absolutely flat curve was aimed at. The slight over-compensation has no apparent effect on amplifier performance, and it offers an extremely good square wave response having no noticeable overshoot with rise times as fast as 1μS.

The gain control, R_7, can be re-calibrated to suit the new amplifier if required. The calibration is carried out in the same manner as previously described. The maximum sensitivity will be in the region of 1.25 volts/cm. That is, the 3 volt peak-to-peak square wave calibration signal should give a deflection of about 2.4 cm.

EDITOR'S NOTE.—If this amplifier circuit is employed in an oscilloscope having the same layout as that previously described, the input wiring to R_7 and from R_7 to V_1 control grid should be screened, using low capacitance screen cable.

Encapsulated Module for Thyristor Control

Mullard announce thyristor drive module MY5000, which is designed to simplify the use of thyristors in a wide range of ordinary electrical applications. This is the simplest module of a range and will drive up to two 70 amp. high current thyristors at the same time; for example, as two legs of a single-phase bridge circuit.

Although more complicated drive modules are necessary for sophisticated high accuracy motor speed control with complex feedback loops, this low cost module will provide a most satisfactory economic solution for the many simple applications of motor speed control, furnace control, light dimming and also the control of a.c. power by a back-to-back thyristor arrangement.

One of the problems for thyristor users is the provision of reliable drive pulses that will satisfactorily fire the thyristors and also control the position of the pulse by means of a control element or feedback loop. Each application naturally requires its own feedback loop arrangement, but by using a Mullard module which provides properly toleranced thyristor drive pulses, only the d.c. and feedback problems remain. The more common of these problems will be covered in Mullard Technical Reports.

The trigger module MY5000 is completely protected against environmental effects by plastic encapsulation, a feature which protects circuit components and interconnections from damage by mechanical vibration or shock.

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Part Four

by Craig Mackay

BRIDGE BUILDING

In this article, the last of a series of four, the author combines the bridge network techniques previously described in a single comprehensive design. The complete bridge is mains operated, and offers a capacitance range of 10pF to 10μF, and a resistance range of 10Ω to 10MΩ

THIS MONTH, THE CONSTRUCTION OF A COMPLETE bridge measuring instrument will be described. The circuit diagram is shown in Fig. 21.

The bridge proper is identical to that shown in Fig. 8 (Part 1 of the series) and mains a.c. is employed for the source. Facilities are included for the use of an external source oscillator injected by means of suitable sockets on the front panel. The variable 2.5kΩ resistor, R_{17}, gives an approximate indication of the power factor of capacitors in the range 0.1 to 10μF. This may be calibrated directly in percentages for 50 c/s a.c. or left to give a good-bad indication only (good corresponds to zero resistance in the variable component).[1]

The null indicator consists of a two-stage amplifier connected to a 3Ω loudspeaker. Although it is not normally used as an output valve, an EF91 is employed for the output stage because of the low output power required to fully drive the speaker. The preset variable resistor included in the grid

[1] A power factor calibration for R_{17} will only apply on the 0.1 to 10μF range (see Part 1) for a particular bridge-energising frequency. The latter could be the 50 c/s mains source. The unknown capacitor is balanced in the usual way with R_{17} set to zero resistance (=good). If it is found that the null indication can be made more precise by adjustment of R_{17}, this shows that the capacitor under test has a power factor which can be evaluated from the reactance of the standard capacitor and the resistance inserted by R_{17}. For general home-constructor work, however, an accurate power factor calibration is seldom required, and R_{17} may be employed to give an approximate indication between "good" and "bad".

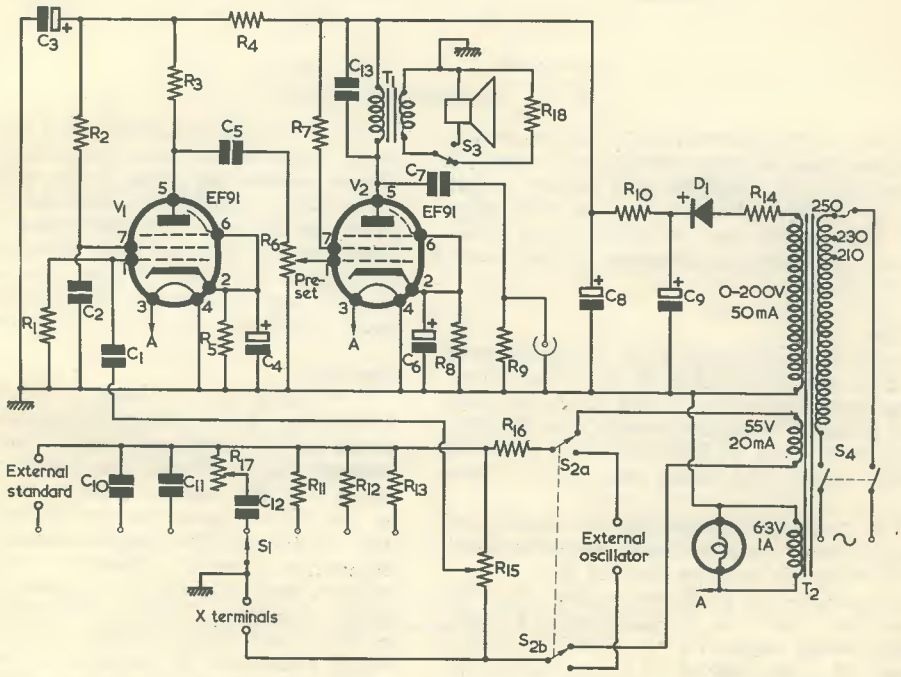

Fig. 21. The circuit diagram of the complete bridge instrument. The ranges switched in by S_1 were detailed in Part 1 of this series

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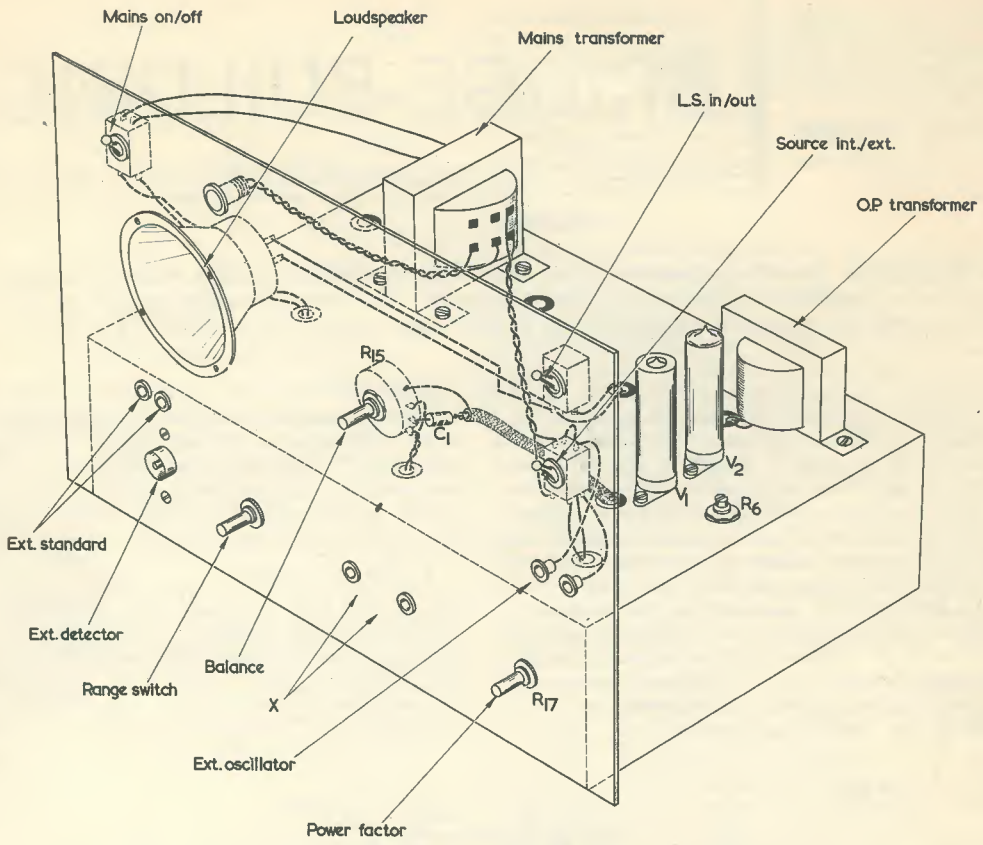

Fig. 22. The layout above the chassis

circuit of the output valve controls the maximum output power, thus avoiding damage to the speaker by overloading. The amplified null voltage is also available, at external terminals, for use with other detectors. The speaker may be switched out by S_3, a 3Ω resistor being connected across the secondary of T_1 in its place.

Construction

The layout of this instrument is not particularly critical. Care should be taken to avoid "cooking" any bridge components by placing them too close to sources of heat. These components, and the early detector circuits, must be kept well away from the stray fields around the mains and output transformers.

