THE Radio Constructor

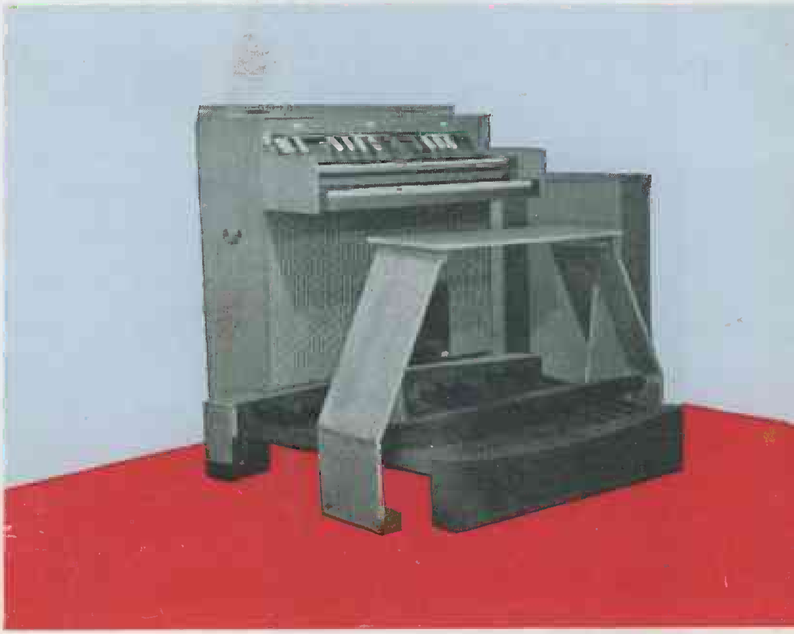
RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 16 NUMBER 1
A DATA PUBLICATION
PRICE TWO SHILLINGS

August 1962

Transistorised Electronic Organ

● Low Cost Record Player Amplifier ● A Decibel Meter ● A Valve Tester Design ● Radio Veronica ● Photoflash Slave Unit ● High-Low Impedance Microphone Pre-Amplifier ● Cathode Followers and their Uses ● Small Power Supply Unit ● The Good Companion Transfilter Portable

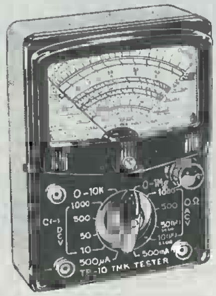


SUPERB COMMUNICATION RECEIVERS

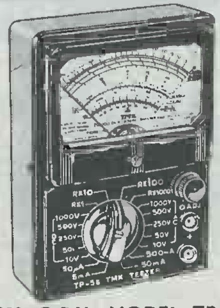
AMERICAN AR88D RECEIVERS. Fresh release of these renowned sets. 14 valves, 6 wavebands, covering 500 kc/s–32 Mc/s. Incorporate every possible refinement and have internal A.C. mains pack for nominal 115/230V. Thoroughly reconditioned, immaculate in appearance, and in perfect working order. ONLY **£35** (add carriage 30/– and 50/– deposit on returnable transit case). S.A.E. brings illustrated leaflet.

MARCONI CR. 100/8 COMMUNICATIONS RECEIVER. Covers 60 kc/s to 30 Mc/s. Complete with all valves, maker's instruction manual, and internal A.C. power unit for 200/250 volts. BRAND NEW IN ORIGINAL TRANSIT CASES. Aerial tested before despatch. ONLY **£35** (carr. etc., 40/–). S.A.E. for full details.

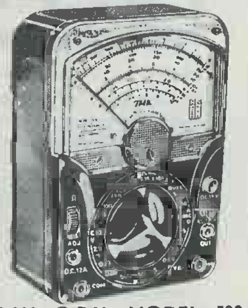
TEST METERS FOR EVERY PURPOSE & POCKET



2,000 O.P.V. MODEL TP-10. Reads A.C. and D.C. volts up to 1,000; D.C. Current to 500mA; resistance to 1 Meg; Capacitance to 1μF; Decibels from —20 to +36; Output jack for Audio Measurements. Size $3\frac{1}{2}$" x 5" x $1\frac{1}{2}$". **£3.19.6**



20,000 O.P.V. MODEL TP-5S. Reads Voltage up to 1,000; D.C. at 20,000 ohms per volt and A.C. at 10,000 o.p.v.; D.C. Current to 500mA; Resistance to 10 Meg.; Capacitance to 0.1μF; Decibels from – 20 to +36. Size $3\frac{1}{2}$" x $5\frac{1}{4}$" $1\frac{3}{4}$". **£5.19.6**



30,000 O.P.V. MODEL 500. Volts to 1,000: D.C. at 30,000 o.p.v., A.C. at 20,000; 12 Amps D.C. Current; 60 Meg. Resistance; —20 to +56 Decibels; Internal buzzer short circuit warning. Size $3\frac{5}{16}$" x $6\frac{5}{16}$" x $2\frac{3}{4}$". **£8.19.6**

All new stock, with leads, prods & internal batteries. 6 mths. guar. backed by full service facilities. Details S.A.E.

AMPLIFIER TYPE A1413. Ex-R.A.F. For normal A.C. mains use. 5Z4 rectification with 6V6 output. Input and output jack sockets, gain control, fully fused. 600 ohms output transformer, easily changed for 3 ohms type. Standard rack mounting size 19" x 7" x 6". Used, good condition. ONLY **59/6** (carriage, etc., 10/6).

POWER UNITS TYPE 234. Primary 200/250V 50 cycles. Outputs of 250V 100mA and 6.3V 4A. Fitted double smoothing. For normal rack mounting (or bench use) having grey front panel size 19" x 7". Fitted input and output voltmeter, **79/6**, or model less meter, **59/6** (carriage either type 10/6).

12 VOLT AMERICAN DYNAMOTORS. Deliver 220 volts at 100mA. Size $5\frac{1}{2}$" x $3\frac{1}{2}$" diameter. Ideal for running Electric Shaver, etc., from car battery. ONLY 32/6 (post 2/6).

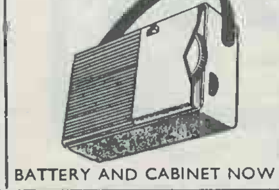
AVOMETER MODEL 7 LEATHER CASES, fitted with carrying handle and long strap. **BRAND NEW. ONLY 32/6** (post 2/6).

PCR COMMUNICATION RECEIVERS

Manufactured by **Pye and Philips**. One of the Army's most versatile and sensitive sets. RF stage and 2 of IF, using 6 British I.O. type valves. Large 180 degrees. Illuminated and Calibrated Dial. Flywheel tuning with locking device. Aerial trimmer. Tone and volume controls. Band switch from panel jacks for speaker or phones. In black metal case, size 17" L x 8" H x 10" D. Model PCR covers 6–18 Mc/s, 200–550 metres and 850–2,000 metres and has internal 5" speaker. **£6.19.6. Model PCR2** has similar L & M waveband coverage. Short wave 6–22 Mc/s, but no speaker. Used but excellent condition, **£5.19.6.** Every receiver aerial tested before despatch. Add 10/6 carr. all models. Designed to operate from bulky EXTERNAL power supply, but any set can be fitted with BRAND NEW COMPONENTS INTERNAL PACK for 200/250V a.c. at extra cost of **£2.**

S.A.E. *FOR ILLUSTRATED LEAFLET*

"P.W." 6 TRANSISTOR PERSONAL RECEIVER

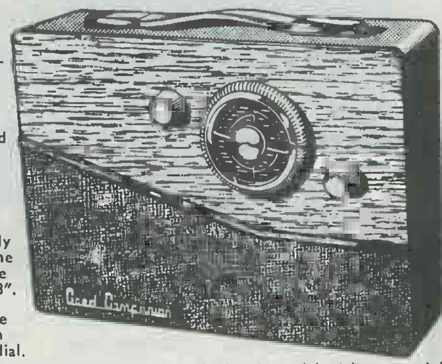


Designed by the technical staff of *Practical Wireless*: easy to build, using printed circuit and 1st grade Matched Transistors and Diode. Full Medium and Long Wave coverage to internal speakers. All parts sold separately (new components only) enabling you to buy as required, and full detailed price list will be sent on request. Constructional details 1/6. Newly designed OSMOR Cabinet and reduced price. TOTAL COST INCLUDING BATTERY AND CABINET NOW **£8.10.0.** S.A.E. for 7 transistor version.

THE "GOOD COMPANION" Mk. II

Using transfilters, the latest manufacturing technique to save alignment difficulty.

THE FINEST COMBINED PORTABLE and CAR RADIO YET DESIGNED FOR THE HOME CONSTRUCTOR



★ 750mW output.

★ 6 transistors and 2 diodes.

★ Full Medium and Long Wave coverage.

★ Quality speaker.

★ Brilliantly styled 2-tone cabinet, size 11" x 8" x 3".

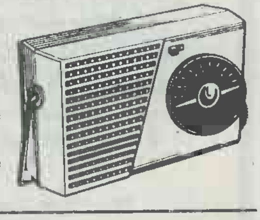
★ Very fine tuning with calibrated dial.

★ Latest printed circuit. ★ Internal high gain aerial with car aerial socket. Easy to follow construction data (available separately 3/6). All parts sold separately and full illustrated details will be sent on request.

Total Cost **£9.19.6**

With alternative luxury cabinet using 7" x 4" speaker, **£10.19.6.** Either type, plus 5/– post and ins. (Battery 3/6 extra.)

"POCKET 4" TRANSISTOR RECEIVER



Uses miniature speaker, proper tuning condenser, and volume control. Built-in aerial makes unit efficient and portable. Ideal for the beginner. Full medium wave coverage. All components and case for only **42/6** (p. & p. 2/6). Ten-page constructional book free with parts or separately 1/6. S.A.E. for parts price list.

HARRIS ELECTRONICS (LONDON) LTD

(DEPT. M)

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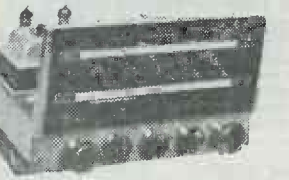
Please include carriage costs on ALL items.

(Open until 1 p.m. Saturdays.) We are 2 mins. from High Holborn (Chancery Lane Station) and 5 mins. by bus from King's Cross.

ARMSTRONG AF 208 AM/FM RADIOGRAM CHASSIS



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

Price **£22.18.0** Carr. Free

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

Acos Hi-Fi Pick-up for LP, and/or 78, 7", 10" and 12" records. Silent motor, heavy turntable, auto stop. Completely assembled on base plate. **£6.5.0** post free

SINGLE PLAYER BARGAIN

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

Our Price £8. 19. 6.

SUMMER SALE PRICES

New boxed VALVES 90-day Guarantee

0Z4	5/–	6K7G	5/–	EABC80	8/–	PCL82	10/–
1R5	6/–	6K8G	5/–	EB91	4/–	PCL84	10/–
1S5	6/–	6L6G	8/–	EBC41	8/–	PL81	10/–
1T4	3/–	6N7M	5/–	EBC81	8/–	PL83	8/–
2X2	2/–	6Q7G	6/–	EBF80	9/–	PY80	7/–
3S4	7/–	6SN7	5/–	ECH42	9/–	PY81	8/–
3V4	7/–	6V6G	5/–	ECH81	9/–	PY82	7/–
3Q5	7/–	6X4	5/–	EF85	6/–	PY83	8/–
5U4	6/–	6X5	6/–	EF89	8/–	PQ25	7/–
5Y3	6/–	12AT7	6/–	EL32	5/–	SP41	3/–
5Z4	9/–	12AU7	6/–	EL84	7/–	SP61	3/–
6AC7	4/–	12AX7	7/–	EY51	9/–	U22	7/–
6AM6	4/–	12BH7	7/–	EY86	9/–	UBC41	8/–
6AT6	6/–	12K7	5/–	EZ40	7/–	UBC81	9/–
6BA6	7/–	12K8	14/–	EZ80	7/–	UBF89	9/–
6BE6	5/–	12Q7	5/–	EZ81	7/–	UCH81	9/–
6BW6	7/–	25Y5G	9/–	E1148	1/–	UCL82	10/–
6C4	5/–	35L6	9/–	HABC80	10/–	UCL83	12/–
6D6	5/–	35Z4	5/–	HVR2A	5/–	UF89	9/–
6G6	4/–	807	5/–	KT33C	8/–	UL41	9/–
6H6	3/–	954	2/–	KT76	8/–	UY41	7/–
6J5	5/–	DAF96	8/–	MU14	7/–	UY85	7/–
6J6	5/–	DF96	8/–	PCC84	8/–	UU9	7/–
6J7G	6/–	DK96	8/–	PCF80	8/–	VR150	7/–
6K6	5/–	DL96	8/–	PCF82	8/–	W81	6/–

SETS OF VALVES

DK96, DF96, DAF96, DL96 8/– each or 29/6 set.
1R5, 1T4, 1S5, 3S4 or 3V4 Set of four 19/6

NEW ELECTROLYTICS FAMOUS MAKES

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

QUALITY 2-STAGE HI-FI AMPLIFIER

A.C. only, 200–250V Valves ECL82 and EZ80. 3 watt quality output. Mullard tone circuits, bass boost, treble and volume controls, Separate engraved front-panel with de-luxe finish. Heavy duty output transformer 3 ohm. Shrouded mains transformer. Stove enamelled chassis size 6in. x 5in. x 3in. **Bargain price £4.10.0.** Circuit supplied.

COMPLETE RADIO CHASSIS £4.19.6 p. free

4 Mullard valves, 5" speaker, frame aerial. 4 pre-set stations. 1 long, 3 med. wave.

Superhet Circuit.

Size 9" x 6" x 5¼" high. Tested ready for use. 200/250V A.C.–D.C. Mains. **Brand New** Guaranteed 12 months

DE LUXE MODEL

As above but with illuminated dial. Fully tunable over medium wave 200–550 M and long wave 1,000–2,000 M. Guaranteed 12 mths.