Keep the stray capacitances between chassis and the source terminals to a minimum, as such capacitances will cause inaccuracies to creep in.

The author's layout is shown in Fig. 22. The instrument was built on a four-sided 18 s.w.g. aluminium chassis measuring 9 x 6 x 2½in, with a front panel 10 x 7in, also of 18 s.w.g. aluminium. The chassis was bought already made up, as the saving given by making it up from sheet aluminium was not thought to be worth-while. Drilling details are given in Fig. 23.

The wiring diagram is shown in Fig. 24 and both these diagrams are self-explanatory. The under-chassis screens are made up as required from 18 s.w.g. sheet aluminium. Earthed screened leads must not be used for connecting the energising source to the bridge as those generally have a high capacitance to chassis. It is in order to use screened leads to feed the detector, however, as stray capacitance here has no effect on the balance position.

Operation

First check and thoroughly test the completed instrument. Then connect the unknown component across the "X" terminals. At one point the balance position will be found. The position of the range switch will then indicate a value which is multiplied by the factor shown on the "balance" scale (see Fig. 7 of Part 1). This gives the value of the unknown component directly. When the high capacitance range is used, balance is first obtained by the main control and the null-point is "sharpened" by means of the power factor control. This gives a power factor indication in addition to the components value. The preset control in the amplifier should be adjusted as required. The completed bridge will give an accurate indication of component values between 10Ω and 10MΩ and between 10pF and

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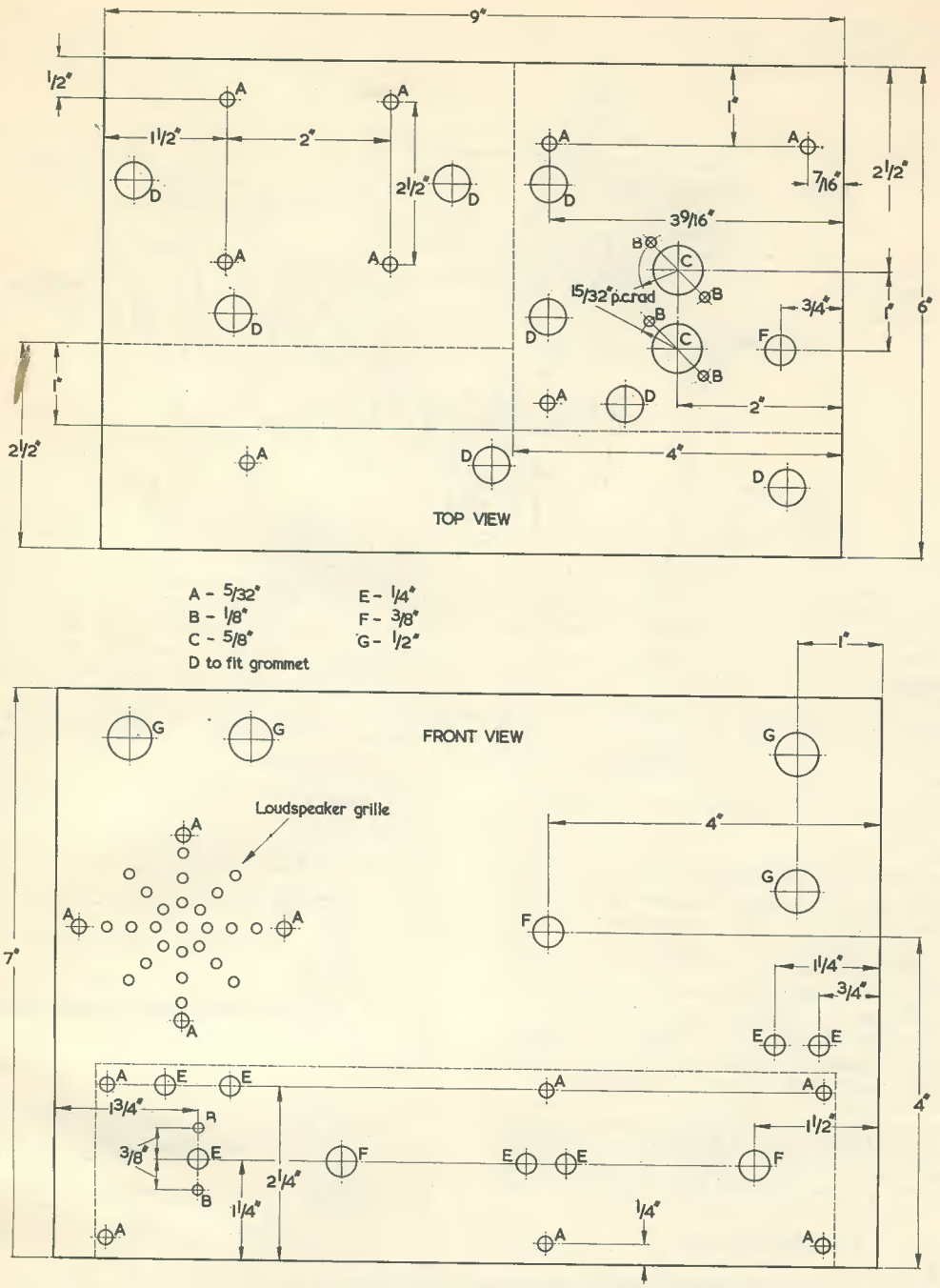

Fig. 23. Drilling details. The group of four "A" holes in the top view (top left) apply to the transformer employed in the prototype and may not correspond to alternative components

10μF, together with rough indications down to 1Ω and 1pF and up to 100MΩ and 100μF. It is important not to expect razor sharp balance on the low capacitance, and high resistance ranges, for this will just not be forthcoming. Where balance is indistinct, a good idea is to gently rock the main control to either side of the balance position, estimate the average setting and, hence, the final value. Accurate

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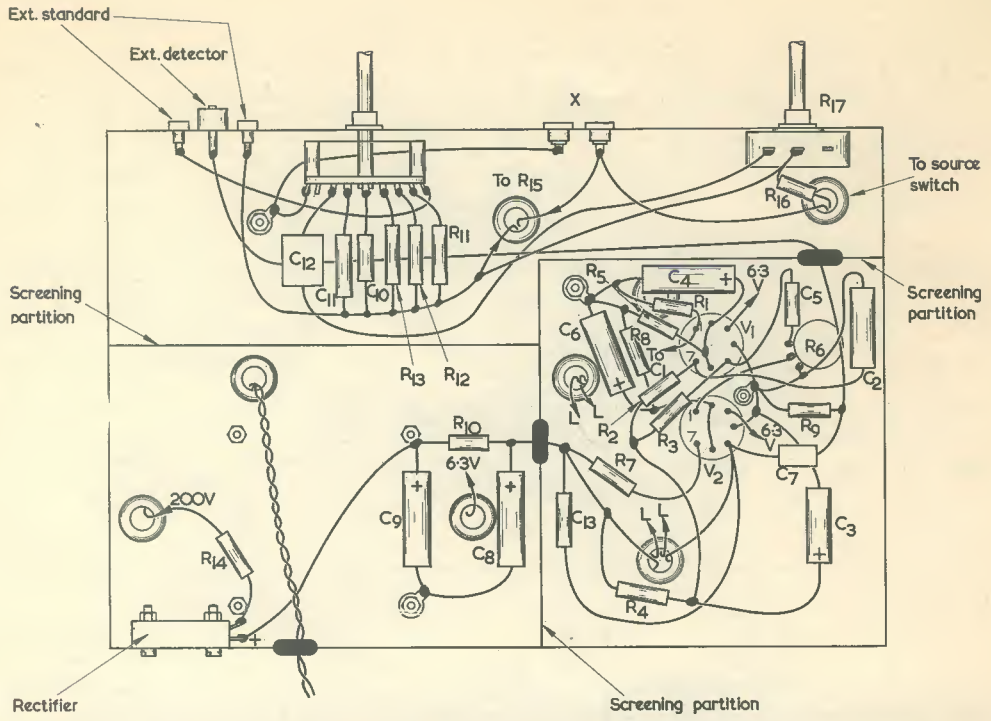

Fig. 24. The principal wiring below the chassis. The lead to the external detector socket from the junction of R_9 and C7 should be screened. The two pairs "LL" are from the output transformer secondary. These enter the valve compartment at one grommet and pass out at another

readings are possible by means of this method.[2]

Conclusion

A wide range of possible variations on the basic theme of component bridges has been given in this short series of articles. The constructor is encouraged to experiment with the various circuits suggested. All should work; some better than others. Those who have, so far, restricted their attention to the construction of radio receivers and amplifiers will find that no additional qualifications or experience are necessary to be able to construct testgear of the nature described in these four articles.

[2] The stray capacitance across the test leads should be borne in mind when making measurements on the lowest capacitance range. If it is thought to be large, this capacitance should first be measured with the leads open circuit but in position, the value measured being subtracted from the apparent value of the component under test.