Bargain Price £5.19.6

MAINS TRANSFORMERS 200/250 AC

Post 2/- each

STANDARD 250–0–250, 80 mA., 6.3 v. 2.5 a. tapped 4 v. 4 a., Rectifier 6.3 v. 1 a. tapped 5 v. or 4 v. 2 a. 22/6
Ditto 350–0–350 ... ... 29/6
MINIATURE, 200 v. 20 mA., 6.3 v. 1 a. 10/6
MIDGET, 220 v. 45 mA., 6.3 v. 2 a. ... 15/6
SMALL, 220–0–220 v. 50 mA., 6.3 v. 2 a. 17/6
STANDARD, 250–0–250 65 mA., 6.3 v. 3.5 a. 17/6
HEATER TRANS., 6.3 v. 1½ a. ... 7/6
Ditto 6.3 v. 4 a. 10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 22/6
AUTO. TRANS. 150 w., 0, 10, 120, 200, 230, 250 v. 22/6
AUTO. TRANS. 500 w., 0, 115, 200, 230, 250 v. 82/6
PARMEKO MAINS TRANSFORMER. Made for special contract, the ratings can safely be doubled. Guaranteed 2 years. Primary 0-110-210-230-250 v. H.T. 300-0-300 v. 50 mA. L.T. 6.3 v. 1.8 a. Weight 6 lb. ... **Price 17/6, post 2/6**
MAINS POWER PACK. Size 3¾ x 4¾ x 4 in. with mains transformer, metal rectifier and condensers to provide smoothed H.T. output 220 v. 45 mA. D.C., L.T. 6.3 v. 2 a. Centre tapped A.C. All ready built on a strong metal chassis.. Brand new. ... ... **Bargain 29/6, post 2/6**

O.P. TRANSFORMERS. Heavy duty 50 mA, 4/6. Miniature 3V4, etc., 5/9. Small, pentode, 4/6. Multi-ratio push-pull, 7/6. Multi-ratio push-pull 10 w., 15/6. Goodmans heavy duty 10/20 w. 6K push-pull, 30/–; Estone ultra-linear OT/ML 10 w. 45/–.
L.F. CHOKES 15/10 H. 60/65 mA, 5/–; 10 H. 85 mA, 10/6; 10 H. 120 mA, 12/6; 10 H. 150 mA, 14/–

TELEVISION REPLACEMENTS
Line Output Transformers
from 45/- each, NEW Stock
and other timebase components
Most makes available. S.A.E. with all enquiries

FULL WAVE BRIDGE CHARGER RECTIFIERS. 2, 6 or 12 v. 1½a., 8/9; 2 a., 11/3; 4 a., 17/6. Free charger circuit.
CHARGER TRANSFORMERS. Tapped input 200/250 v. for charging at 2, 6 or 12 v. 1½ a., 15/6; 2 a., 17/6; 4 a., 22/6.
4 AMP. CAR BATTERY CHARGER with amp. meter Leads, Fuse Case, etc., for 6 v. or 12 v., 69/6.

BOOKS (*List S.A.E.*)

40 Circuits for Germanium Diodes	3/–
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TINNED COPPER WIRE 16 to 22 swg. ½ lb. 3/–
COPPER ENAMEL WIRE ½ lb. 16 to 22 s.w.g 2/9, 24 to 30 s.w.g. 3/6, 32 to 40 s.w.g. 4/6

CRYSTAL MIKE INSERT 6/6
Precision engineered. Size only 1½" dia. x ⅛"

ACOS STICK MIKE 39-1 ... ... 35/–
T.S.L. DE LUXE STICK MIKE ... 25/–

SPEAKER FRET. Gold cloth, 17in. x 25in., 5/–; 25in. x 35in., 10/–. **TYGAN**, various colours, 52in. wide, from 10/– ft.; 26in. wide from 5/– ft. Samples S.A.E. Expanding Metal, Gold, 12in. x 12in., 6/–

BAKER SELHURST LOUDSPEAKERS

12" Baker 15W Stalwart 3 or 15Ω, 45–13,000 c.p.s. **90/–**

12" Stereo 12W, 35–16,000 c.p.s. Foam suspension **£6.17.6**

12" Baker Ultra Twelve, 20 c.p.s. to 25 kc/s **£17.10.0**

15" Auditorium, Bass Mk II 35W 20 c.p.s. to 12 kc/s. **£18**

Send S.A.E. for leaflet and enclosure details

LOUDSPEAKERS P.M. 3 OHM. 2½in. 3in. 4in.-19/6; 5in. Rola, 17/6; 7in. x 4in., 18/6; 4in. Hi-Fi Tweeter, 25/–; 8in. Plessey, 19/6; 6½in. Goodmans, 18/6; 10in. R.A., 30/–; 12in. Plessey, 30/–; 10in. x 6in. E.M.I. 27/6; E.M.I. 13½" x 8" 45/–; Stentorian HF1012 10in., 95/–; HF1016, £8. 12 in. R.A. 15Ω 45 -.
CRYSTAL DIODES. G.E.C., 2/–; GEX34, 4/–; OA81, OA70, 3/–. Crystal Coils HAX, 3/–. DRR2, 4/–.
CRYSTAL SET BOOKLET 1/–.
H.R. HEADPHONES, 4,000 ohms, brand new, 15/– pair. Low resistance phones, 7/6 pair, **SWITCH CLEANER FLUID**, squirt spout. 4/6 tin.

C.R.T. BOOSTER TRANSFORMERS

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

TYPE A. LOW LEAKAGE WINDINGS. OPTIONAL 25% and 50% BOOST ON SECONDARY: 2 V. OR 4 V. OR 6.3 V. OR 10.3 V. OR 13.3 V. WITH MAINS PRIMARIES. 10/6.

TWIN GANG CONDENSERS. Transistor 208 pF and 176 pF, with trimmers and screen, 12/6 each; 365 pF, miniature, 1⅞in. x 1½in. x 1¾in., 10/–; 500 pF standard with trimmers, 9/–; midget, 7/6; midget with trimmers, 9/–. 500 pF slow motion drive, 9/–.
SHORT WAVE. Single 10pF, 25pF, 50pF, 75pF, 100 pF, 160 pF, 5/6 each.
TUNING AND REACTION CONDENSERS. 100 pF, 300 pF, 500 pF, 3/6 each, solid dielectric.
CONDENSERS. 0.001 mfd. 7kV T.C.C., 5/6; ditto 20 kV., 9/6; 0.1 mfd. 7 kV., 9/6; 100 pF to 500 pF Micas, 6d.; Tubular 500 v. 0.001 to 0.05, 9d.; 0.1, 1/–; 0.25, 1/6; 0.1/350 v., 9d.; 0.5/500 v., 1/9; 0.01/2,000 v., 1/9; 0.1/2,000 v., 3/6.
CERAMIC CONDENSERS. 500 v. 0.3 pF to 0.01 mfd., 9d. 0.1/30v., 1/3.
SILVER MICA. 10% 5 pF to 500 pF, 9d.; 600 pF to 3,000 pF, 1/–; close tolerance (plus or minus 1 pF), 2.2 pF to 47 pF, 1/–; ditto 1% 50 pF to 815 pF, 1/–; 1,000 pF to 5,000 pF, 1/9.

465 Kc/s. SIGNAL GENERATOR. Price 15/– Uses B.F.O. Unit ZA 30038 ready made with valve 1S5. **POCKET SIZE** 2½in. x 4½in. x 1in. Slight modifications required, full instructions supplied. Battery 8/6 extra 69 v. + 1½ v. Details S.A.E.

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

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

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

RADIO COMPONENT

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

VOLUME CONTROLS

Long spindles. Midget 5K ohms to 2 Meg.
L/S 3/– D.P. 4/6
Stereo L/S 10/6 D.P. 14/6
Linear or Log Tracks.

80 ohm CABLE Coax

Semi-air spaced $\frac{1}{4}$in. Stranded core, 6d. yd. 40 yds. 17/6; 60 yds. 25/-
Fringe Quality, Air Spaced 1/- yd.

EXTENSION SPKR. CONTROL 10 Ohm 3/–.
TELESCOPIC CHROME AERIALS 13in. extending to 43in. 8/6 each.
RESISTORS. Preferred values. 10 ohms to 10 meg. $\frac{1}{4}$ w., 4d.; $\frac{1}{2}$ w., 4d.; 1 w. 6d.; $1\frac{1}{2}$ w. 8d.; 2 w. 1/-.
HIGH STABILITY. $\frac{1}{2}$ w. 1%, 2/-. Preferred values. 10 ohms to 10 meg. Ditto 5%, 10 ohms to 22 meg. 9d.

WIRE-WOUND RESISTORS 10 ohms- 10,000 ohms
5 watt 1/3
10 watt 1/6
15 watt 2/-
12.5K to 50K 10 w 3/–

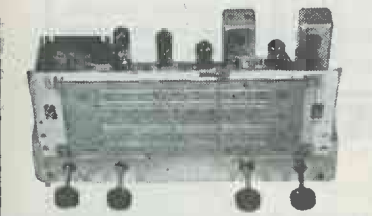
I.F. TRANSFORMERS 7/6 pair
465 kc/s Slug Tuning Miniature Can. 2in. x 1in. x 1in. High Q and good band width. Data sheet supplied.

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

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

TRIPLEXERS, Bands I, II, III, ... 12/6
COAXIAL PLUGS, 1/–. **PANEL SOCKETS,** 1/–
LEAD SOCKET, 2/–. **OUTLET BOXES,** 4/6
BALANCED TWIN FEEDER, 6d. yd., 80 or 300 ohms
TWIN SCREENED FEEDER, 1/6 yd. 80 ohms.
TRIMMERS. Ceramic 30, 50, 70 pF. 9d.; 100 pF. 150 pF. 1/3; 250 pF. 1/6; 600 pF. 750 pF. 1/9; Philips, 10 pF, 30 pF. 1/– each.

1962 RADIOGRAM CHASSIS



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

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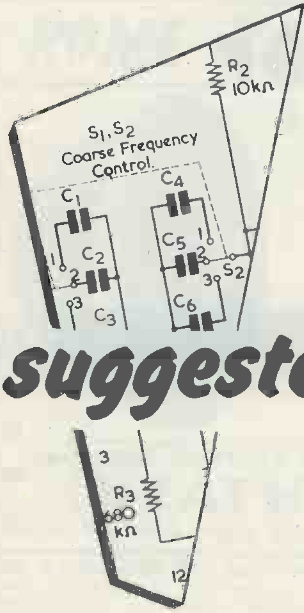


suggested circuits

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

No. 141 Low-Cost Record Player Amplifier

In the March issue of *The Radio Constructor* our contributor Recorder pointed out, in the "Radio Topics" feature, that it would be of interest to include a low-cost gram amplifier in "Suggested Circuits", and that such an amplifier could employ the UL84–UY85 combination now commonly used in the more inexpensive commercially made record players.

The writer agrees that an amplifier of this type may well be of interest to readers, not only because it could be built at a relatively small expenditure, but also because it could demonstrate several circuit practices which are relatively "standard" in commercial design and which may not be generally known amongst amateurs.

In order to keep costs at a low level the design described in the present article employs a transformerless power supply, with the result that the amplifier chassis is connected to one side of the mains. *It is essential, in consequence, that the details given later concerning safety precautions be carefully followed.*

The Circuit

The circuit of the amplifier appears in Fig. 1 and, as may be seen, it employs a single UL84 amplifier which obtains an h.t. supply by means of a UY85 rectifier.

The UL84 is commonly used in commercially manufactured record players and, on its own, is capable of driving a loudspeaker at adequate volume when supplied by a high output crystal pick-up of the type fitted to most popular 4-speed gram decks and auto-changers. It has a fairly high mutual conductance of around 9mA/V, and it offers an output power of 5.2W at 10% distortion. The last point ensures that it will not be readily overloaded under the operating conditions envisaged here. The UL84 draws a high anode current (60mA at 200V under normal working conditions) but this factor represents no great disadvantage when half-wave rectification direct from the mains supply is employed. On the other hand, the high anode current precludes the use of inexpensive mains transformers having half-wave h.t. windings for home-constructor applications, as the maximum h.t. current rating available in components of this class is 45mA only. It is for this reason that a transformerless power supply, similar to those employed in commercial record players, is suggested here.

The amplifier is by no means in the high fidelity class, emphasis being placed more on economy than on audio quality. Nevertheless, it should be capable of offering an output which is comparable with that given by a mains table model receiver.

In Fig. 1 the output of the crystal pick-up is applied, via the isolating capacitors C_1 and C_2, to the volume control R_1. R_1 has a fairly low value for crystal pick-up operation, and this fact, together with the presence of C_1 and C_2, causes some bass cut in the input applied to V_1. This bass cut is not necessarily a disadvantage in the present application.

V_1 amplifies in conventional fashion, it being biassed by the cathode components R_4 and C_4. The amplified signal is applied to the primary of the speaker transformer. The UL84 requires a fairly low anode load impedance, and this is provided by an output transformer having a ratio of 30:1.

A top-cut control is provided by C_3, R_2 and R_3. The use of a tone control across the primary of the output transformer is far from being a high fidelity design technique, but it offers an advantage here. Theoretically, it might seem preferable at first sight to put the tone control in the grid circuit of the amplifier, and have a "tone correction" circuit consisting of a fixed resistor and capacitor in series across the transformer primary. However, a fixed "tone correction" circuit would cause a permanent reduction in the output of the higher audio frequencies, and the separate tone control could only introduce further losses. In the present circuit it is desirable to obtain the maximum amount of gain possible from the single amplifier valve employed, with the result that it is beneficial to make the "tone correction" circuit (which is essential anyway) variable, so that it can also function as a tone control.

A disadvantage with the tone control circuit used here is that high a.f. currents flow through the potentiometer when its slider is at the maximum cut (minimum resistance) end of the track. As a result, the track may eventually become burnt out at this point. In Fig. 1, R_3 is inserted in series with the potentiometer to limit a.f. currents at the maximum cut setting, but such a resistor is not normally encountered in commercial record players. Track burn-out is only liable to occur if the amplifier is used for a considerable length of time with the tone control set to maximum cut, and some constructors may in consequence prefer to delete R_3, returning the lower end of R_2 direct to the UL84 anode.

The h.t. supply for the UL84 anode is obtained direct from the h.t. reservoir capacitor C_6. The use of an unsmoothed h.t. supply results in a low hum level in the speaker, this being perceptible when the pick-up is at rest but relatively unnoticeable whilst a record is being played. The supply for the UL84 screen-grid is smoothed by R_5 and C_5.

The h.t. rectifier, V_2, has its anode coupled to the mains input via the limiter resistor R_6. Switch S_1 applies the mains supply to the rectifier, the gram motor, and the heater chain via the dropper resistor R_7. The series heater requirement of V_1 and V_2 is 83V at 100mA, and R_7 drops 157V at this current. In consequence, this resistor has a value (1,570Ω) which causes the correct heater current to flow for mains input voltages of 240. Switch S_1 may be ganged with either R_1 or R_2, according to the constructor's requirements.

Mains Isolation

Since a transformerless power supply is employed, the amplifier chassis is connected to one side of the mains supply. As a result, this chassis must be mounted inside the record player cabinet such that no "live" points whatsoever are accessible. Ventilation apertures should be such that no finger can be passed through to touch any live part. If knobs with grub screws are employed, the grub screw holes should be filled with wax to prevent accidental contact. Also, the chassis should be mounted such that no live mounting bolt heads or similar metal fixing devices appear at any accessible point. Although not directly connected to chassis, the speaker frame should also be considered as being live, and it must be treated in the same way as the amplifier chassis. It is advisable to use an insulating speaker fabric such as Tygan, and to avoid speaker coverings consisting of expanded metal. It should not be possible to touch the speaker frame with the finger should the fabric be accidentally damaged.

The chassis of the gram deck, or auto-changer, is not connected to the amplifier chassis. The gram chassis presents a large area of metal to the user and it must, in consequence, be isolated from the amplifier chassis. In Fig. 1 the 0.002μF isolating capacitor, C_7, is fitted to reduce hum injection in the grid circuit of the amplifier. The two 0.002μF capacitors C_1 and C_2 similarly isolate the pick-up from the amplifier chassis. The braiding of the insulated screened lead between C_1 C_2 and the pick-up is connected to *neither* the amplifier chassis *nor* the gram chassis, as such connections would increase hum level. In some gram decks it may be found that the pick-up cartridge connects to a tagstrip via an unscreened twisted pair. In this case, the insulated screened lead would be used to couple the tagstrip to C_1 and C_2 in the amplifier.