Components List

Resistors

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

R_1	1MΩ
R_2	270kΩ
R_3	47kΩ
R_4	10kΩ 1W
R_5	180Ω
R_6	25kΩ log potentiometer, pre-set
R_7	1kΩ
R_8	180Ω
R_9	100kΩ
R_{10}	2kΩ 2W
R_{11}	100Ω ½W ±1% Hi-stab
R_{12}	10kΩ ½W ±1% Hi-stab
R_{13}	1MΩ ½W ±1% Hi-stab
R_{14}	100Ω 1W
R_{15}	10kΩ wirewound potentiometer, linear track
R_{16}	3kΩ 2W
R_{17}	2,500kΩ variable resistor, linear track
R_{18}	3Ω 1W

Capacitors

C_1	0.01μF
C_2	0.1μF
C_3	8μF 250V wkg. electrolytic
C_4	25μF 12 V wkg. electrolytic
C_5	0.01μF
C_6	25μF 12V wkg. electrolytic
C_7	0.01μF
C_8	8μF 250V wkg. electrolytic
C_9	8μF 250V wkg. electrolytic
C_{10}	100pF ±1%
C_{11}	0.01μF ±1%
C_{12}	1μF ±1%
C_{13}	0.01μF

Valves

V_1	EF91
V_2	EF91

Rectifier

D_1	Contact-cooled, 250V 50mA

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Transformers

T_1 Miniature output transformer
T_2 Mains transformer. Secondaries 0–200V 50mA, 6.3V 1A, 55V 20mA (See Parts 2 and 3)

Switches

S_1 1-pole 7-way, range selector switch
$S_{2(a)}$, (b) d.p.d.t. toggle, source selector switch
S_3 s.p.d.t. toggle, speaker muting
S_4 d.p.d.t. toggle, mains on-off

Sockets

1 valveholder, B7G, with screen (for V_1)
1 valveholder, B7G, without screen (for V_2)
6 wander plug sockets
1 coaxial socket

Miscellaneous

3Ω loudspeaker, 3in
6.3 volt pilot lamp and holder
3 knobs (one for balance control)
Chassis, nuts, bolts, grommets, etc.

HIGH OUTPUT ELECTRONIC METRONOME

By K. BERRY

SOME TIME AGO THE AUTHOR DEVELOPED AN ALL-transistor electronic metronome. This was a transistor multivibrator running from its inbuilt 9 volt battery. A small loudspeaker was driven directly by one of the transistors. Whilst this unit worked well, it was found that for some purposes the output power was insufficient, and consideration was given to the design of a high powered metronome. The unit described in this article is the result of such work.

One feature of the transistor metronome was the use of high value (50μF) capacitors in the tuning circuit. Electrolytic capacitors are necessitated by the need for a long time constant (R x C) coupled with the fact that transistors are low impedance devices—hence there is a small R, which needs a large C. Electrolytic capacitors are sold subject to a very large tolerance and are wont to drift in value. If possible, therefore, their use should be avoided. The elimination of electrolytic capacitors could, perhaps, be achieved by the use of sophisticated circuitry with its attendant cost and complexity, but it was felt that this approach was not the right one. In any case, the design of a transistor output stage which would give a high enough output power and a suitable power supply would result in a rather expensive piece of equipment.

In view of these considerations, it was decided to design an electronic metronome employing valves and details of this are given in this article.

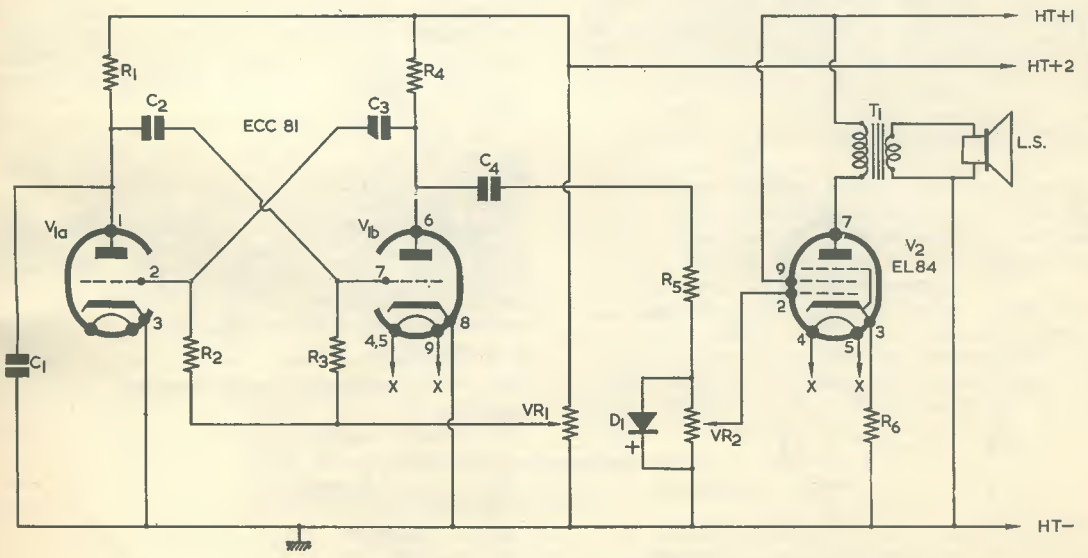

Fig. 1. The circuit of the high output electronic metronome

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Components List
(Fig. 1)

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

R_1	10kΩ 1 watt
$R_{2,3}$	680kΩ (see text)
R_4	10kΩ 1 watt
R_5	330kΩ
R_6	470Ω 1 watt
VR_1	100kΩ potentiometer, linear
VR_2	100kΩ potentiometer, log

Capacitors

C_1	39pF, ceramic or silver mica
$C_{2,3}$	0.5μF paper, 350V wkg.
C_4	0.01μF paper, 350V wkg.

Valves

V_1	ECC81
V_2	EL84

Diode

D_1	OA81

Transformer

T_1	Speaker transformer, 40:1

Miscellaneous
1 loudspeaker, 3Ω impedance
2 B9A valveholders
Knobs, etc.

Circuit

The circuit of the electronic metronome is given in Fig. 1. It will be seen that two valves are used. The first valve, V_1, is a double triode, and it acts as a multivibrator. The rate of operation is varied by the positive potential applied to the two grids by VR_1. The multivibrator gives a constant mark-space ratio, and only the repetition rate is varied by VR_1. The output of $V_{1(b)}$ is differentiated by C_4 and the subsequent resistance and fed to the grid of the output valve V_2 via volume control VR_2.

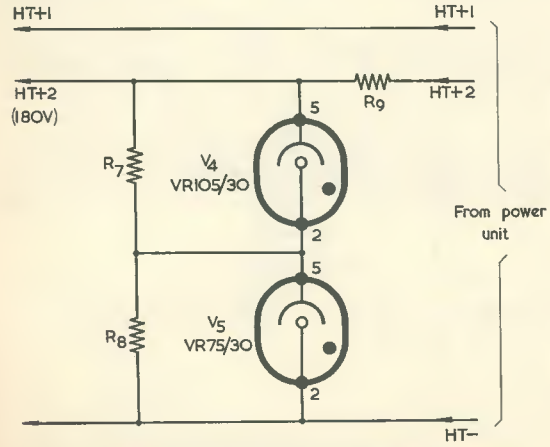

Fig. 3. Frequency stability may be improved, if desired, by adding voltage regulator tubes to the power supply circuit

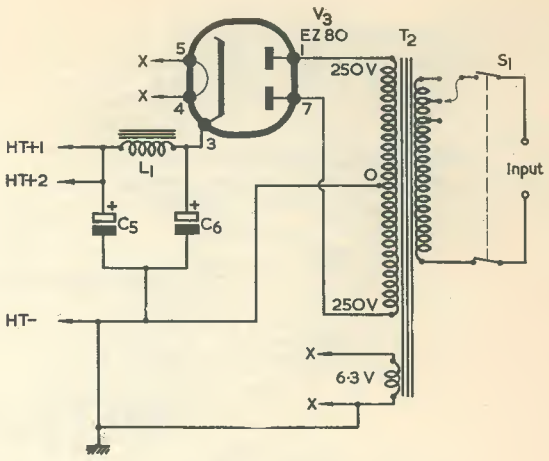

Fig. 2. A suitable power supply unit

Components List (Fig. 2)

Capacitors

$C_{5,6}$	32+16μF electrolytic, 350V wkg.

Valve

V_3	EZ80

Transformer

T_2	Mains transformer. Secondaries: 250-0-250V at 60mA*, 6.3V at 2A

Choke

L_1	Smoothing choke. 8 Henries at 60mA*

Switch

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

Miscellaneous
1 B9A valveholder

*Increase rating to 90mA if regulator circuit of Fig. 3 is used.

The positive-going spikes produced in the differentiation process are bypassed to ground by germanium diode, D_1. This is necessary to prevent a double frequency "beat" occurring, with alternate beats loud and soft.

The small capacitor C_1 (39pF), connected from the anode of $V_{1(a)}$ to chassis was found to be necessary in practice if stable operation at the lowest rates was to be obtained.

The components used in the prototype were quite straightforward. Capacitors C_2 and C_3 are paper components. The speed control, VR_1, is a 100kΩ linear potentiometer. Either a carbon track or wirewound control is suitable, though the latter is to be preferred.

Components List (Fig. 3)

Resistors

R_7	56kΩ ½ watt 10%
R_8	33kΩ ¼ watt 10%
R_9	2.2kΩ 3 watts 10%

Valves

V_4	VR105/30
V_5	VR75/30

Miscellaneous
2 octal valveholders

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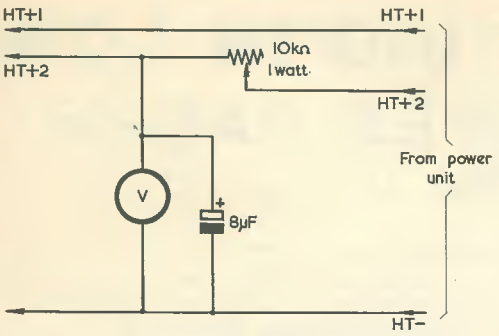

Fig. 4. A simpler means of obtaining the desired h.t. voltage

Power Supplies

The circuit of Fig. 1 requires an h.t. supply of 200 to 250 volts at 50 to 60mA, and a circuit for a suitable power unit is shown in Fig. 2.

It is worth noting that the speed of operation of the metronome is somewhat dependent upon the h.t. supply voltage. This variation is small with normal variations. For instance, if VR_1 is set to give 150 beats per minute at an h.t. potential of 250 volts, reducing the h.t. potential to 200 volts (i.e. by 20%) causes the speed to rise to 155 beats per minute (an increase of about 3%). This sort of voltage reduction will occur after prolonged use when the rectifier valve ages, and it may be eliminated by stabilising the h.t. voltage of the multivibrator by regulator tubes as shown in Fig. 3. This is not essential, however, and is only required where great accuracy of speed is needed. The regulator tubes could be dispensed with if the rheostat and voltmeter of Fig. 4 were employed instead, and the voltage manually adjusted (when necessary) to, say, 200 volts.

Construction

The layout of the unit is not critical, and the constructor may build it in the manner which he finds most convenient. Fig. 5 shows a suggested layout.

A possibly convenient form of construction might consist of building the metronome into an old radio, since such a chassis will have a suitable power supply, together with a loudspeaker and output transformer, etc. It will also have a dial, which could be re-calibrated with the metronome scale.

Operation and Calibration

When the unit has been wired in accordance with the circuit diagram it should function without any difficulty. Failure to operate can only indicate incorrect wiring or faulty components. If either C_2 or C_3 have low insulation resistance the circuit may fail to operate properly or even at all.

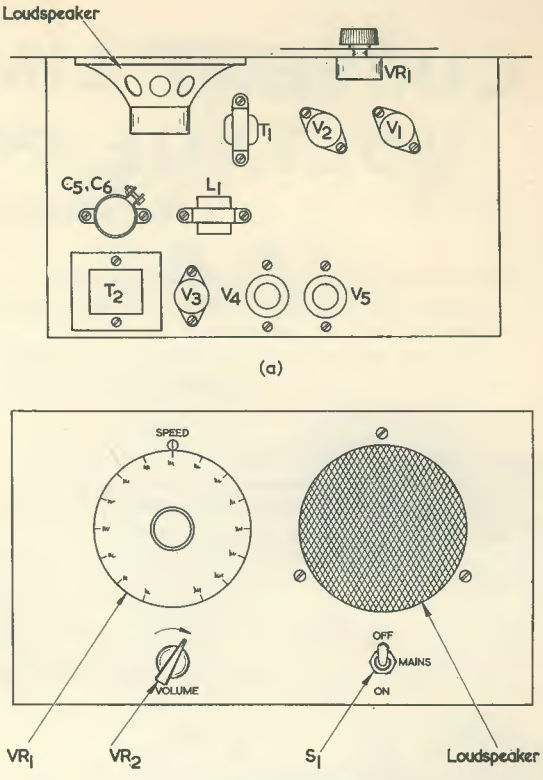

Fig. 5 (a). A suggested chassis layout. It is assumed that voltage regulator tubes are employed (b). Front panel layout

Once the circuit is working, set VR_1 for the lowest speed of operation and count the number of beats per minute, then set it for the fastest speed and count once again. The slowest and fastest rates should be about 40 and 240 respectively. If this range is not obtained the time constants R_2 C_3 and R_3 C_2 are incorrect and must be changed. This may be done as follows. If the unit runs too slowly reduce R_2 and R_3 (try 560kΩ), and if the unit runs too quickly, increase R_2 and R_3 (try 820kΩ). If these changes do not correct matters, then either C_2 or C_3 must be widely out in value and fresh capacitors should be tried in their places.

Having obtained the correct speed range, it only remains to calibrate the unit, which may easily be done by counting the number of beats whilst using a stop-watch or watching the second hand of a clock. Of course, if one has access to an electronic counter—then there is no problem at all!

WHARFEDALE WIRELESS WORKS LTD.

Mr. Peter Dye recently joined Wharfedale Wireless Works Ltd. as Managing Director after a period as Marketing Manager with Racal Electronics and several years with EMI Ltd., as Manager of the Recording and Relay Equipment Division. Mr. G. A. Briggs, who founded the Company thirty-two years ago, still continues as Chairman. Wharfedale Wireless Works is, of course, a company within the Rank Organisation.

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CURRENT LIMITING IN LOW VOLTAGE POWER PACKS

By JOHN G. DEW, B.Sc.

In this article our contributor discusses the basic methods of obtaining short-circuit current limiting in low voltage power packs, demonstrating the simple calculations that are required for determining component values. He concludes by describing a low voltage power pack offering continuously variable voltage output with short-circuit current limiting, or a fixed voltage output with adjustable short-circuit current

THE USUAL LOW VOLTAGE POWER PACK FOR transistor work has a circuit as shown in Fig. 1. This has one big disadvantage, however. If the output terminals are accidentally short-circuited, the only restrictions to current flow are the internal resistances of the transformer and diodes. As these resistances are normally low, a short-circuit will often burn something out—usually all four diodes!

The situation is changed when some form of

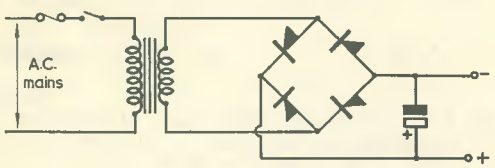

Fig. 1. The usual low voltage power supply

voltage regulation is employed. The usual method is to use a power transistor operating in the emitter-follower mode, as in Fig. 2. A battery is seldom used to supply the base potential, two other methods being the most popular: a potentiometer or a zener diode.

The Potentiometer Method

The potentiometer is connected across the d.c. supply, and the slider feeds the base of the transistor. As we are concerned with short-circuits, we must examine the worst conditions. If the slider is connected to the negative line, a short-circuit on the output will apply the d.c. supply across the base-emitter junction of the transistor—obviously undesirable. Thus, some limiting resistance must be

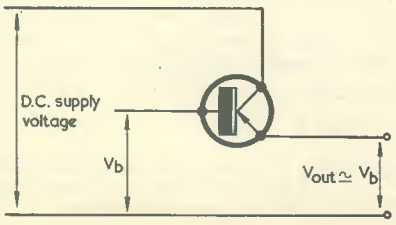

Fig. 2. A transistor regulator

included in the base circuit. Assuming a maximum permissible base current of 0.5 amp and a supply of 20 volts, we need $R_b = 40\Omega$.

However, let us now calculate the short-circuit output current. If the current gain of the transistor is 50, the 0.5 amp base current will allow 0.5×50, or 25 amps to flow—again undesirable. There is a simple remedy for this, however. If a resistor R_c is put in the collector circuit (see Fig. 3) it will have little effect on the output so long as there is a volt

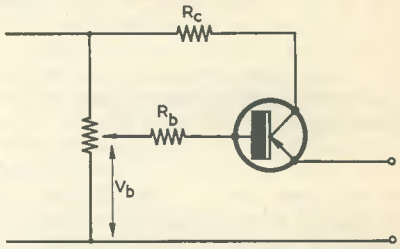

Fig. 3. Potentiometer control of base potential

or so between collector and emitter. If one attempts to draw a very high current, the collector-emitter voltage falls because of the voltage drop across R_c, and the transistor cannot pass the high current. Thus, automatic current limiting is achieved.

There is one drawback in using a potentiometer to supply the base voltage: the base circuit resistance, divided by the current gain of the transistor, is transferred to the output circuit. If the potentiometer has a total resistance of 500Ω, at mid-point the base will "see" two 250Ω resistors in parallel, or 125Ω. Thus the maximum output resistance would be $(125\Omega + 40\Omega) \div 50 = 3.3\Omega$, which is rather high.