C_1, C_2 and C_7 are mains isolating capacitors and it is essential that they be new and reliable components with an a.c. working voltage of 300 *or more. Do not use "surplus" or second-hand components in these positions.* These capacitors should be wired up such that they cannot be accidentally short-circuited by a piece of bare wire ½in long. To satisfy this requirement C_7 may be "strung" between the two chassis. Similarly, the left-hand lead-outs of C_1 and C_2 (see Fig. 1) may project away from the amplifier chassis rather than be returned to a standard tagstrip mounted on that chassis.

Fig. 1 illustrates the mains connections applicable to a 3-way mains plug. This is the preferable method of connection, since it ensures that the gram chassis is reliably earthed. If a 2-way plug has to be employed, only the live and neutral supply leads are used, the earth lead being left unconnected. It may be necessary to reverse the mains plug in order to reduce hum when a 2-way plug is employed. Connections to the mains supply are discussed further at the end of this article.

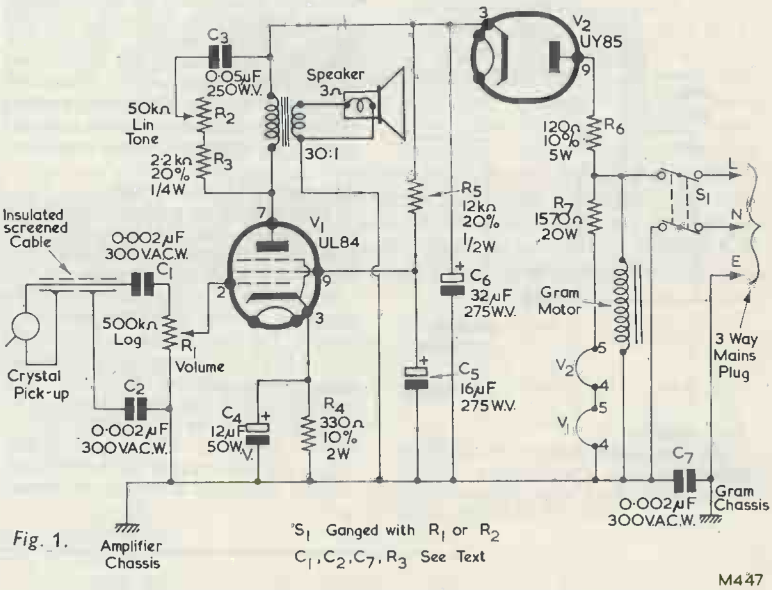


Fig. 1.

The Speaker and Cabinet

Because of the live amplifier chassis, the record player will need to be fitted in a wooden cabinet which meets the isolation requirements just detailed. Such a cabinet will also, of course, house the gram deck as well.

The cabinet will function as an enclosure for the speaker, and should closely approach an infinite baffle (i.e. it should almost completely enclose the rear of the speaker) in order to partially restore the bass lost in the grid circuit of V_1. With some cabinet layouts the near-infinite baffle effect will be given when the cabinet lid is closed. A reasonably sensitive speaker is required, and it can consist of any inexpensive unit between four to six inches in diameter, or an equivalent elliptical unit.

The amplifier dissipates some 40 watts of heat (R_7 alone dissipates nearly 16 watts) and it will be necessary to provide a means of ventilation. Fortunately, the volume of air in the average record player cabinet is large in proportion to that of an amplifier employing the circuit of Fig. 1, and it is fairly simple to provide the requisite ventilation apertures at convenient points.

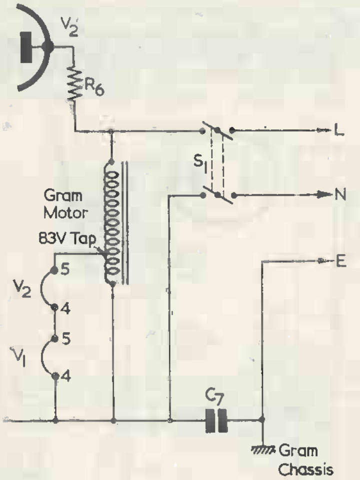


Fig. 2.

Performance

As was stated earlier, the amplifier should give a comfortable volume when driven by a high-output crystal pick-up of the type fitted to most popular 4-speed gram decks and auto-changers. If it is desired to check the output level of a particular pick-up before commencing on the construction of the amplifier, this may be done by using a temporary mock-up of the circuit with such components as C_3, R_2 and R_3 omitted. Alternatively, the pick-up may be temporarily applied to the output pentode grid circuit of a conventional mains radio receiver. The output pentode stage of such a receiver should offer a degree of gain fairly close to that given with the present amplifier.

When completed, it will be found that the amplifier causes a perceptible hum level to be heard in the speaker, although this should be unnoticeable when a record is played at normal level. Sound quality should be adequate, considering the limitations of the circuit, and will of course be equivalent to that given by commercially manufactured record players employing the same type of amplifier.

Alternative Heater Supply

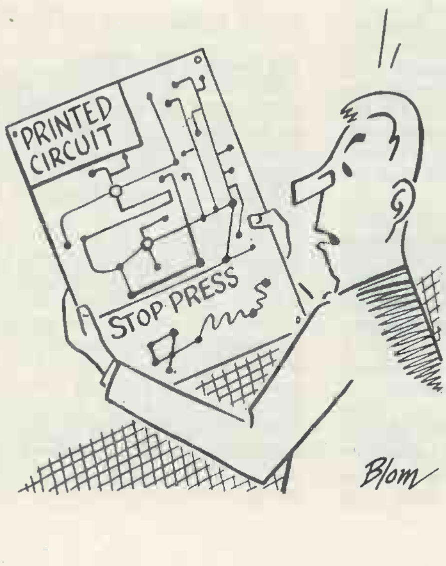
The motors in a large number of gram decks and auto-changers supplied to record player manufacturers nowadays have an 83 volt tap (or "80 volt tap") in the windings. The function of this tap is to provide a supply for the heaters of a UL84 and UY85 in series. If the home-constructor obtains a gram deck having such a tap the heaters of V_1 and V_2 may be connected up as shown in Fig. 2. The circuit of Fig. 2 has the advantages of deleting the heater dropper, R_7, and of consequently reducing the overall heat dissipated by the amplifier.

British Standard 415

The isolating capacitors employed in the present circuit have values considerably lower than those used in many commercially manufactured record players currently on sale or in production. British Standard 415:1957 (Safety Requirements for Radio or other Electronic Apparatus) lays down that the leakage current to earth from the whole group of terminals intended for the connection of modulating apparatus (in this case, the pick-up) shall not exceed 2mA. For a 250 volt mains supply, this corresponds to a total isolating capacitance of 0.0025μF. The present circuit meets the 2mA requirement provided that the connections to the pick-up cannot be touched by the user, whereupon the only component providing isolation is C_7.

Many commercial manufacturers employ isolating capacitors having an a.c. working voltage of 300, as are specified here, but such capacitors do not meet all the voltage requirements in B.S.415. Specially produced ceramic isolating capacitors which meet the specification, and which are usually marked "B.S.415", are available to manufacturers but not, so far as the writer is aware, to the home-constructor.

The present circuit meets the requirements of B.S.415 if the connections to the pick-up cannot be touched by the user and if the connection to the mains is via a three-way socket which causes the gram chassis to be reliably earthed.



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A Decibel Meter

By T. W. CARREYETT, GRAD. BRIT. I.R.E.

THIS ARTICLE DESCRIBES THE DESIGN, TOGETHER with some development notes, of a rather special type of peak valve voltmeter. The output meter is calibrated in decibels on a linear scale over a 10dB range. The full reading of the meter could cover about a 25dB range, but the output circuit alignment has been concerned with obtaining the maximum linear decibel scale only. As the decibel is proportional to a given change in a ratio of two powers, and since one of these powers is the reference power, calibration to such a reference power has been left to the user who can mark or note a position on the output meter for such an input. The standard reference power is 1mW developed across 600Ω. Therefore, if the output meter is marked for an input of 0.775V across a 600Ω load, this point can always be referred to as a decibel zero level. In the prototype, with 60dB of attenuation built-in, the sensitivity could be adjusted to obtain a centre reading on the output meter when zero level was applied.

The sensitivity catered for in the instrument is from 1mV to 25V. This range has been well covered as, with maximum sensitivity, readings below 1 mV can be taken and, with full attenuation, input volts well above 25V can be read off. Within this range lie the general responses of most equipment whose outputs are generally calculated in decibels. On the maximum sensitivity range responses of pick-ups, tape heads, microphones, and the like, can be read directly off the meter. With the use of the attenuators responses of pre-amplifiers (for a variety of inputs) or power amplifiers can easily be calibrated.

The input of the meter consists of two attenuators, between which a series of taps in 2dB steps enables a selection from 0–98dB to be built into the input circuit and read off from the attenuators. This wide range of attenuation is useful in checking the response of filters, transformers and attenuators, etc. As the amplifier has a gain of over 60dB the meter can also be used for checking on signal-to-noise ratios, and with the use of a couple of parallel 'T' filters simple intermodulation and harmonic distortion tests can be carried out as well.

Readers will probably think of many other useful tests for which the meter can be used to gather interesting information, and these could include loudspeaker responses (the prototype had no loss in its response at 10 c/s), or cross-talk measurements between circuits or tape tracks. It was with the view of tackling these type of tests that the author developed the present instrument. Some references of circuit information are given at the end of the article.

The block layout of the meter is shown in Fig. 1. As can be seen from this the input signal is applied through an attenuator. The attenuator comprises two circuits, one working in steps of 20dB from 0dB to 80dB, and the other in steps of 2dB from 0dB to 18dB. The total amount of attenuation which can therefore be built into the circuit is 98dB. Following the attenuator is an amplifier, the gain of which is about 60dB, and which incorporates a sensitivity control. The output of the amplifier is taken from a see-saw phase inverter and the balanced

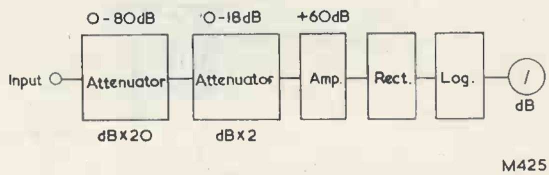
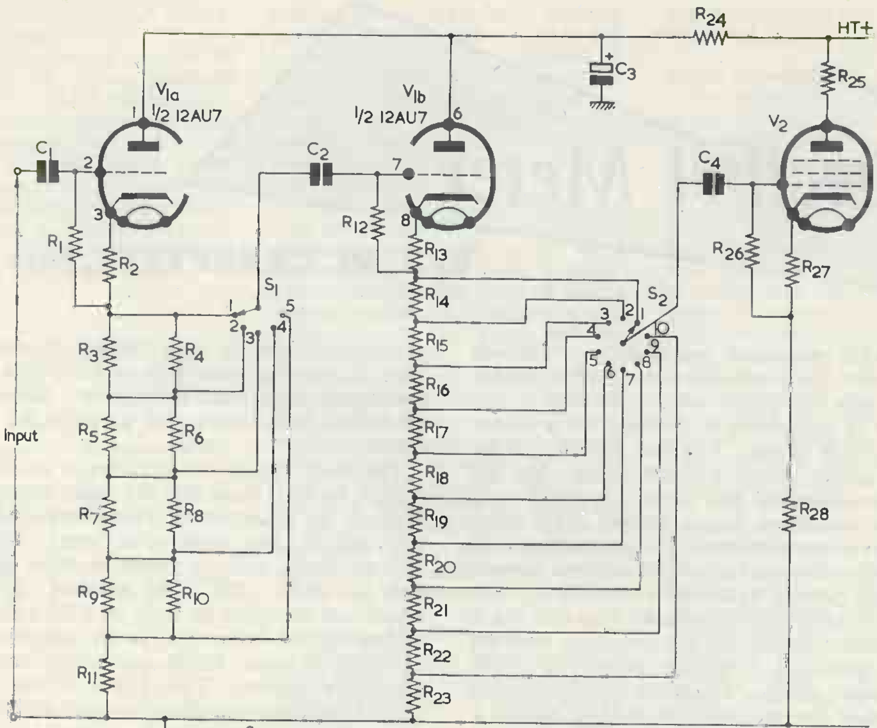


Fig. 1. Block layout of the meter

two-phase output applied to a full-wave diode rectifier circuit. The smoothed d.c. voltage is the peak output for the input signal, and this is now used as bias to operate a variable-mu pentode. The pentode characteristic is aligned to enable it to operate as a logarithmic stage. The output meter is connected in the anode circuit of the pentode and registers, over a reasonable part of its scale, the logarithm of the applied d.c. input. Because of this characteristic the scale may be calibrated in decibels, a fair proportion of the scale being linear.

The Attenuator Circuit

The input to the meter is provided by the attenuators, these being built into two cathode-follower stages as shown in Fig. 2. The input impedance is quite high (10MΩ), thus avoiding any insertion losses which could give false results. The attenuation required is selected from a tapping in the cathode load. The series of tappings of the first cathode load has been arranged to give 20dB steps.



S_1

dB loss	Position
0	1
20	2
40	3
60	4
80	5

S_2

dB loss	Position
0	1
2	2
4	3
6	4
8	5
10	6
12	7
14	8
16	9
18	10

M426

Fig. 2. The attenuator circuits. V_2, C_4 and R_{25} to R_{28} are part of the amplifier circuit and appear also in Fig. 3

The second cathode follower is designed from the same principles, with its load arranged to provide tappings in 2dB steps.

The loss for the attenuators was derived as follows. Since the loss in decibels is 20 $\log_{10}$ voltage ratio and since the current through the cathode load and tapping points will be the same, then in place of voltage ratio resistance ratio can be used. Therefore, with reference to the standard dB voltage ratio tables, the required resistance values can be found. For example, to find the required tapping point from a 100kΩ load to produce an attenuation of 18dB a voltage ratio of 7.94 is required. In consequence, $\frac{100\text{k}\Omega}{\text{Rx}} = 7.94$ and $\text{Rx} = \frac{100}{7.94}$ so that Rx is 12.6kΩ. All other values are found from the same principle.[1] Since a voltage ratio of 10 corresponds to 20dB the required resistance ratio for the 20dB tapping points is therefore 10, and since the load value is 100kΩ, for a loss tapping point of 20dB the required resistance tap will be a $\frac{100\text{k}\Omega}{10}$ or 10kΩ.

The 40dB tap will be at $\frac{100\text{k}\Omega}{100}$ or 1kΩ and so on.

The attenuator resistors can be built around the switches and the entire assembly should then be well screened.

The insertion loss introduced by each attenuator stage was found to be about 1.5dB. So the total loss to be accounted for in the subsequent amplifier due to these stages was 3dB only which, of course, presented no problems. The frequency response of the attenuator stages was found to be satisfactory from 10 c/s to 60 kc/s. Also, no signal distortion was introduced with amplitudes ranging from 1mV to 25V. The output from the attenuator stage is fed into the amplifier, the time constant of the

[1] A possibly simpler approach would consist of using tables which give ratios less than unity. Thus, the voltage ratio for 18dB is0.126, and the corresponding resistor in a 100kΩ chain would then be 12.6kΩ.—*Editor*.