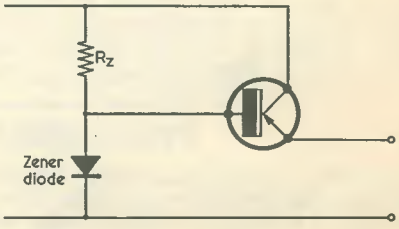

Fig. 4. Zener diode control of base potential

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Components List

Resistors

R_1	100kΩ ½ watt
R_2	22kΩ ½ watt
R_3	240Ω 2 watts
R_4	47Ω 3 watts
R_5	33Ω 2 watts
R_6	20Ω 20 watt wirewound
VR_1	5kΩ wirewound
VR_2	500Ω 5 watt wirewound

Capacitors

C_1	2,500μF 25V wkg.
C_2	500μF 25V wkg.

Semiconductors

TR_1	OC28, OC29, OC35, OC36, GET573
D_1–D_4	Diodes rated 50 p.i.v. minimum at 2 amps. (BYZ13 would be suitable)
Z_1	VR9-B (A.E.I.). Also, with R3=470Ω, OAZ207 (5% tolerance on V_Z) or OAZ212 (15% tolerance on V_Z)

Transformer

T_1	Secondary: 15 volts at 3 amps, e.g. Douglas MT21AT, or 17 volts at 2 amps, e.g. 12 volt battery charger transformer

Switches

S_1	1-pole 1-way
S_2	1-pole 4-way
S_3	2-pole 2-way

The Zener Diode Method

If a zener diode is used to supply the base voltage, as in Fig. 4, its slope resistance is quite low, say 20Ω. This would contribute an output resistance of 20Ω÷50=0.4Ω, which is much more satisfactory. The use of a zener diode has another advantage; if the output is short-circuited, the base current is limited by R_Z, and no collector resistor is required. With intelligent design, a very low output resistance can be combined with a reasonable short-circuit current.

As an example of design, assume a supply voltage of 20 volts d.c., a maximum regulated current of 500mA, a 10 volt zener diode and a transistor current gain of 50.

Then the maximum regulated base current= 500÷50=10mA. So the zener diode current on no-load is also 10mA.

$$\text{Then, } R_Z=\frac{20V-10V}{10mA}=1{,}000\Omega$$

The short-circuit base current is thus

$$\frac{20V}{1{,}000\Omega}=20mA.$$

Therefore, the short-circuit output current= 20mA×50=1 amp.

A Practical Circuit

The use of a zener diode has one disadvantage—the output voltage is fixed. The author combined the best of both worlds with the circuit of Fig. 5, which provides a fixed voltage, very low impedance, supply and a continuously variable, medium impedance, supply.

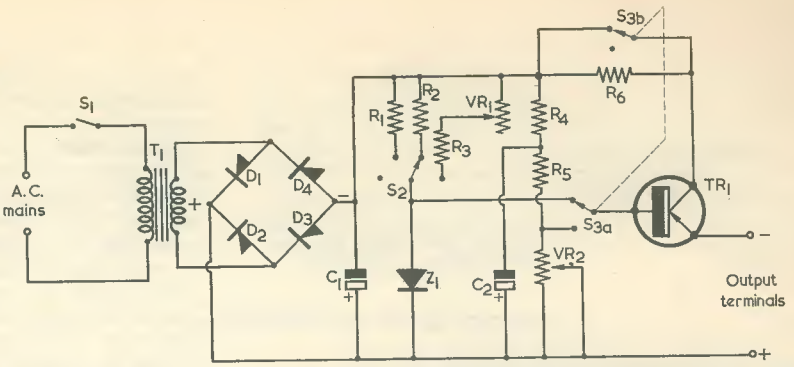

Fig. 5. The complete power supply circuit. Switch S_2 controls the short-circuit output current when the zener diode is selected by $S_{(3a)}$. The alternative setting of S_3 causes output voltage to be controlled by VR_2. With zener control the short-circuit output currents given in practice will be proportional to the gain of the transistor and, if desired, may be calculated as described in the text. Alternatively, of course, they may be measured

As an extra refinement the zener diode supply resistance is made variable, since this controls the short-circuit output current. To cover the complete range, a variable resistor is used to control the higher currents, and a fixed resistor for a selection of lower currents. One switch position open-circuits the zener supply, and the output current is then limited to the leakage current of the transistor.

The zener voltage which is used is a matter of personal preference, but it is limited by the rectified voltage available. If, as in the prototype, a 15 volt transformer is used to give a rectified voltage of about 20, the maximum zener voltage is about 12. Any higher voltage will result in heavy short-circuit output currents compared with the maximum regulated output. The author chose a 9 volt diode, as the unit can then be used to power any equipment designed for a 9 volt battery.

There are two points to be remembered when considering thermal stability. First, the transistor may dissipate up to 20 watts under short-circuit conditions, and should be mounted on about 24 square inches of aluminium sheet; and second, a transformer with a given rating on resistive load will have a lower rating when used with a rectifier. This is because the heating effect depends on the square of the current, which is greater for a peaky waveform than it is for a sine wave of the same mean value.

This point does not, however, apply to a transformer which is rated for rectifier work. For example, a battery charger transformer is intended for operation with a rectifier, and is suitably rated; one having a 17 volt secondary (for charging a 12 volt car battery) would be ideal in this application.

One further point concerns smoothing. Although only a single reservoir capacitor is used, the "ripple" content of the output is very low because of the smoothing in the base circuit. In one position of S_3 the zener diode effectively decouples the base supply, and in the other position the 500μF capacitor, C_2, provides more conventional smoothing of the base.

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AUTOMATIC CODE SENDER

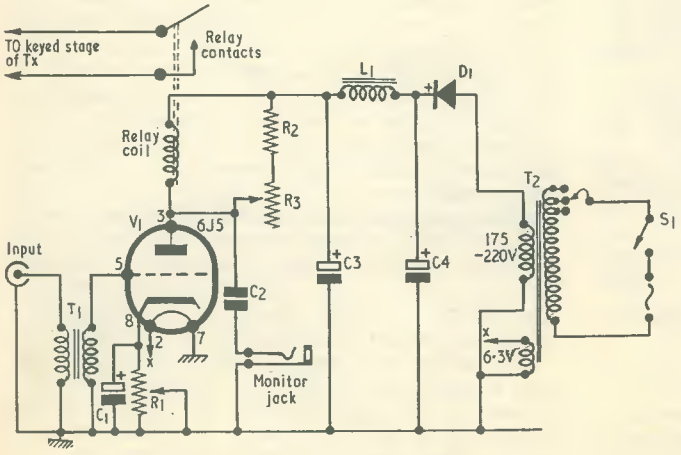
By S. G. Wood, G5UJ

THIS ARTICLE DESCRIBES AN IDEA WHICH OBVIATES that most tedious and tiring chore—the manual sending of lengthy c.w. CQ calls. When correctly adjusted it is sufficiently accurate to handle speeds of up to 25 to 30 w.p.m., the maximum being dependent, of course, on the relay employed.

A glance at the accompanying circuit diagram will disclose its almost stark simplicity. Nothing "awkward" in the way of components is called for and, apart from the relay, everything may well be found in the average junk box.

Pre-Recorded Morse Signal

A pre-recorded morse signal, in the form of a keyed a.f. tone, is provided by the low impedance output of a tape recorder. This is fed to the input socket. A reverse-connected speaker transformer, T_1, steps up the signal voltage and applies it to the grid of the triode V_1. This valve passes a high anode current when positive half-cycles are applied to its grid, the average current being sufficient to energise the relay. The relay contacts then key the transmitter. Valve and relay operating conditions are controlled by adjusting R_1 and R_3. The a.f. signal at the anode of V_1 may be checked at the monitor jack.



The circuit of the automatic sender unit. A pre-recorded morse signal is fed, from a tape recorder, to the input socket

The relay used should be capable of operating sufficiently quickly to follow the morse characters, and of being energised by the anode current of the triode. Some experiment may be required here. The writer obtained adequate results with a P.O. type 3000 relay, this having a 2,000Ω coil and two sets of make contacts. Only one set of contacts was used for the present application.

A small triode of the 6J5 class was originally used, but almost any small triode valve will serve. If a miniature type is preferred, a 6C4 should be equally effective. Requirements in the way of power supply are quite modest. The mains transformer is a small component giving some 175 to 220 volts at 15 to 20mA, together with 6.3 volts for the triode heater. A smoothing choke is shown in the L_1 position, but this could be replaced by a 1kΩ 1 watt resistor, if desired. The rectifier, D_1, may be a "metal" or contact-cooled component having the appropriate rating.