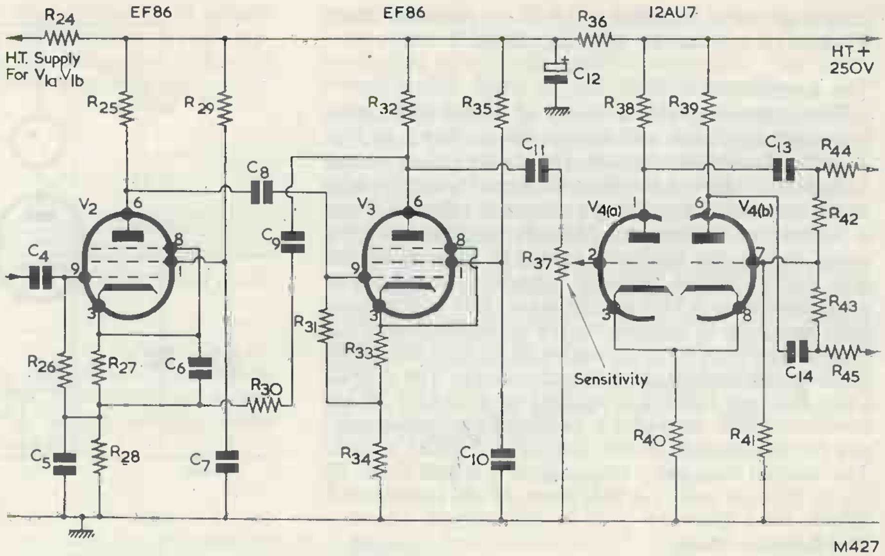


Fig. 3. The amplifier

Components List

Resistors (all ¼W 10% unless otherwise stated)

R_1	10MΩ 20%	
R_2	3.9kΩ	
R_3, R_4	180kΩ	Close tolerance, according to meter accuracy required
R_5, R_6	18kΩ	
R_7, R_8	1.8kΩ	
R_9, R_{10}	180Ω	
R_{11}	10Ω	
R_{12}	1MΩ 20%	
R_{13}	3.9kΩ	
R_{14} to R_{23}	See table. Close tolerance, according to meter accuracy required	
R_{24}	5.6kΩ 20%	
R_{25}	220kΩ	
R_{26}	1MΩ 20%	
R_{27}	2.2kΩ	
R_{28}	100Ω	
R_{29}	1MΩ	
R_{30}	100kΩ	
R_{31}	1MΩ 20%	
R_{32}	220kΩ	
R_{33}	2.2kΩ	
R_{34}	100Ω	
R_{35}	1MΩ	
R_{36}	8.2kΩ 1W 20%	
R_{37}	1MΩ potentiometer, log.track	
R_{38}, R_{39}	100kΩ matched 5%	
R_{40}	2.2kΩ	
R_{41}, R_{42}, R_{43}	270kΩ matched 5%	
R_{44}, R_{45}	100kΩ matched 5%	
R_{46}	2.7MΩ	
R_{47}	2.5kΩ potentiometer, wirewound	
R_{48}	82kΩ	
R_{49}	47kΩ	
R_{50}	50kΩ potentiometer, linear track	
R_{51}	47kΩ	

Capacitors

C_1, C_2	0.1μF
C_3	16μF electrolytic, 275 w.v.
C_4, C_5	0.1μF
C_6	0.01μF
C_7	0.5μF
C_8	0.1μF
C_9	2μF paper
C_{10}	0.5μF
C_{11}	0.1μF
C_{12}	16μF electrolytic, 275 w.v.
C_{13}, C_{14}	0.5μF
C_{15}	0.1μF

Valves

V_1	12AU7
V_2, V_3	EF86
V_4	12AU7
V_5	EB91
V_6	EF92

Meter

0–1mA meter

Switches

S_1	1-pol[illegible]
S_2	1-pole 10-way

TABLE

Resistor		*Suggested preferred values (kΩ) in parallel to produce desired resistance*
R_{14}	20.6kΩ	56 and 33kΩ
R_{15}	16.4kΩ	180 and 18kΩ
R_{16}	13kΩ	100 and 15kΩ
R_{17}	10.2kΩ	68 and 12kΩ
R_{18}	8.2kΩ	—
R_{19}	6.6kΩ	15 and 12kΩ
R_{20}	5.2kΩ	22 and 6.8kΩ
R_{21}	4kΩ	10 and 6.8kΩ
R_{22}	3.2kΩ	18 and 3.9kΩ
R_{23}	12.6kΩ	82 and 15kΩ

coupling being arranged so that frequencies down to about 5 c/s can be accommodated.

The Amplifier

The main amplifier consists of two EF86's with interstage feedback and the circuit is shown in Fig. 3. The feedback extends the range from about 15 kc/s to 40 kc/s, a further extension to over 50 kc/s being arranged by peaking capacitors. One of these is connected across the cathode resistor and the other across the feedback injection resistor of the first EF86. These peaking capacitors cause some overshoot on a 4 kc/s square wave, but at the same time they help to provide a reasonable flat frequency response for sine waves to above 60 kc/s for the entire amplifier (including the phase inverter). The output from the two EF86's is applied to a 12AU7 phase inverter, which provides a balanced two-phase output for application to the full-wave rectifier circuit. The overall frequency response is ±0.2dB from 10 c/s to 20 kc/s and ±0.5dB from 25–60 kc/s.

The Rectifier Stage

The rectifier stage is shown in Fig. 4. The circuit is conventional and has no other purpose than to rectify the input signal. A full-wave diode rectifier was used in order to maintain a reasonably linear response from about 5 c/s, as at such low frequencies the linearity of a half-wave circuit tends to fall off. The reliability of a thermionic diode was also favoured as the meter may be damaged if a diode failed. The d.c. output from the rectifier is taken from the anode load, where it is smoothed by a 0.1μF capacitor. The negative voltage output is then applied to the logarithmic stage. A negative voltage output was chosen so as to form a meter guard.

The Logarithmic Stage

The logarithmic stage, which is shown in Fig. 5, is virtually a d.c. amplifier arranged with a logarithmic characteristic. The search for a suitable valve was very soon narrowed down on looking at the characteristic curves for variable-mu pentodes, the final choice being an EF92. By adjustment of the screen voltage, this EF92 characteristic can be arranged to provide a good approximation to a logarithmic curve over a reasonable range. Therefore the output current will be approximately the logarithm of the applied input voltage, and can be read off in decibels by a milliammeter connected in the anode circuit. A total range of about 25dB can be accommodated on the scale of which 10dB is linear. Since only a small accurate range was required a span of 10dB was quite adequate, larger measurements being made with the aid of the attenuators. The meter used has a f.s.d. of 1mA and the Adjust Zero control is adjusted for f.s.d. with zero signal input. The negative voltage applied to the grid of the EF92 biases back the valve, reducing the anode current. From the valve curves it can be seen that, with an anode voltage of 250V and a screen voltage of 150V, the first part of the curve appears to be more linear than logarithmic. However, from about 0.7mA a slope approximating to a logarithm curve is found. The point of using a negative bias voltage is that this automatically provides a meter guard, since any high input peaks will only drive the meter towards its mechanical zero.

As a guide to the alignment of this stage the following readings were taken after aligning the logarithmic stage in the prototype:

H.T. rail	260V
Anode	160V
Screen	150V

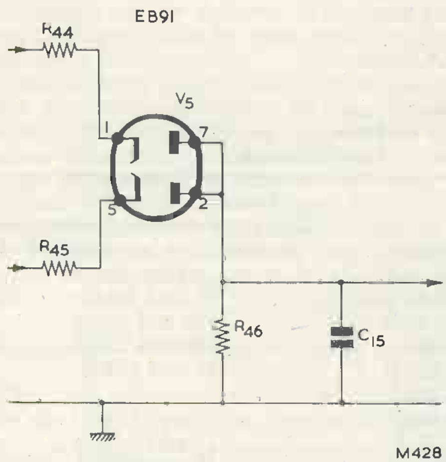


Fig. 4. The output of the amplifier is applied, via R_{44} and R_{45}, to the rectifier stage, shown here

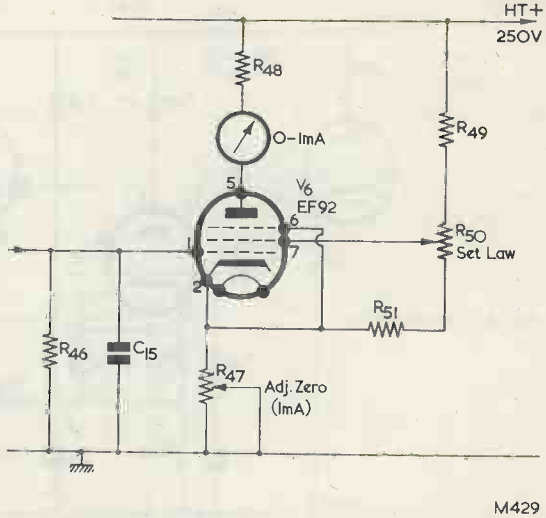


Fig. 5. The logarithmic stage. The rectified peak voltage appears across R_{46} and C_{15} (Fig. 4) and is applied to G_1 of V_6

These readings were given with G_1 taken to chassis via a 2.7MΩ resistor in parallel with a 0.1μF capacitor. The meter readings for changes of 2dB were as follows, 0.5mA corresponding to zero dB:

dB	mA	dB	mA
0	0.5	0	0.5
−2	0.6	+2	0.4
−4	0.68	+4	0.3
−6	0.74	+6	0.2
−8	0.82	+8	0.12
−10	0.87	+10	0.05

With the meter aligned to 0.4 a fairly linear scale of ±5dB is given.

Power

The power requirements call for an h.t. voltage of 250 and a current of 8mA. A humdinger across the heater supply may be found helpful when operating at maximum sensitivity.

General Points

If the attenuator having the 2dB steps is to be used with low inputs of 1mV it will be advisable to use the best resistors one can afford, for here is a stage that can really make a lot of noise on a low level input if noisy resistors are used. It may be preferable to use high stability resistors. The same remarks also apply to the 20dB attenuator.

Another point is that the attenuator circuits including the switch, should be well screened with the shortest run of input cable possible. The input cable should come directly into the attenuator without going through input terminals if the high input impedance is to be preserved.

The accompanying table shows suggested values of resistor for making up the resistors in the 2dB chain. Thus, the 20.6kΩ resistor may be provided by a 56kΩ and a 33kΩ resistor in parallel. No parallel combination is needed for the 8.2kΩ resistor, as this is already a preferred value. The figures in the table give a very close approximation to the required value.

References

Studio Engineering, B.B.C. Training Staff (Iliffe)
Vacuum Tube Voltmeters, J. F. Rider (J. F. Rider Publications)

Book Reviews . . .

THE ELECTRONIC MUSICAL INSTRUMENT MANUAL. By Alan Douglas, M.I.R.E., M.A.I.E.E. 302 pages, 5½ x 8¾in. Published by Sir Isaac Pitman & Sons Ltd. Price 37s. 6d.

Some years ago, the reviewer had the experience of being shown around an electronic organ factory. At the end of the assembly line was a test room in which each organ was brought up to peak performance by a competent musician who was also an electronic engineer. The concept of someone laying down a testmeter to play a snatch of Bach conveys only some of the fascination which exists in this combined world of electronics and music.

The book under review, now in a revised and enlarged fourth edition, covers all important facets of electronic musical instruments including, in particular, the electronic organ and allied instruments. Its chapters cover conventional multi-note instruments; the production and mixing of electrical oscillations; amplifiers, tone controls and loudspeaker equipment; commercial electronic instruments; and experimental methods of tone generation. The section on commercial instruments has no less than 108 pages devoted to it, and these include full circuit diagrams, of which nine are printed on insets folded into the leaves of the book.

The Electronic Musical Instrument Manual is a book which can be read with pleasure by any engineer who is interested in unusual applications for valves or transistors, and it is an essential work for those who are active in the field of electronic instruments. It is admirably set up, provides extensive references, and is generously illustrated.

RADIO ENGINEERING FORMULAE AND CALCULATIONS. By W. E. Pannett, A.M.I.E.E. 216 pages, 4¾ x 7¼in. Published by George Newnes Ltd. Price 21s.

Radio Engineering Formulae and Calculations now appears in its second edition, a new section on Sound Reproduction having been added to the 1959 first edition, together with the amendment of several examples. The book is aimed primarily at the practising engineer who, because of preoccupation with administrative, constructional or maintenance work, has allowed his earlier skill in handling formulae and calculations to become dulled. It can, however, be of equal value to the junior engineer and the student.

This book is attractive because it compresses, in a non-bulky volume, a very large mass of formulae and allied information. Whenever a formula is introduced, worked examples follow with each step clearly shown. The range covered is very diverse, and includes such subjects as the sag of the wire rope holding a curtain aerial under wind load to the formulae needed for calculating crossover network components in a high fidelity loudspeaker system.

TELEVISION RECEIVER SERVICING, Volume Two, Second Edition. By E. A. W. Spreadbury, M.Brit.I.R.E. 475 pages, 5½ x 8½in. Published by Iliffe Books Ltd. Price 35s.

Television Receiver Servicing is a comprehensive work in two volumes, of which Volume Two has now been published in its second edition. The second edition of Volume One was reviewed in our August 1961 issue.

The present edition of Volume Two has been brought up to date and covers the video stage, tuning circuits, sound channel, and power supplies of the television receiver. There is also a large section devoted to aerials, aerial installations, and signal distribution systems. A short chapter at the end of the book compares 625 and 405 line operation and refers to the effect on service work of the increased number of lines.

The text is aimed primarily at service engineers who already have a reasonably good grasp of radio servicing principles, and illustrates the fact that the author is fully conversant with the day-to-day problems and activities of a practical service workshop.

A VALVE TESTER DESIGN

By P. A. Robinson

Commercially manufactured valve testers offering a comprehensive number of checks are expensive, but they are nevertheless of considerable use to the amateur. The writer, who had been requiring a valve tester for a considerable time, decided to build one himself, and the resulting instrument is the subject of this article. The complete tester offers a considerable number of checks, these including mutual conductance, inter-electrode leakage and emission. The valve under test may also be made to function as an a.f. amplifier, signal input being provided either by a small medium-wave receiver or by a neon oscillator. Many other checks are possible by reason of the extreme flexibility of the design.

An important feature of the tester is the use of terminals and flying leads for interconnection between the valveholders and the power supply and test components. These enable any test circuit within reason to be rapidly built up and applied to the valve for a speedy examination of its capabilities.

Apart from the mains transformer, which was specially wound, nearly all the components employed in the writer's unit were obtained from salvaged or ex-Service equipment, and the cost of construction was extremely low.

Basic Layout

As may be seen from the illustrations, the unit is built into a small wooden case. This was an ex-W.D. spare valve box, with internal dimensions of 6½ x 6 x 8½in, plus a further 1⅜in depth in the lid. The valveholders are mounted on one side and a control panel fitted at the top. The pins on the valveholders are wired to a set of terminals numbered 1 to 9, each terminal corresponding to the similarly numbered pins of the valveholders. Terminal 10 connects to centre spigots, where applicable. Also appearing on the panel are terminals carrying different services, and these are coupled to the numbered valveholder terminals by flying leads as required. Thus, a very large number of different circuit combinations may be set up at will. Also available at the panel is a continuously variable heater voltage with potentials up to 51 volts, and two potentiometers which may be conveniently wired in for specific checks. A further set of terminals offers a typical a.f. amplifier anode circuit, whilst a socket provides an audio output from a neon oscillator. Two wander plugs and sockets enable h.t. rectifiers to be checked in a working circuit. One further terminal is blank, and provides an anchor point for components or wiring. An external meter (or meters) is employed with the tester, this being connected into circuit as required. Another facility consists of the provision of a small medium-wave crystal receiver in the lid of the case. This enables speech and music to be fed into a valve under test and offers a particularly useful check on the functioning of the valve as an audio amplifier.

The whole basis of the tester rests on the fact that any circuit required by the user may be quickly wired up and put into practice. In the prototype, the writer went to considerable trouble to obtain old-fashioned pillar-type terminals for the panel as, in his opinion, these are far and away the best for this particular job.

The Power Supply

The power supply circuit is given in Fig. 1. In this diagram, a mains transformer has an h.t. secondary offering 240 volts at 100mA, and an l.t. secondary offering 6.3, 21 and 51 volts at 1A. The h.t. secondary is applied via rectifier W_1 to the reservoir capacitor C_1, the rectifier being connected into circuit via wander plugs and sockets. The

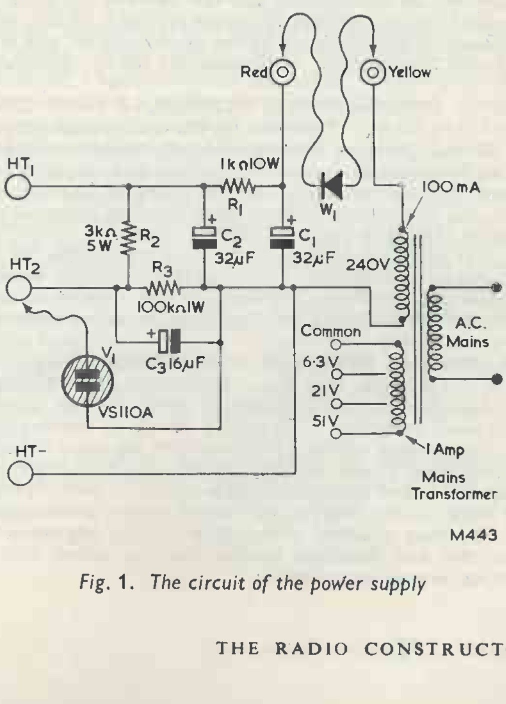


Fig. 1. The circuit of the power supply

rectified h.t. voltage across C_1 is smoothed via R_1 and C_2 and is applied to the h.t.+1 terminal. This offers an output of some 250 volts.

An h.t.+2 terminal is also provided, this being connected to C_2 by way of R_2 and C_3. The voltage available here is of the order of 220 volts, but this drops to a stabilised 110 volts when the wander lead from the VS110A stabiliser is connected to the terminal. The stabilised h.t. facility is not essential but was included for two reasons. Firstly, it was felt that mutual conductance tests for an anode voltage of 100 would be desirable, and the VS110A gives a voltage of 110, which is sufficiently near this figure for most rough practical work. Secondly, as will be seen later, the 110 volt potential is extremely useful for checking inter-electrode insulation.

The l.t. secondary of the transformer is applied to four terminals on the panel, these being labelled with the appropriate voltages. Adjacent to these terminals is an 80Ω heater shunt resistor wound on a flat strip of mica and fitted with two flying leads.

In use, the valve to be tested is plugged into the appropriate socket and two flying leads terminated in crocodile clips connected to the terminals corresponding to the heater pins. Also connected across these terminals is an a.c. voltmeter, the type employed by the writer being a Universal Avominor. The ends of the shunt resistor are connected to the appropriate l.t. secondary terminals, and the two heater crocodile clips are then applied experimentally to the shunt resistor until the required heater voltage is obtained. This process is quite quick but it is advisable, of course, to commence with the crocodile clips close together and to keep a watchful eye on the meter. For 6.3 volt valves the shunt resistor is not needed, the valveholder heater terminals being connected direct to the 6.3 volt secondary terminals.

This method of heater voltage selection satisfies all valves with heater requirements up to 50 volts, and offers an extremely cheap and simple solution to the heater voltage problem which appears in all valve testers. It is preferable not to use the shunt resistor with 1.4 volt battery valves, and for these a separate dry cell should be employed.

The shunt resistor employed by the writer was home-constructed and employed wire taken from a 750 watt bowl fire replacement element purchased at Woolworth's stores. The wire was wound on to a stout mica strip measuring 2 x 6¾in. No attempt should be made to straighten out the spiral wire before winding on to the mica strip because it is too tough and springy. Instead, the wire should be wound directly on to the mica straight from the spiral. The wire is pulled through the finger and thumb held together as tightly as possible, whereupon the spiral uncoils itself against the other side of the finger and thumb.

In the writer's tester the power supply circuit was mounted on its own baseboard (see illustration), this being then fitted to the bottom of the case; also shown is the terminal panel, the valveholder panel, and the heater shunt resistor.

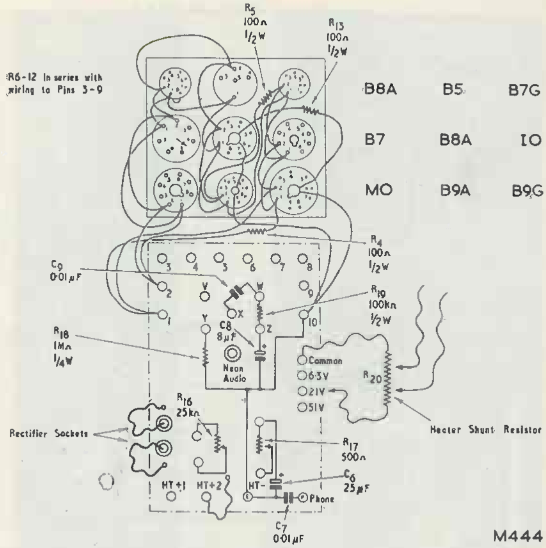


Fig. 2. Top panel and valveholder wiring

Testing H.T. Rectifiers

It is possible to test h.t. rectifiers by connecting these into circuit in place of the power supply rectifier, the wander plugs for the latter being removed from their sockets. The rectifier to be tested is then connected to these sockets. A metal rectifier may be connected directly, whilst valve rectifiers will require a heater voltage which may be obtained from the shunt resistor. The heater should not, of course, be connected to the h.t.−terminal

Testing the triode section of an ECL80

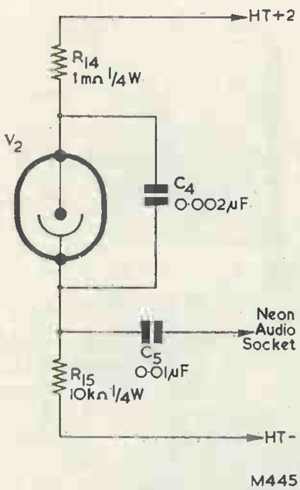


Fig. 3. The neon audio oscillator

with directly heated rectifiers although it may be so connected if the cathode-heater insulation of indirectly heated rectifiers allows the rectified h.t. voltage to appear between these two electrodes. Great care should be taken to ensure that the rectifier is connected with correct polarity as, otherwise, the electrolytic capacitors in the tester will break down, with resultant damage to the mains transformer and the rectifier itself.

A suitable load resistor may be connected between the h.t.+1 and h.t.− terminals, a testmeter switched to the requisite current range being inserted in series. The load resistor should have a value applicable to the rectifier being tested. It may also be necessary to insert a limiting resistor in series with either the anode or cathode of the rectifier under test, and the value required here may be determined from the literature for the valve. Mains transformer losses will provide a limiting resistance on their own and this may be roughly assessed by measuring the resistance of the secondary winding. The physical limiting resistor inserted in series with the rectifier under test may then have a value equal to the limiting resistance specified for the valve minus that of the secondary winding.

If a good quality rectifier is employed in the tester, it can provide a useful basis of comparison with the rectifier under test.

Testing for Cathode-Heater Leakage

A simple and effective method of checking for cathode-heater leakage consists of connecting the VS110A stabiliser to the h.t.+2 terminal and applying this voltage, via a series 22kΩ resistor and a testmeter switched to read 5mA f.s.d. or more, to the cathode. The heater is connected to the h.t.− terminal. With this arrangement short-circuits which appear only when the valve under test has really warmed up can almost be "seen" coming on. This test may also be carried out with the heater positive and the cathode negative.

Short-circuits between other electrodes may similarly be detected by use of the 110 volt h.t. supply together with the series resistor and meter.

Connections to the Valveholders

It was intended with this valve tester to not only take static readings of valve characteristics but also to have provision for running valves under dynamic conditions, such as would be given by operating them as a.f. amplifiers and the like. Initially, this proposed method of working was unsuccessful as, due to the considerable amount of wiring around the valveholders, it was almost impossible to eradicate instability. The writer contacted the Automatic Coil Winder & Electrical Equipment Co. Ltd., who very kindly sent a detailed description of a method used by them many years ago when they developed their first valve testers and encountered the same trouble.

The scheme is very simple and very effective. It consists of making any wiring associated with the valveholder pins and their junction block terminals into a "ring main", and of inserting at some convenient point in each "ring" a 100Ω resistor. This resistor damps down surges in its "ring" and so prevents feedback via the wiring.

In the writer's tester this wiring method was adopted, and Fig. 2 illustrates the "ring main" wiring for pins 1 and 2 and the centre spigots. Other pins are wired up to their terminals in the same manner.

The Neon Oscillator

A neon oscillator circuit is employed in the tester and is incorporated in the power unit. It employs the circuit given in Fig. 3.

The a.f. output from the neon oscillator is applied via C_5 to the a.f. output socket on the panel situated midway between terminals Y and Z.

Panel Components

A number of components are fitted to the panel terminals to facilitate testing and to enable circuits to be quickly set up. These are shown in Fig. 2.

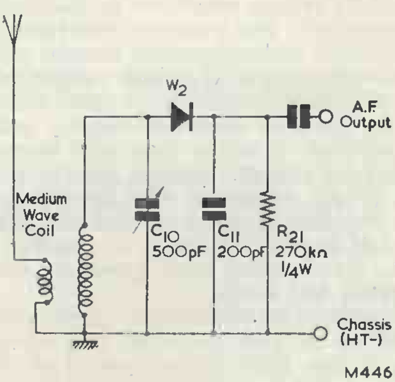


Fig. 4. The crystal receiver circuit

The first of these to consider is R_{16}. This is a 25kΩ variable resistor and may be employed to vary the h.t. voltage applied to the anode of a valve under test. R_{17} is a 500Ω variable resistor and will normally be interposed between the h.t.— terminal and the cathode of the valve under test. It may then be adjusted to provide different values of bias for the valve, either for static or dynamic testing. The cathode of the valve is automatically decoupled by C_6 when this method of connection is adopted.

Resistors R_{18} and R_{19}, together with capacitors C_8 and C_9, are also permanently wired on to the panel, these connecting to the h.t.— terminal and to terminals W, X, Y and Z, as shown in Fig. 2. The values of R_{18}, R_{19} and C_8 are typical of those employed in normal a.f. amplifying circuits, in which R_{18} would function as a grid leak, R_{19} as an anode load resistor and C_8 as an h.t. decoupling capacitor.

Terminal V is blank, and may be employed for anchoring purposes.

The Crystal Receiver

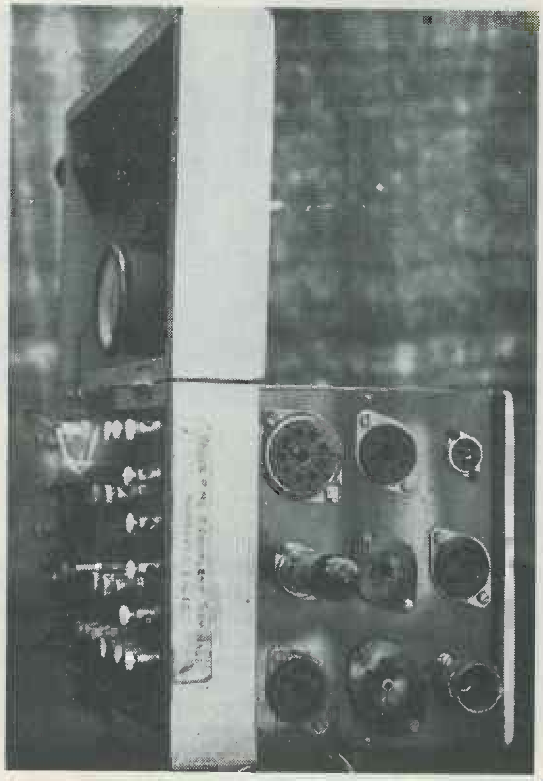
The crystal receiver is included merely to provide an inexpensive source of speech or music for testing purposes. Its circuit is given in Fig. 4 and, as may be seen, it is quite straightforward in design.

The components are mounted on the lid of the unit.

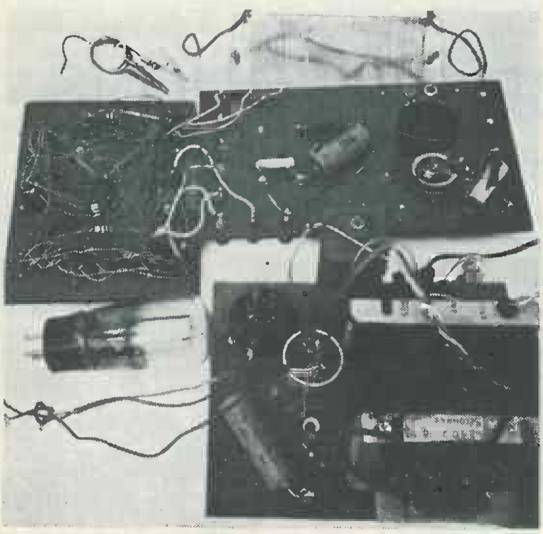
Testing a Valve

When a valve is to be tested, its pin connections and electrode potentials are checked in the appropriate literature and it is plugged into the tester. Connections are then made to the terminals as applicable, after which the correct heater voltage is set up in the manner described earlier.

The tests which follow depend upon the constructor's requirements, it being remembered that the flexibility offered by the terminal connections enables many different circuit combinations to be quickly set up. With the aid of an external meter, or meters, static checks can be carried out. These include tests for emission and mutual conductance. The latter may be checked by measuring the change in anode current against change in grid voltage, the latter being varied by adjusting R_{17}.