The Tape

The signal obtained from the tape may be provided by an endless loop of tape on which the required morse message has been previously recorded.* The pre-recording is carried out by feeding a manually keyed a.f. note into the recorder at an appropriate input socket. The recorder is, of course, switched to "record" during this operation. When it is later used for automatic code sending, it is switched to "playback", whereupon the keyed a.f. tone is fed to T_1 and the triode, as just described.

*This may incur the use of an unmanageably long loop of tape, and an alternative idea could consist of pre-recording, for 10 minutes or so, on a tape which proceeds through the recorder in the normal manner. The tape could then by played back in the same way, the appropriate section being rewound when it came to an end.—EDITOR.

Components List

Resistors
- R_1 1kΩ potentiometer, wirewound
- R_2 1kΩ 20% 1 watt
- R_3 10kΩ potentiometer, wirewound

Capacitors
- C_1 25μF electrolytic, 25V wkg.
- C_2 0.05μF paper, 250V wkg.
- C_3 8μF electrolytic, 350V wkg.
- C_4 16μF electrolytic, 350V wkg.

Inductors
- *L_1 Smoothing choke
- T_1 Speaker transformer, 40:1 to 70:1
- *T_2 Mains transformer

Valve
- *V_1 6J5

Rectifier
- *D_1 H.T. rectifier

Relay
- *Relay with set of make contacts

Switch
- S_1 s.p.s.t. toggle

Sockets
- Input socket
- Jack

*These components are discussed in the text.

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The writer obtained his keyed a.f. tone for the pre-recording process by tuning his receiver, with the b.f.o. switched on, to a harmonic of his transmitter oscillator. This procedure had the advantage of requiring no additional equipment. An alternative approach would consist of keying an audio oscillator.

The most important item, the tape recorder, should be in good working order. As continuous monitoring is envisaged with this equipment, it should be possible to interrupt the CQ sequence, and introduce the end of message manually on the station key, and this can be done by quickly replacing the automatic key jack-plug at the transmitter with that from the normal key.

Many variations of this particular idea will probably occur to the reader, and the design undoubtedly presents plenty of scope for much interesting and rewarding experiment.

RADIO TOPICS . . .

by Recorder

I DON'T KNOW WHETHER IT'S THE custom these days to demonstrate the properties of static electricity to students with the aid of a Wimshurst machine, but it certainly used to be in the days before the war. Great fun it was too, and especially at my school, because despite frenzied cranking on the part of our physics master the wretched machine would never generate enough electricity to deflect the tiniest of pith balls.

When, whilst I was on a radio course in the R.A.F. in 1940, the Wimshurst machine was once more to be the centre of a demonstration, I looked forward wickedly to further energetic but unsuccessful attempts to produce static electricity. But our R.A.F. instructor had a trick or two up his sleeve and, when the machine refused at first to operate, he quickly rubbed up a glass rod and held it, in its charged state, against the whirling metal segments of the machine. At once the machine came to life, and the beatific smile of our instructor could be seen shining happily behind a veritable fusillade of vivid discharges between the spark gaps.

Visual Demonstrations

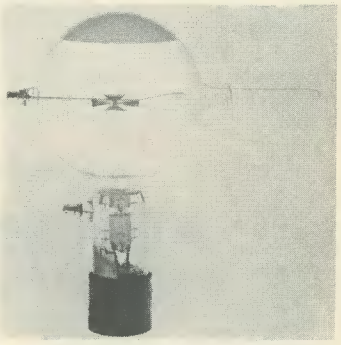
Despite the occasional unpredictable behaviour of the physics teaching devices of twenty to thirty years ago, the visual demonstrations they provided made a far greater impression on the student's mind than any amount of lecturing and reading could possibly provide. There is nothing like seeing for oneself, and if the student can actually *watch* a convincing demonstration of a basic law of electricity he is all the more satisfied about its veracity.

With these thoughts in mind I have found myself very impressed by a range of electrical apparatus recently introduced by the Rank Organisation especially for demonstration purposes in schools, technical colleges and universities. These, described as Demonstration Tubes, are available from Rank Audio Visual, Woodger Road, Shepherds Bush, London, W.12, and consist of a series of glass housings with electrode structures designed for specific demonstrations. Also available are supports for the tubes, and magnetising coils to illustrate the effects of magnetic deflection on an electron beam.

A typical example in the Rank Demonstration Tube range is the Maltese Cross Tube shown in the accompanying photograph. The original Maltese Cross experiment, as demonstrated by Sir William Crookes, made use of a cold cathode and sufficient energising voltage to cause the glass of the tube to fluoresce, a shadow then being thrown by the metal Maltese Cross. However, it is possible for these conditions to cause the generation of x-rays, a risk that is overcome in the Rank tube by employing a hot cathode. Further, a fluorescent material is coated on the inside of the bulb to make the shadow more readily visible. These two factors make it possible to operate the tube at potentials as low as 1,000 volts d.c. for a partly darkened room and 2,500 volts d.c. for daylight. The heater of the cathode is rated at 6.3 volts 0.6 amps, and may be run from a small heater transformer. Visible in the photograph are two small paddles depending from the Maltese Cross; these enable the Maltese Cross to be rotated to any desired position by a magnet held outside the bulb. The glass stem below the bulb fits into a separate support (which also takes the stems of other Tubes in the range) with the result that the whole apparatus may be conveniently set up in a very short time.

Similar in shape to the Maltese Cross Tube are an Elementary Diode and a Perrin Tube. The Elementary Diode is starkly simple, with a clearly visible tungsten filament and a flat circular anode some distance away. This tube may be used for the demonstration of thermionic emission and the plotting of I_a V_a curves at various filament temperatures. The Perrin Tube which, like the Maltese Cross Tube, has a hot cathode with a 6.3 volt 0.6 amp heater, shows amongst other things the effects of electron beam deflection; and is similarly capable of operating at voltages of the order of 2,500. Yet another hot-cathode tube demonstrates cathode ray deflection by means of two internally fitted electrostatic deflector plates. Both these last two tubes allow the effects of magnetic deflection to be observed.

Finally, two cylindrical tubes appear in the range, each fitted with



The Maltese Cross Demonstration Tube produced by Rank Audio Visual. The use of a hot cathode and fluorescent screen enables this historic experiment to be demonstrated convincingly at low supply potentials

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internal electrodes and an evacuating stem having a glass tap for connection to a vacuum pump. The first of these, the Elementary Discharge Tube, contains an electrode at each end and demonstrates the visual and electrical effects of passing a current through air at reduced pressure. The Canal Ray Tube is basically the same but has a disc cathode at one end perforated with three holes. These cause positive ions, travelling in the opposite direction to electrons, to become visible as faint pink luminous columns, or "canal rays".

All these devices are designed to make the life of the physics teacher as easy as possible and to provide him with reliable and impressive display equipment. And you don't need to charge up a glass rod to start them operating, either!

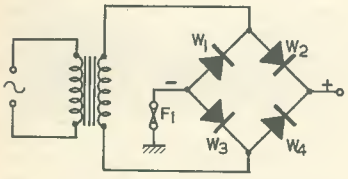


Fig. 1. A single fuse, as shown here, may not offer full protection to a bridge rectifier circuit

Bridge Rectifier Faults

You may recall that, in our November issue, we published "Transmitter Power Supply Using Semiconductors" by E. Lawrence. This contribution described the use of silicon rectifiers in a bridge circuit offering 1,000 volts d.c. at 200mA for the h.t. circuits of a transmitter.

The article has prompted a comment from a reader, Mr. J. S. Brown of Borehamwood, concerning fault conditions in bridge rectifiers. In his letter, Mr. Brown states:

"I have met these silicon supplies professionally, one of which developed a fault which caused damage

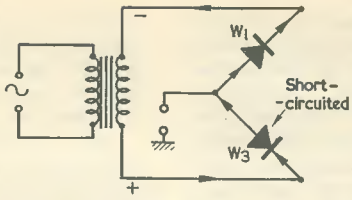


Fig. 2. If, for instance, rectifier W_3 breaks down and becomes short-circuited, a heavy current can flow as indicated

to the transformer. One of the silicon rectifiers developed a short-circuit; and although fuse F_1 blew (see Fig. 1), a circulating current continued to flow through half the bridge and the transformer secondary.

"The solution we adopted (more for convenience than other considerations) was to mount an additional fuse in series with one leg of the secondary.

"I am not suggesting, of course, that any other bridge circuit would not be prone to the same fault whether or not it used silicons."

To illustrate the effect described by Mr. Brown, the accompanying Fig. 1 illustrates a bridge rectifier circuit with a fuse (F_1) between the negative output terminal of the bridge and chassis. If, however, rectifier W_3 breaks down, the circuit shown in Fig. 2 is set up. In this diagram, and during the half-cycle when the upper end of the transformer secondary is negative, conventional current flows through the short-circuited W_3 and, in the forward direction, W_1. Such a current will be very heavy and can damage the transformer and possibly W_1 as well. Prevention of this effect, as put forward by Mr. Brown, is to insert fuse F_2 in one of the secondary leads, as shown in Fig. 3.