The valveholders mounted on the side of the tester



The basic components of the tester

Dynamic tests at a.f. can also be carried out, a particularly useful check consisting of testing as an a.f. amplifier. For this, the grid of the valve is coupled to terminal Y and the anode to terminal W. Terminal Z is then connected to the h.t.+1 or h.t.+2 terminal, the latter being stabilised or not according to requirements. R_{18} now functions as a grid leak and R_{19} as an anode load. The output from the neon oscillator or crystal receiver is then applied to the grid. One of the leads from a pair of high impedance headphones is next connected to the Phone terminal shown in Fig. 2. To evaluate the degree of amplification given, the remaining headphone lead is applied to the valve grid, at terminal Y, and to its anode, at terminal X. In both instances, the headphones are isolated from the flow of direct current by C_7. They are also isolated from the h.t. positive potential on the anode by C_9. When the headphones are connected to terminal X, the effects of varying bias may be judged by adjusting R_{17}.

Final Points

Several points need to be dealt with before finally concluding.

The first of these is that there is, of course, no necessity to fit the valve tester into the particular case chosen by the writer. Any suitable housing can be employed, and it may be found that wiring is simpler to carry out if terminals, sockets and valveholders are all mounted on a single panel.

Secondly, the use of terminals allows flexibility together with a considerable saving in cost as compared with a tester employing switching. A little practice soon makes the user familiar with the terminals, and initial checks can be made with valves already in stock. It is helpful to provide a circuit diagram in the lid which shows the terminal functions, and this can consist of a reproduction of Fig. 2 without the valveholders or the wiring thereto from terminals 1, 2 and 10.

Components List

Resistors

R_1	1kΩ 10W
R_2	3kΩ 5W
R_3	100kΩ 1W
R_{4-13}	100Ω ½W
R_{14}	1MΩ ¼W
R_{15}	10kΩ ¼W
R_{16}	25kΩ w.w. potentiometer
R_{17}	500Ω w.w. potentiometer
R_{18}	1MΩ ¼W
R_{19}	100kΩ ½W
R_{20}	Heater shunt resistor (see text)
R_{21}	270kΩ ¼W

Capacitors

C_1	32μF 350 w.v. electrolytic
C_2	32μF 350 w.v. electrolytic
C_3	16μF 350 w.v. electrolytic
C_4	0.002μF mica or paper
C_5	0.01μF paper
C_6	25μF 25 w.v. electrolytic
C_7	0.01μF paper
C_8	8μF 350 w.v. electrolytic
C_9	0.01μF paper
C_{10}	500pF variable, solid dielectric
C_{11}	200pF mica

Miscellaneous

V_1	Stabiliser type VS110A
V_2	Neon bulb
W_1	Metal rectifier, 250V 100mA
W_2	Crystal diode, OA71 or equivalent

Mains transformer: Non-standard, specially wound for tester. Secondaries: 240V at 100mA; 0–6.3–21–51V at 1A

Medium-wave coil with coupling winding

Valveholders—as required

27 pillar-type terminals

3 sockets

3 wander plugs

Crocodile clips, flexible connecting leads, etc.

SEMICONDUCTOR DIMENSIONS

AN AID FOR EQUIPMENT DESIGNERS

As the dimensions of semiconductor devices are an interchangeability feature of importance to all equipment manufacturers, the Electronic Valve and Semiconductor Manufacturers' Association (V.A.S.C.A.) has published a booklet, "Record of Semiconductor Outlines". This contains 43 drawings of semiconductor outlines and bases which have reached an advanced stage of standardisation in the Services, British Standards Institution and the International Electrotechnical Commission.

The primary object of the drawings is to indicate the space which should be allowed in an equipment for the devices and also any other features of importance to interchangeability. This dimensional information should enable equipment designers to achieve a design which allows for the maximum mechanical interchangeability between devices supplied by different manufacturers. The drawings, it is hoped, will also assist makers of accessories.

The booklet, which covers a variety of diodes, transistors, rectifiers and controlled rectifiers, also gives advice on the interpretation of the drawings and includes an explanation of the symbolic names in current use.

There is also an index of cross references to related drawings in K1007, J.E.D.E.C. and I.E.C. documents. The booklet which follows closely on the release of another V.A.S.C.A. publication on semiconductor devices, is produced by V.A.S.C.A. as a service to industry and is being distributed by its members. It can also be obtained from V.A.S.C.A. headquarters, Mappin House, 156-162 Oxford Street, London, W.1, price (prepaid) in the U.K., 7s. 6d. (post free)—overseas 1s. extra towards packing and postage.

Radio Veronica

DURING A RECENT VISIT TO HOLLAND, THE writer had the unique experience of visiting the broadcasting station Radio Veronica which, as some readers are probably already aware, is located on board a ship laying some miles off the Dutch coast. The reason for this unusual location is also possibly known—it is a pirate station, using the term pirate in the same sense as applied to illicit amateur radio transmissions. The story behind this venture, if all the details could be revealed, makes as exciting reading as many a more classical story of piracy on the high seas. Be it sufficient for the moment to say that the whole idea occurred to three Dutch industrialists, whose request to the licensing authority for permission to operate a commercial broadcasting station for advertising purposes, had not unexpectedly been turned down, there being a Government broadcasting monopoly.

In order to surmount this difficulty, the industrialists purchased a ship in a foreign port, fitted her out with a broadcast radio station and then towed her to the present position some six miles off Scheveningen, from where she has radiated programmes of music interspersed with advertisements for the past year or so. To date, none of the authorities concerned have discovered a method of stopping the radiations, although they have made some ingenious attempts to do so!

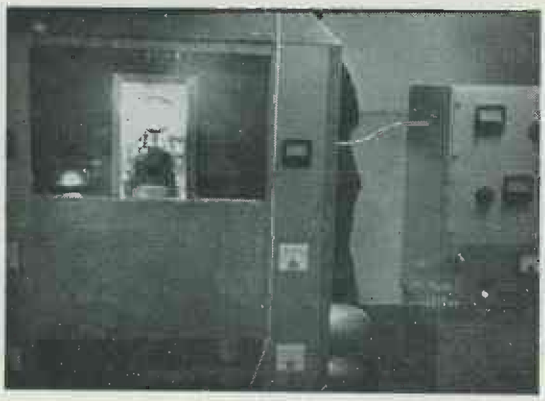
Our trip to Radio Veronica was a memorable one. Having had our passports checked at the small port from which we left, we boarded a small fishing vessel now converted to act as a tender to Veronica. Along with the relief crew, abundant provisions, barrels of oil and some crates of radio equipment, we headed out into the North Sea on a cold and blustery morning. However, the trip out was of no account with the hazards of getting aboard in the rather turbulent sea that was running at the time. The tender came alongside and, as the two ships rose and fell, one had to jump for it at just the right moment—or else! Fortunately we landlubbers just made it!

The vessel is shown in the QSL card illustration. She was originally a lightvessel used by the German Navigational Authority, most of her original engines and equipment having now, of course, been removed. Two diesel generators now provide the quite considerable amount of electric power required to operate the transmitter and other equipment.

A most attractive little studio has been built in what was formerly the main cabin area, this being illuminated from the deck skylights above. As may be seen from the illustration, a console having four

tape decks, switches, control panels, etc., provides for programme and control. All programme material is recorded on magnetic tape ashore and taken out to the ship for subsequent use.

The transmitter has been built into a nearby bay and much of the work on it has been carried out by the radio engineering staff of the vessel. Due to the comparative high power used, together with the added difficulties of damp and confined space, forced air cooling is most extensively used and one of the ducts used for this purpose can be seen in the illustration showing the main amplifying valve.



Radio Veronica transmits on a frequency of 1,563 kc/s with a power of 2.5kW in the aerial. A normal multiwire broadcast aerial is used and some trouble has been experienced with induced current in the wire rigging of the ship, this gradually being overcome by the expedient of putting insulators in all the affected guy wires and stays.

The programmes emanating from Radio Veronica are, of course, in Dutch but despite this they are becoming popular with a wide audience both on the Continent and in this country. Good reception is apparent along most of the south and east coasts of England and reception reports are very welcome. The attractive QSL card will be sent to those who report and the address is: Radio Veronica, Zeedijk 27A, Hilversum, Holland.

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

CR100 Receiver.—J. F. Adams, 54 Richmond Road, Gillingham, Kent, would like to obtain the manual for this receiver, either on loan or purchase.

* * *

A.C. Stabilising Transformer Unit.—L. Abell, 98 Ash Road, Denton, near Manchester, seeks information on this unit, marked SR/T.568T 500V.A. LTP2067, and would appreciate circuit details and original usage.

* * *

Transistor Signal Strength Meter.—E. R. Geyer, Annville, Torryburn, Fife, would like to obtain a circuit for use in setting TV aerials.

* * *

T1941 (T28/APT1) Radar Transmitter.—A. Mirfin, 55 Glen View Road, Greenhill, Sheffield 8, wishes to borrow for a few days the circuit or any other information on this American equipment.

* * *

Gram-Deck.—D. Byrne, G3KPO, Jersey House, Eye, Petborough, wishes to obtain information on this unit and also the Cossor 343 oscillator and the Admiralty Test Set SE2.

* * *

Spencer West TV Model 181.—C. H. Wood, Eastone House, York Road, South Milford, Yorks, requires the loan (or would purchase) the manual or circuit diagram of this receiver. Photostat copy, or any other information would be greatly appreciated—all expenses defrayed.

* * *

Receiver Unit Type 159, Switch Unit Type 35A.—D. G. Chapman, 20 Sackville Road, Hove, Sussex, requires any information available on these units, particularly with regard to connections and power requirements.

* * *

Transistorised Grid Dip Oscillator.—E. L. Simpson, G3GRX, 31 Dukes Road, Hexham, Northumberland, requires any information on the Heathkit G.D.O. or any other transistorised unit having a 500μA meter, also circuit, etc., of a small all-band transmitter built into a TU5 cabinet.

* * *

Test Set 74A.—G. Ferguson, 7 Beech Avenue, Cudworth, near Barnsley, requests information and circuit diagram of this unit.

* * *

Measuring Pressure.—S. F. Goodyear, White Chimneys, New Road, Hythe, Southampton, would like to know if any reader can suggest a means of measuring the pressure applied by an instrumentalist's fingers. Whatever the measuring instrument is, it should be able to be applied to any of the string instruments and to as many of the woodwind instruments as possible—wherever there is not a hole under the key—and should register the pressure immediately, and preferably on to a dial or roll of paper. This implies very small dimensions where it is attached to the musical instrument—not exceeding ⅛in thickness and pressure should be registered whilst the instrument is being played. Best solution offered to date is that of stress gauges, but these would be affected by nearness of the hand and of the string or key.

* * *

Rolex Amplifiers.—A. Sproxton, 2 Laings Corner, Mitcham, Surrey, has obtained a four and a six valve amplifier which were made in India. The units are designed to work either from a 6V vibrator or the 240V a.c. supply but are less the valves and vibrator. Could any reader please supply information on the valve line-up or lend the circuits of these amplifiers?

* * *

PCR2 Communications Receiver.—R. J. Ellis, Pines, Woolton Hill, near Newbury, Berks, is anxious to obtain the circuit diagram of this 6–22 Mc/s receiver and any details of bandspread modifications.

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

part 12

understanding radio

By W. G. MORLEY

IN LAST MONTH'S ISSUE WE COMPLETED OUR DISCUSSION on the subject of capacitance and capacitors. We shall now turn our attention to another basic property of radio. This is inductance, which must be introduced by a preliminary consideration of magnetism.

Magnetism

Magnetism is a familiar phenomenon. We have all encountered typical examples of magnetism, these being probably most frequently shown by the behaviour of *permanent magnets*. Permanent magnets can be made from alloys of iron and other metals (the proportion of iron predominating) and they have the ability to retain their magnetic qualities over very long periods of time, if not indefinitely.[1] Commonly met permanent magnets are the bar magnet and horseshoe magnet, as shown in Fig. 58. If a bar magnet or horseshoe magnet is dipped into a container of iron filings it is found that most of the filings adhere to the ends, and it follows that the magnets exert greatest external magnetic influence at these points. The ends of a magnet are described as its *poles*.

When a bar magnet is suspended by a cord, or pivoted at its centre, it takes up a constant position relative to the Earth. This is because the Earth itself has the properties of a magnet, one magnetic pole being situated near the geographical north pole, and the other magnetic pole being situated near the geographical south pole. One pole of the pivoted bar magnet is attracted towards the north and this is known as the north-seeking pole of the magnet. The other pole is attracted towards the south, and is described as the south-seeking pole. In practice, the word "seeking" is deleted from the description of the magnet poles, and these are known in abbreviated form as the *north pole* and *south pole* respectively. The pivoted bar magnet is a *compass*, insofar that it indicates the direction of the magnetic north and south poles of the Earth.

If the north pole of one bar magnet approaches the south pole of another, as in Fig. 59 (*a*), the two poles are attracted together. If, however, two north poles are brought together, as in Fig. 59 (*b*), they repel each other. Repulsion occurs also when two south poles are brought together. This behaviour may be summarised by stating that *unlike magnetic poles attract each other and like magnetic poles repel each other*.

It is possible to convert a rod of steel or similar material into a bar magnet by stroking it in one direction for a dozen or so times with a pole of a permanent magnet. See Fig. 60 (*a*). After this

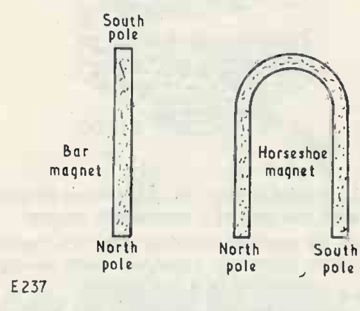


Fig. 58. Two typical permanent magnets: the bar magnet and the horseshoe magnet

[1] A typical permanent magnet alloy may contain small proportions of aluminium, nickel, cobalt and copper. Since the war, permanent magnets have been made also from "ferrites", these being ceramic-like materials consisting of oxides of iron and other metals.

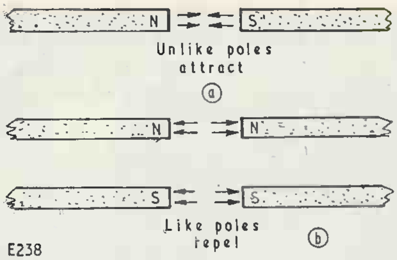


Fig. 59 (a). If the north and south poles of two magnets are brought together they attract each other

(b). When like poles are brought together, they repel each other

treatment the rod of steel becomes capable of picking up iron particles by itself, and shows all the characteristics of a bar magnet. A simple explanation of this effect may be made by assuming that the steel rod is made up of a very large number of particles, each exhibiting the properties of a bar magnet. Before the external magnet was applied these particles were arranged in random fashion, as in Fig. 60 (*b*), with the result that the net magnetic effect was negligible. Stroking the rod caused the particles to become arranged in more orderly fashion, as in Fig. 60 (*c*). If the bar had been stroked by the south pole of the external magnet the particles would have become orientated such that their north poles were all pointing in the direction of the stroking movement. Because, after the stroking process, the particles have like poles all facing in the same direction, their combined effect is to cause the rod to behave as a bar magnet.

Magnetism may be made to appear in a magnetic

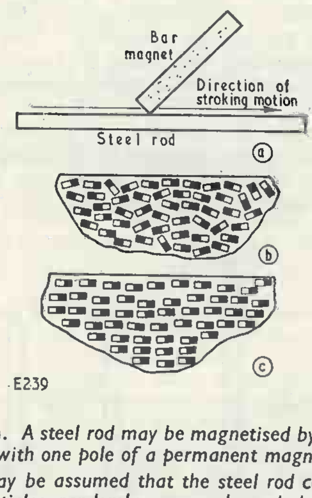


Fig. 60 (a). A steel rod may be magnetised by stroking it with one pole of a permanent magnet

(b). It may be assumed that the steel rod consists of many particles randomly arranged, each having the properties of a bar magnet

(c). The stroking process orientates the particles so that they form an orderly pattern with similar poles in one direction

material by processes other than stroking with a permanent magnet. A typical instance is given in Fig. 61 (*a*). In this diagram a rod of soft iron has one end held near the north pole of a permanent magnet. The rod then behaves like a bar magnet, the south pole of which is towards the north pole of the permanent magnet. This effect may be explained by stating that the north pole of the permanent magnet attracts the south poles of the particles in the rod, with the result that their combined effect causes the rod to behave as a bar magnet. It is usual to say, in this instance, that the permanent magnet *induces* magnetism into the rod. If the rod is brought closer to the permanent magnet its magnetic strength increases. When it is in contact with the permanent magnet, as in Fig. 61 (*b*), it functions largely as an extension of the permanent magnet, whose effective pole shifts almost entirely to the end of the rod. This effect is of value in many radio applications, because it enables the poles of a permanent magnet to be applied effectively to specific points or areas by way of rods, or other shapes, functioning like the soft iron rod of Fig. 61 (*b*). Piece-parts which effectively extend the poles

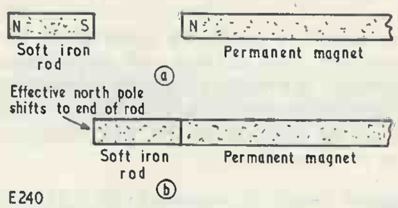


Fig. 61 (a). Magnetism may be induced in a soft iron rod by holding it close to the pole of a permanent magnet

(b). If the soft iron rod is in contact with the magnet, the pole of the latter shifts largely to the end of the rod

of permanent magnets in this manner are known as *pole-pieces*.

We have already seen that certain alloys of iron retain magnetism almost indefinitely and that they can, therefore, be used for permanent magnets. On the other hand, there are magnetic materials which do not retain magnetism and cannot therefore be so employed. Such materials readily allow magnetism to be induced in them, however, and are especially useful for such applications as the pole-pieces just discussed. The rod shown in Fig. 61 (*b*) was made of soft iron but, for practical pole-pieces, it would be preferable to employ iron alloys which exhibit similar or improved magnetic properties in this respect, and which are physically more durable. Typical "soft" magnetic materials[2] are alloys of iron and silicon.

The individual poles of a horseshoe magnet have a magnetic effect immediately around them which is similar to that of the poles of a bar magnet. When a rod of soft iron (or similar material) is positioned

[2] "Soft" because their magnetic behaviour is like that of soft iron.

as shown in Fig. 62 (*a*), the rod effectively extends the pole with which it is in contact, and brings it close to the other pole of the magnet. A high level of attraction exists between the two unlike poles with the result that, unless prevented from doing so, the rod of soft iron will rapidly move into contact with the remaining pole, as in Fig. 62 (*b*). A *magnetic circuit* is, in consequence, set up. If the soft iron rod were returned to the position of Fig. 62 (*a*) the magnetic circuit would then be broken. This is analagous with behaviour in an electric circuit. Whereas in the latter a cell or battery may provide an electromotive force, in this instance the permanent magnet provides a *magnetomotive force*.

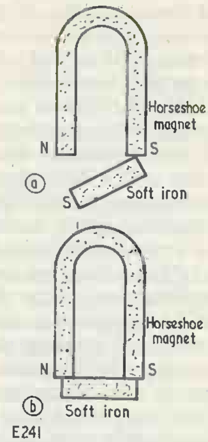


Fig. 62 (a). When a soft iron rod is positioned as shown here, a high level of attraction exists between the north pole and the extended south pole in the rod (b). A magnetic circuit is set up when the rod is in contact with both poles

Magnetic Fields

We have already seen[3] that when an e.m.f. appears across two conductors (in the case discussed, the plates of a capacitor) lines of electric force appear between them. These lines of electric force constitute an electric field. A similar effect appears between magnetic poles, and Fig. 63 (*a*) shows the *magnetic field* around a bar magnet. It is always assumed that magnetic force operates from north pole to south pole and the *lines of magnetic force* shown in the diagram are given arrows which indicate this direction. The lines of force are more concentrated at the poles, these being the points where the magnet has greatest external influence. Although not shown in Fig. 63 (*a*), each line of force is unbroken. It leaves the bar magnet at the north pole, continues externally to the south pole, then returns to the north pole through the magnet itself.

It is possible to determine the shape of a magnetic field by holding a card over the magnet and sprinkling iron filings over it. If suitably dispersed, the iron filings then follow the lines of force existing in the plane of the card's surface. The magnetic field may also be plotted with the aid of a compass, as in Fig. 63 (*b*). The indications given by the compass at various points around the magnet show the direction of the field at those points.

In Fig. 64 (*a*) we see an electric conductor in the form of a wire passing through a card at right angles, a source of e.m.f. being applied such that a current flows through the wire. If we held a compass near the wire we would find that it would be deflected from its normal position, and if we were to move the compass about the wire we would find that we could plot a magnetic field in the same manner as occurred in Fig. 63 (*b*). The field would consist of a number of concentric circles whose direction, as indicated by the arrows in Fig. 64 (*a*), is clockwise when the upper end of the conductor is connected to the positive terminal of the source of e.m.f. If we were to reverse the connections to the source of e.m.f. so that the upper end of the conductor connected to its negative terminal, we would obtain the same field as before, but its direction would be anti-clockwise.[4]

Fig. 64 (*a*) demonstrates the important fact that, when an electric current passes through a conductor, a magnetic field is set up about that conductor. It is possible to cause the field around the conductor to become considerably stronger by winding the conductor into the form of a *coil*, as in Fig. 64 (*b*). A source of e.m.f. having the polarity indicated can then be applied. Fig. 64 (*c*) shows a cross-section through the coil and illustrates the behaviour of the magnetic fields around the individual conductors. If this diagram is considered with reference to Fig. 64 (*b*) it will be seen that the current flowing through the upper set of conductors is that which would be given if the positive terminal of the source of e.m.f. were on our side of the paper. The direction of the lines of force immediately around the upper conductors is, in consequence, clockwise. The current flowing through the lower set of conductors is that which would be given by a positive terminal below

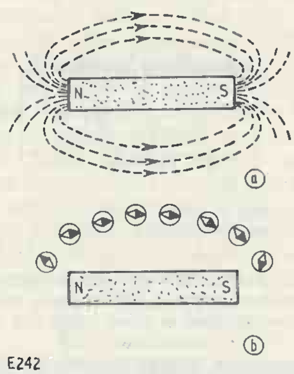


Fig. 63 (a). The magnetic field around a bar magnet (b). The field may be plotted with the aid of a compass moved about the magnet

[3] In "Understanding Radio" part 8, April 1962 issue.

[4] It is assumed here that the field around the conductor is sufficiently strong to override the Earth's magnetic field, which would otherwise affect the compass indications.

the paper, and the direction of the lines of force immediately around the lower conductors is anti-clockwise. However, it is only the lines of force that are close to the conductors which retain the circular form. Those further away combine with others from neighbouring conductors to form a composite field which extends through and outside the complete coil. The fact that the upper conductors have a clockwise field and the lower conductors an anti-clockwise field further assists in the production of a strong composite field, because the combined lines of force from both sets of conductors are in the same direction inside the coil, and are in the same direction outside the coil.

The overall effect of winding the conductor into a coil is that a composite magnetic field is obtained which is very nearly the summation of the individual fields around the length of the conductor. This combined field is much stronger than that around a single straight conductor carrying the same current.

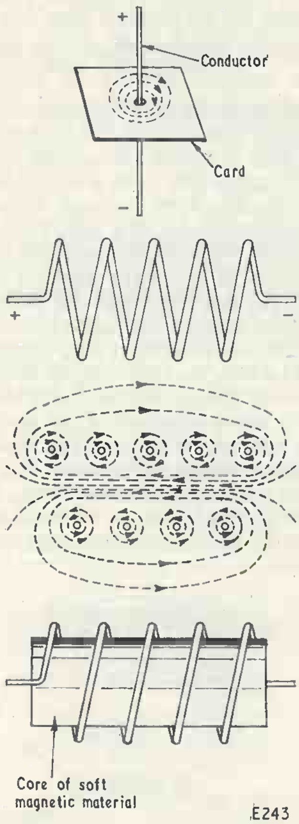


Fig. 64 (*a*). *When a current flows through a conductor, a circular magnetic field appears around it*
(*b*). *A stronger field is given when the conductor is wound into a coil*
(*c*). *Cross-section through the coil, showing how the lines of force around each conductor combine to form a single composite field*
(*d*). *The strength of the magnetic field may be increased by inserting a core of soft magnetic material*

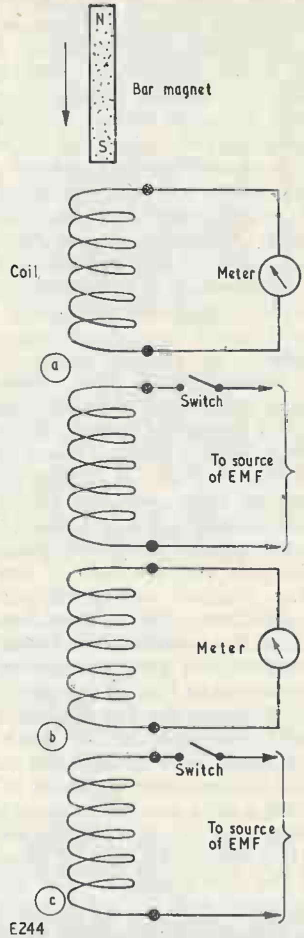


Fig. 65 (a). A voltage is induced in the coil shown here if the magnet is lowered into or raised out of it
(b). A voltage is similarly induced in the lower coil when the switch connected to the upper coil is opened or closed
(c). Illustrating the effect of self-inductance

An even stronger field may be obtained by placing a rod, or *core*, of soft magnetic material inside the coil, as in Fig. 64 (*d*). The lines of magnetic force now become concentrated in the core, which then exhibits the same properties as a permanent bar magnet. The reason why the core allows a stronger magnetic field to appear is that it has the ability to allow more lines of magnetic force to pass through it than does a similar quantity of air of the same dimensions. This ability is defined in terms of the *permeability* of the core material. In general terms, the higher the permeability of the core in Fig. 64 (*d*), the stronger will be the magnetic field produced by the combination of coil and core.

There is, however, a complicating factor here, this being due to the fact that if the magnetomotive force applied to the core is increased (by means which we shall discuss in the next paragraph) a point is reached at which this core becomes *saturated* and can offer no further increase in the strength of the magnetic field. The permeability of the core is, in consequence, considerably lower at saturation point than when it supports magnetic fields of lower strength. The permeability of a practical core material varies continually as the magnetic field it supports alters in strength, and so permeability cannot be looked upon as a constant factor. The relationship between permeability and magnetomotive force is complex, and we shall deal with this in greater detail in a later article in this series.

As is to be expected, the strength of the magnetic field given by the coil and core of Fig. 64 (*d*) will change according to the current flowing through the coil and the number of turns it possesses. In fact, the magnetomotive force operating in the core varies directly as current and turns, with the result that this force is doubled either if current is doubled or if the number of turns in the coil is doubled.

Since the core of Fig. 64 (*d*) becomes magnetised due to the passage of an electric current, the combination of coil and core is normally described as an *electro-magnet*.

Induction

Fig. 65 (*a*) illustrates a coil of wire connecting to a sensitive moving-coil meter. A bar magnet is held above the centre of the coil. If we quickly lower the magnet into the coil the meter will show a sudden deflection, falling to zero again after the magnet has come to rest. The reason for the momentary deflection is that a voltage has been *induced* in the coil by the lines of magnetic force around the magnet, this voltage being generated when the lines of force are in motion relative to the coil. When the lines of force are stationary, as occurs when the magnet is brought to rest inside the coil, no further voltage is induced and the meter returns to zero. If we quickly raise the bar magnet from the coil the meter will once more give a momentary deflection, but this will now be in the opposite direction. By raising the magnet we are once again moving the lines of force relative to the turns of the coil and are thus once more inducing a voltage. However, the direction of movement of the field is opposite to that in the previous case, and so the polarity of the voltage becomes reversed.

Summing up the effect we may say that if a moving magnetic field cuts the turns of a coil a voltage is induced in that coil. If the moving field is reversed in direction, the polarity of the voltage reverses also. Obviously, voltage will be induced in the same manner if the magnetic field is stationary and the coil is moving.

Fig. 65 (*b*) shows two coils mounted side by side. The upper coil is connected to a source of e.m.f. by way of a switch, and the lower coil is connected to a sensitive moving-coil meter in the same way as the coil of Fig. 65 (*a*). Let us now examine what happens when we close the switch. Immediately before the switch is closed, there is no magnetic field about the upper coil and the meter gives a zero indication. When the switch is closed a magnetic field at once begins to form around the upper coil. This field does not become established immediately —it has instead to build up until it reaches full intensity. In the process of building up, lines of magnetic force pass outwards and away from the upper coil and some of these cut through the turns of the lower coil. In consequence a voltage is induced in the lower coil and the meter suffers a temporary deflection, returning to zero when the magnetic field from the upper coil is fully established and is at rest. If, now, the switch is opened, the magnetic field around the upper coil commences to collapse and, once more, moving lines of force cut the turns of the lower coil. This time, however, they are moving in the reverse direction. Again, a voltage is induced in the lower coil and the meter suffers a temporary deflection, this deflection now being in the opposite direction to that given previously.

In Fig. 65 (*c*) we have a single coil connected via a switch to a source of e.m.f. When the switch is closed, a magnetic field at once commences to build up around the coil. What we must now consider is the fact that this *increasing field causes lines of force to cut the turns of the coil which produces the field.* Thus, whilst the coil is itself producing an increasing field, the field is in turn inducing a voltage in the *same coil*. The induced voltage *opposes* the applied voltage, with the result that the initial current flow is relatively low. As the field expands, the induced voltage drops and current increases. When the field is fully established the induced voltage is at zero, and the only factor which limits current is the resistance of the wire forming the coil. Briefly, it may be stated that, if a voltage is suddenly applied to a coil, the electro-magnetic properties of the coil offer an opposition to the flow of current through its turns.

This same opposition will be evident if there are *any* changes of current in the coil. When a steady current flows through the coil a stationary magnetic field appears about it and the coil offers resistance only. If an attempt is made to change the current (either to raise or lower it) the coil will at once produce an induced voltage which will oppose the change in current. The new current will only flow after a period of time has elapsed.

The ability of a coil to oppose changes in the current flowing through it is defined in terms of its *self-inductance* or, more usually, *inductance*. A coil with high inductance offers a greater opposition to current change than does a coil with low inductance.

The basic unit of inductance is the *henry*,[5] this being subdivided into the *millihenry* (one thousandth part of a henry) and the *microhenry* (one millionth part of a henry). All three units are frequently encountered in radio work. The abbreviation for henry is H, for millihenry mH, and for microhenry μH.