Taking a closer look at Fig. 3, it occurs to me that there is now no need for fuse F_1, and that the negative output terminal of the bridge could be connected direct to chassis. Fuse F_2 will then give all the protection previously offered by F_1 as well as guarding against the situation shown in Fig. 2.

Tough Telephones

Finally, a brief note concerning "Stanofones", the tough field telephones manufactured by Standard Telephones & Cables, Ltd. "Stanofones" are especially made to withstand the rigours of building sites, forest clearing, farms, shops and factories. (And if they are to be used at *some* building sites I've encountered, the language they handle will be pretty tough and rigorous, too!) They consist of one-piece telephones that will operate at distances of up to 60

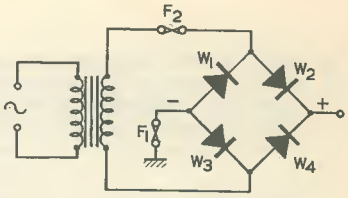


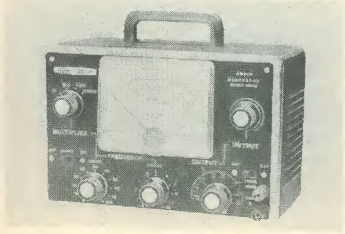
Fig. 3. Further protection is given by adding F_2

miles using a pair of wires. They are completely self-contained with their own batteries and calling signal device, and retail at £4 16s. per instrument.

U.K. enquiries for the "Stanofone" should now be sent to F. W. Reynolds Ltd., at 170 Chiltern Drive, Berrylands, Surbiton, Surrey. This agency appointment is of particular interest because Mr. F. W. Reynolds was, himself, one of the three engineers who suggested the "Stanofone" when he worked with S.T.C. some years ago.

Export enquiries for the "Stanofone" are still handled by S.T.C. Private Communications Division at Footscray, Kent.

HEATHKIT AUDIO GENERATOR



A restyled version of the well-established Heathkit Audio Generator, model AG-9U, has joined the new-presentation series of Heathkit test instruments.

The high performance standards have been retained: Range 10 c/s to 100 kc/s; Distortion less than 0.1% (20 c/s to 20 kc/s); Decades accuracy ±1% and ±2%; High grade, large scale, 200mA, f.s.d. meter; Bridged-T frequency control network; Constant output (approx. ±1dB) over the whole frequency range; High output (10 volts f.s.d. controllable down to 3mV f.s.d.).

The price of the 1965 version of this versatile generator has been kept to £22 10s. 0d. as an easily assembled kit, or £30 10s. 0d. assembled and ready for use.

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New Positive Temperature Coefficient Resistors give Better and Cheaper Motor Protection

Cheaper and more effective protection of electric motors is given by a new range of positive temperature coefficient resistors announced by Mullard.

Unlike conventional protection devices the new miniature resistors are incorporated directly in the windings of the motor. An excessive increase in the temperature of the windings (above about 110°C) causes a large and rapid increase in the value of the resistor and thus cuts off the motor's power supply.

New techniques of temperature measurement and compensation are also made possible.

Positive temperature coefficient resistors will find application in protecting motors which control production runs, operate lifts or cranes, and power electric trains. They are particularly useful for protecting remotely controlled motors, as for example those used in isolated pumping stations.

When used to protect multi-speed motors only one resistor is required for each winding no matter how many speeds the motor is capable of. With conventional (bimetal switch) protection a separate device is necessary for each speed.

Other applications include temperature measurement and compensation in transistor circuits, and current limiting in protection of relays used in telecommunication and similar equipment. In all applications they have the added advantage that units incorporating the resistors will automatically "fail safe" should the resistor or its associated circuitry become open-circuit.

Positive temperature coefficient resistors are made from doped barium titanate ceramics and exhibit a high positive temperature coefficient above the Curie temperature. At present five basic types are available; of these the P50/35/07/01 is particularly suitable for temperature measurement and temperature compensation in transistor circuits. The other types can be used as current limiters in circuit stabilisation and protection, in particular the P80/110/33/01, with a Curie point of 110°C has been developed for motor protection. The resistors (excluding leads) will fit into a cylinder of 9.2mm internal diameter by 11mm long.

Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers, as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Contributions on constructional matters are invited, especially when they describe the building of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate sheets. Typewritten articles should have maximum spacing between lines. In handwritten articles, lines should be double-spaced. Diagrams need not be large or perfectly drawn, as our draughtsmen will re-draw in most cases, but all relevant information should be included. Sharp and clear photographs are helpful, where applicable. If negatives are sent, we usually work from these rather than from prints. Colour transparencies normally reproduce badly—black and white photographs are very much better. Details of topical ideas and techniques are also welcomed and, if the contributor so wishes, will be re-written by our staff into article form. All contributions must be accompanied by a stamped addressed envelope for return, if necessary, and should bear the sender's name and address. Payment is made for all material published.

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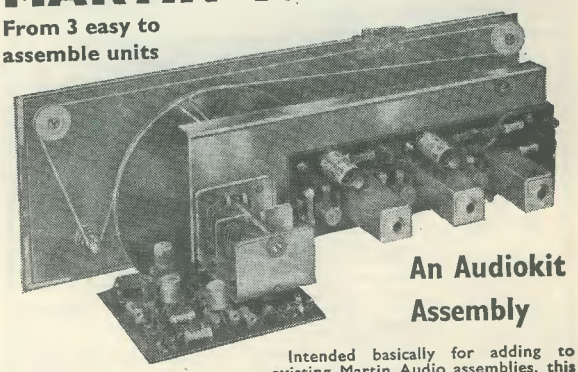

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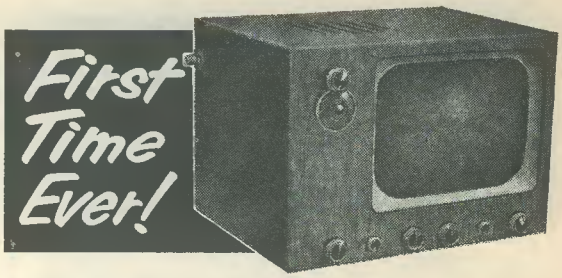

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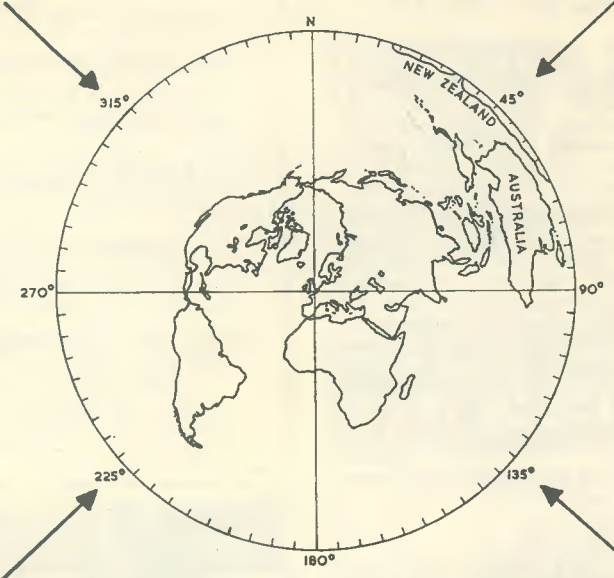

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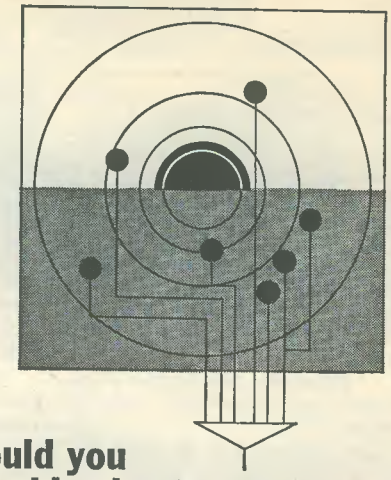

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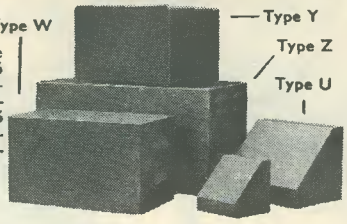

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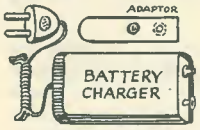

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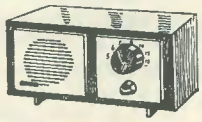

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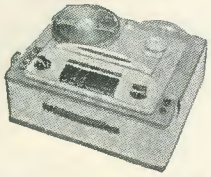

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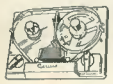

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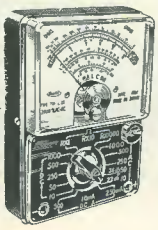

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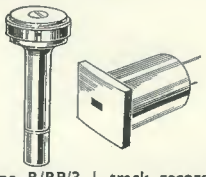

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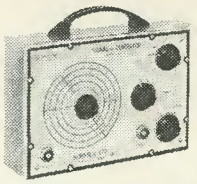

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9-Transistor Portable Trans-receivers. Supplied complete with leather cases, batteries, aerials, etc., in presentation case. Range up to 5 miles in favourable conditions. Sizes 6½" x 3" x 1½". Superhet crystal controlled on transmit and receive.
Price **£21** per pair. P.P. 3/6

DYNAMIC MICROPHONES

Special offer of 50kΩ professional quality types.
★ **DM301.** Size 6½ x 1½ x 2" for stand mounting. Response 40 c/s to 15 kc/s. Fitted on/off switch. **PRICE 79/6,** p.p. 2/6. (Normally 5 gns.)
★ **DM107.** Stick type for hand or stand use. Size 7 x 1¼" diam. Response 70 c/s to 16 kc/s. Fitted on/off switch. **PRICE 69/6,** p.p. 2/–. (Normally 4 gns).

POCKET RADIOS

All complete with battery, earphone, carry case and fully guaranteed. 6 and 7 transistor superhet designs.

★ 6-Transistor Med. Wave, **69/6.** P.P. 2/–
★ 7-Transistor Med. Wave, **79/6.** P.P. 2/–
★ 6-Transistor Med./Long Wave, **5 gns.** P.P. 2/6
★ 7-Transistor MW/LW/SW, **£12.** P.P. 3/6

MAINS AND BATTERY RECORD DECKS

ALL COMPLETE with ARM and CARTRIDGE

★ BSR UA14 4-speed	£5.19.6
★ BSR UA15 4-speed	£6.19.6
★ Garrard Autoslim 4-speed ...	£6.10.0
★ Unplugable Head Version ...	£6.19.6
★ Stereo Version	£7.19.6
★ 6–9 volt version	£8.19.6
★ SRP10 4-speed or BSRGU7...	£5. 0.0
★ Garrard AT6 with Stereo Cartridge, 4-speed	£10.19.6
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★ 45 r.p.m. Garrard 6V ...	£1.15.0
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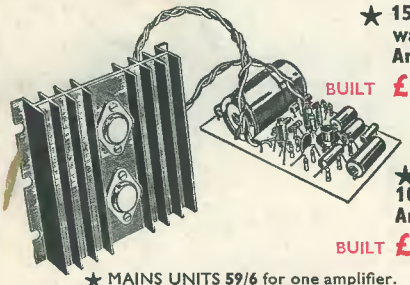
FIRST AND BEST PROVED & TESTED DESIGNS, QUALITY, COMPONENTS & UNITS

TRANSISTOR HI-FI AMPLIFIERS

MONO or STEREO | **10 WATTS and 20 WATTS**



★ 15 to 16 ohm 10 watt Power Amplifier
BUILT **£5-19-6** P.P. 2/6

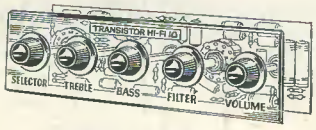
★ 3 to 4 ohm 10 watt Power Amplifier
BUILT **£5-10-0** P.P. 2/6

★ MAINS UNITS 59/6 for one amplifier. or 69/6 to power 2 amplifiers.

★ Mono full function pre-amplifier with 8 input positions. Low noise, high quality and sensitivity. Gives 10 watts with one power amplifier or 20 watts with two amplifiers. Size: 9" x 2½" x 2".

BUILT **£5-10-0** P.P. 2/-

PRE-AMPLIFIERS



★ FRONT PANEL PLATE 8/6

STEREO PRE-AMPLIFIER

Two Channel version of above. For use with two power amplifiers for 10+10 watts. Size: 9" x 3¼" x 1⅝".

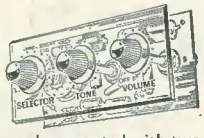
PRICE BUILT **£10-19-6** P.P. 3/6

★ Dark Brown with Gold Front Panel 12/6.

MULTI-INPUT PRE-AMPLIFIER

Simplified pre-amplifier for use with one or two power amplifiers, 8 inputs.

PRICE BUILT **65/-** P.P. 1/6



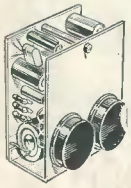
★ Front Panel Plate 6/6.

All the above pre-amplifiers can be used with any valve or transistor power amplifier requiring 250mV for full output. They can be operated with two 9 volt batteries in series or from the power amplifiers. High gain, low distortion, excellent quality designs, combined with value for money.

CIRCUITS AND DETAILS ON REQUEST

Demonstrations of above equipment and VHF FM Tuner can be heard during normal shop hours. All units are fully guaranteed.

TWO PACKAGED TRANSISTOR QUALITY AMPLIFIERS



★ 6-Transistor printed circuit designs. Push-pull output for 3 to 5 ohm speakers. Can be battery operated. 6mV into 1 kΩ sensitivity. Response 40 c/s to 12 kc/s.
Can be used with above pre-amplifiers for mono or stereo in any amplification requiring a low distortion low cost amplifier. Overall sizes: 2½" x 2" x 1¼".

★ 4 watt version operates from 12 to 18 volts. PRICE BUILT **79/6** P.P. 1/6

★ 1½ watt version from 9 to 12 volts. PRICE BUILT **65/-** P.P. 1/6

★ CIRCUITS AND DETAILS ON REQUEST ★

1½ watt and 4 watt

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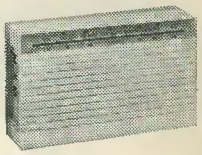
FOR THE HOME CONSTRUCTOR

"REGENT-6" New!

★MEDIUM and LONG WAVE POCKET SUPERHET RADIO. A new 6-transistor printed circuit designed with full coverage on both wavebands. Features "Cleartone" push-pull speaker output, geared tuning and complete set of 1st grade components. Moulded two-tone cabinet size 5" x 3" x 1¼". Easy to follow building details. All parts sold separately.

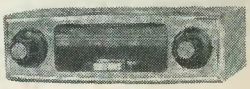


★ Total cost of all parts **85/-** P. & P. 2/- (Battery 2/6 extra)

All Transistor Car Radio

★ ONE HOUR TO BUILD WITH FACTORY ASSEMBLED CHASSIS AND PANELS

6-transistor 3 diode Med. and Long Wave Superhet Design. Features double tuned IFT's, AVC. Permeability tuning with geared drive, push-pull car filling volume. Full tuning of both wavebands. A high sensitivity design on printed circuits to fit any type of vehicle. 12 volt positive earth only. All parts available separately. After sales service and guarantee.



THE "ROADSTER"
★ Total Cost to Build
£8-19-6 P.P. 3/6

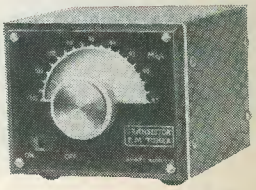
★7 x 4 inch. hi-flux speaker with baffle and car fixing kit 20/- extra.
★ Circuit and details on request.

VHF TRANSISTOR HI-FI FM TUNER

★ HIGH STABILITY — HIGH SENSITIVITY ★

Features 5-Mullard transistors with 4 diodes, compact printed circuit, high gain, low distortion, superhet design. Full tuning from 87/105 Mc/s with geared tuning. AVC and AFC. 9 volt 9mA operation. 50dB S/N. Output up to 1 volt audio. Easy to build and align. Overall size in cabinet 3½" x 2½" x 4". All parts sold separately and guaranteed.

AFTER SALES SERVICE
★ CIRCUIT AND DETAILS ON REQUEST



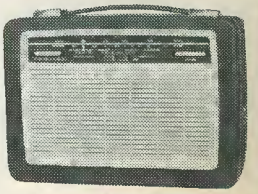
Total Cost with Front Panel
£6-19-6 P.P. 2/6
(Cabinet Assembly 20/- extra)

"CONVAIR" PUSH BUTTON PORTABLE CAR RADIO

★ UNBEATABLE FOR PERFORMANCE AND DESIGN ★

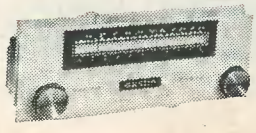
Printed circuit 6-Transistor 2-Diode superhet radio with full tuning on medium and long wavebands. Push-pull output up to 1 watt. Attractive portable cabinet, size 10" x 7" x 3½" with horizontal slow motion tuning dial and push button wave change. Easy to build with superb performance. All parts sold separately. After Sales Service and Guarantee.

★ CIRCUIT AND DETAILS ON REQUEST



★ Total Cost of All Parts
£7-19-6 P.P. 3/6
(Batteries 6/- extra)
★ The Finest Portable Available

NEW! VHF FM TUNER



New 6-transistor superhet design.
Factory built and aligned units.
Covers 88 to 108 Mc/s. Horizontal tuning scale.
Total Cost £12-17-6 *Leaflet on Request*

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