We have already noted that the magnetic field

[5] A coil has an inductance of one henry if, when the current flowing through it changes at the rate of one ampere per second, the e.m.f. across its terminals is one volt.

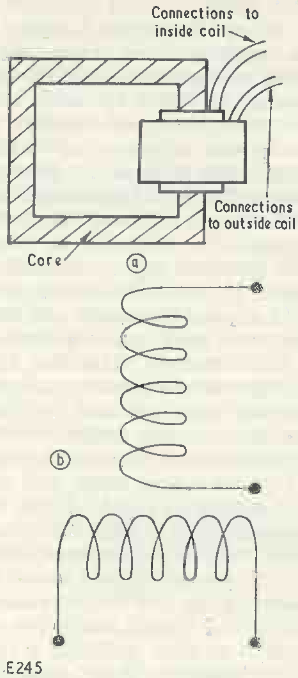


Fig. 66 (a). Two coils having high mutual inductance (b). When the axes of two coils are at right angles there is a very low mutual inductance between them

produced by a coil increases in strength when the number of turns in the coil is increased. Since the magnetic field strength increases with increased turns we may reasonably expect the inductance of the coil to increase also, as there is then a stronger field to induce the voltage which opposes changes in current. This is, in fact, true, and an increase in turns causes an increase in inductance. Similarly, inserting a core of soft magnetic material into a coil causes an increase in inductance, because we are once more causing an increase in magnetic field strength.[6]

Mutual Inductance

We examined the set of circumstances given in Fig. 65 (*b*) before carrying on to the single coil of Fig. 65 (*c*) because it is desirable to establish initially the fact that a coil may produce an expanding magnetic field which is capable of inducing a voltage in a second coil. This point being appreciated, it then became easier to understand how an expanding field may induce a voltage in the coil which *produces* the field. The reason why the upper coil of Fig. 65 (*b*) did not produce a magnetic field instantaneously was, as we may now see, due to its own self-inductance!

Fig. 65 (*b*) showed us also that a changing current in one coil can induce a voltage in a second coil. Because of this the coils are stated to have *mutual inductance*. Mutual inductance may be expressed in terms of henrys, millihenrys and microhenrys in the same manner as self-inductance.[7]

Coils having mutual inductance are frequently described as being *coupled* together. If the coils are brought closer together their mutual inductance increases. Mutual inductance increases further if they share a common core of soft magnetic material. A high level of coupling exists if one coil is wound on top of the other, as in Fig. 66 (*a*), the two coils sharing a common core of soft magnetic material which not only passes through them but forms a complete magnetic circuit outside.

A very low mutual inductance is given when the axis of one coil is at right angles to the axis of the other; as shown in Fig. 66 (*b*). Expanding or contracting fields from the upper coil in this diagram cut the turns of the lower coil symmetrically about its centre, and whatever voltages are induced tend to cancel out. Sometimes, coils are purposely mounted with their axes at right angles to each other in order to achieve a low mutual inductance.

The coupling between two coils is frequently qualified by the terms "loose" or "tight". These terms are relative and have no quantitative meaning. As a comparison, it could be stated that the two coils of Fig. 65 (*b*) are *loosely coupled* whilst those of Fig. 66 (*a*) are *tightly coupled.*

Terminology

Before proceeding further, one or two points of terminology need to be cleared up.

We referred earlier to the induced voltage in the single coil of Fig. 65 (*c*) which opposes the change of current through the coil. This voltage is known as the *back e.m.f.* of the coil.

Coils employed in radio equipment are frequently given alternative names. The generic term for a component possessing inductance is *inductor*. Occasionally, the term *inductance* is applied to the component as well as to the property, but this is an undesirable practice. In some circuits, inductors are employed to prohibit regularly occurring changes in current being passed from one point to another, and they may then be classified as *chokes*.

Next Month

In next month's article we shall carry on to practical inductors, as are employed in radio equipment.

[6] Under certain conditions a magnetic core may not cause an increase in coil inductance, and may even result in a decrease. This point will be dealt with at a later date.

[7] A mutual inductance of one henry is given if, when the current in the first coil changes at the rate of one ampere per second, the e.m.f. across the second coil is one volt.

INDEX—VOLUME 15

The Index for Volume 15 (August 1961–July 1962) of *The Radio Constructor* is now available. Direct subscribers will receive a copy of the Index with this issue of the magazine.

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

NEWS and COMMENT

As readers will be aware, the Report of the Pilkington Committee covers a very wide range of subjects within its terms of reference, the more controversial of these—relating to programme material and the constitution of the Independent Television companies—having been given considerable prominence in the lay Press. There are, also, a number of important technical recommendations, which we are summarising here; these will be dealt with in greater detail in "Radio Topics" in our next issue.

Technical Aspects of the Pilkington Report

Like all European countries, the United Kingdom has undertaken to employ 8 Mc/s channel spacing on u.h.f. (Bands IV and V). Because of this, u.f.h. offers the same number of channels with either the 405 line system (5 Mc/s bandwidth) or a 625 line system (8 Mc/s bandwidth for the standard recommended by the Television Advisory Committee 1960). The Pilkington Committee recommends that a change from 405 to 625 lines be authorised forthwith.

Two methods of achieving the change of standards were put to the Committee. The first is the "duplication" method, which was generally accepted until the I.T.A. submitted a "switchover" scheme in July 1961. Under the "duplication" method the existing two programmes would continue to be transmitted on v.h.f. (Bands I and III). At the same time, duplicate 625 line transmissions of these programmes would be introduced in Bands IV and V. (These signals would, in fact, be generated on the 625 line standard, the 405 line version being obtained by standards conversion.) A third (and possibly a fourth) 625 line programme on Bands IV and V would also be started. After five years there should be about 70% population coverage of all programmes on Bands IV and V, and the remaining coverage would be built up over the following five years or so. The 405 line v.h.f. service in an area would be closed down when a satisfactory u.h.f. service had been provided and an appropriate time allowed for receiver obsolescence. When all 405 line transmissions had been closed down, Bands I and III would be available for re-exploitation using the 625 line standard. The whole process might take ten to fifteen years. With the "switchover" scheme, "shadow" plant would be installed at existing B.B.C. and I.T.A. transmitters during a seven to ten year transition period. This plant would consist of new transmitters and aerials arranged for 625 line operation on re-spaced channels in Bands I and III. At an appointed date the 405 line transmissions would cease, and the two programmes would be switched over to 625 lines from the "shadow" network. Two or more new 625 line programmes could, in the meantime, have been introduced on u.h.f.

Under the "switchover" scheme the situation cannot arise where, for a period of time, national coverage would be on u.h.f. only, with Bands I and III not employed. However, the change-over would have to be synchronised with a change by the French broadcasting authorities to 8 Mc/s channelling, a situation which is not wholly within the control of the U.K. There would also be heavy loading on retail and servicing organisations at the date of "switchover", and there would be no margin for unforeseen difficulties. Also, with the "switchover" method all viewers would be required to previously purchase 405/625-v.h.f./u.h.f. receivers, whilst the "duplication" method allows at least some viewers to buy v.h.f./u.h.f. receivers for 625 lines only. The Committee concludes that the "duplication" method is to be preferred, although it must remain for the opening of a public u.h.f. service to confirm the usefulness of such a service.

U.H.F. transmitting stations for both the B.B.C. and I.T.A. should be co-sited and should have a common aerial mast.

The Committee recommends the introduction of a compatible colour television service (colour system not specified) on 625 lines when the latter is established.

It is recommended that no subscription television service (wherein payment is made by coin-box, or billing, for reception time) be authorised. This applies whether distribution be by wire or by radio transmission.

It is recommended that one service only of local sound broadcasting be planned, and that this should be run by the B.B.C. and financed from licence revenue. At present only the range 88 to 95 Mc/s is employed for f.m. broadcasting in Band II (87.5 to 100 Mc/s), the remainder of the Band being taken up by services such as fire brigade and police. With the present 88 to 95 Mc/s range, a local service in some 250 localities could be provided. More localities, with a better service, would be given if 95 to 97.6 Mc/s were used for local broadcasting, and these frequencies would be preferred if they could be made available. The introduction of local service transmitters should not delay the completion of f.m. coverage of the three national B.B.C. services.

At present, "music by wire" is distributed over G.P.O. lines to business and other premises to provide background music by Reditune Ltd. and Planned Music Ltd. (Muzak). Planned Music Ltd. proposed that their service should be allotted radio frequencies for distribution, but this proposal was rejected by the Committee.

Electronic Expansion

The recent death of Sir Allen Clark, chairman and managing director of the Plessey Company Ltd., is a reminder of the wonderful growth, under Sir Allen's energetic leadership, of the Plessey Company from small beginnings in 1920 with a half a dozen or so employees to the world-famous firm of today. Plessey were, of course, pioneers in the production of portable radios and, later, commercially produced television sets.

Are there opportunities for small businesses to expand in a similar way today?

Judging by the details published by Perdio Electronics Ltd., as required by the regulations of the London Stock Exchange prior to a "placing" of shares, the answer is probably yes.

Perdio was formed early in 1956 and rapidly established an excellent reputation with their portable transistor radios; the name "Perdio" is a contraction of the words personal radio.

From the figures issued by the Central Statistical Office, it appears that for the first two months of this year Perdio sold more than one in eight of all radio sets sold by United Kingdom manufacturers during that period. The Company intends to market shortly a transistorised battery operated television set!

R.A.F. Award Winner

Thanks to the initiative of Flight Sergeant Downie, an air wireless fitter now stationed at Headquarters, Fighter Command, Royal Air Force, aircrew will in future have better reception in their aircraft.

Flight Sergeant Downie evolved a method of checking and adjusting very high frequency radio sets which the Air Ministry has adopted, and rewarded him with £300.

Since he passed out of No. 1 Electrical Wireless School at Cranwell, in the middle 1930s, he has been associated with radio, spending much of his spare time in research. During the last war Flight Sergeant Downie was for a considerable time flying as a wireless operator in Vickers Vincent aircraft of No. 8 Squadron based at Aden.

B.B.C Instals Band IV TV Aerial

The B.B.C. have awarded a contract to Marconi's Wireless Telegraph Company Limited for the supply and erection of a Band IV television aerial to be mounted above the existing Band I aerial at Crystal Palace.

The aerial will be omni-directional, horizontally polarised and of high gain.

It will be of novel design, consisting of eighty elements of end-fire stacked dipoles mounted in angled fashion from the corners of the tower. This new aerial will have a bandwidth which will cover several television channels and will be extremely simple to erect. It is believed that this will be the first of this type of u.h.f. aerial to be installed for television anywhere in the world.

It is planned to have the aerial available for use early in 1963.

New Factory for Morganite Resistors Ltd.

Morganite Resistors Limited, a member of the Morgan Crucible Group, announce that arrangements have been made with the Board of Trade and the Industrial Estates Management Corporation of England for the building of a 50,000 sq. ft. factory on the Bede Trading Estate, Jarrow.

Morganite Resistors manufacture components for the radio, television, electronic and light electrical industries. This new factory—their third—will take over the manufacture of the special types of resistors now made at the Morgan Crucible Group's factory at Norton, Worcester, and will thus concentrate at Jarrow their complete range of electrical resistance products used by all sectors of the electrical industry. The move will involve the transfer of some employees from Norton, but the majority of the 500 required for the new factory will be recruited locally.

NEW HIGH GAIN DOUBLE TRIODE the ECC807

MANY NEW VALVES WITH A VERY HIGH VALUE of mutual conductance have been put on the market during the last few years in order that higher stage gains may be obtained from r.f. and i.f. stages. The gain of a triode *audio* amplifier, however, depends more on amplification factor than on mutual conductance. The new double triode introduced by Brimar, the ECC807, is capable of giving very high stage gains, as its amplification factor is 140. This may be compared with the amplification factor of a commonly used double triode, the ECC83 (equivalent to the 12AX7 and the CV492), which has a value of 100.

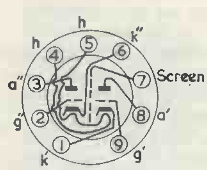
Uses

The ECC807 has been specifically designed for use in high gain pre-amplifier stages operating from low level inputs and is especially suitable for use in tape recorders and in instrumentation. When the two sections are connected in cascade, a total gain of over 5,500 can be obtained.

Hum

The triode unit connected to pins 1, 8 and 9 should be employed as the input stage when the two triode sections are used in cascade, since this method of connection enables a lower hum level to be attained. When the heater centre-tap is earthed, the average hum level referred to the grid is 3μV average (maximum value=5μV), but if either side of the heater is earthed, the maximum value of the hum voltage at the grid would be of the order of 10μV.

The heater rating is 6.3 volts at 0.32 amp.



Base B9A

M431

Limited Ratings

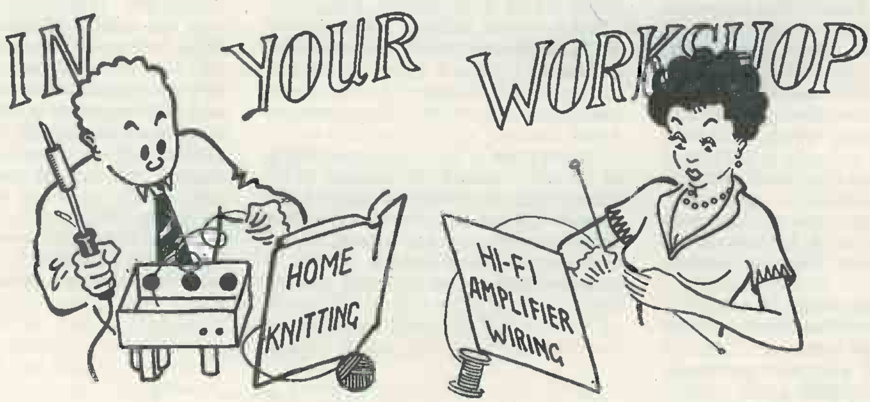
Anode supply voltage: 550 volts max.
Anode voltage: 300 volts max.
Anode dissipation: 1.0 watt max.
Negative grid voltage: 50 volts max.
Cathode current: 8.0mA max.

Maximum Values of Grid-Cathode Resistance:

(1) Fixed Bias: 1.0MΩ max.
(2) Cathode Bias: 2.2MΩ max.
(3) Grid Current Bias: 22MΩ max.

Typical Operation (one section)

Anode supply voltage: 250 volts
Anode resistor: 220kΩ
Cathode resistor: 2.7kΩ
Cathode bypass: 50μF
Grid resistor: 470kΩ
Grid resistor of following stage: 470kΩ
Input voltage (source impedance=600Ω): 285mV
Output voltage (5% distortion): 21.2 volts
Gain per stage: 74.5



This month we find Smithy the Serviceman, together with his able assistant Dick, embarking on a typical summer holiday adventure—a coach Mystery Tour. Somehow or other, they find time also to discuss the question of radiation from television receivers

"YOU'RE NOT SUPPOSED TO KNOW where you're going," explained Dick. "This is a Mystery Tour."

Glumly, Smithy the Serviceman gazed out of the coach window at the passing countryside.

"Well, I don't know," he grumbled. "It seems a funny business to me, not knowing where you're headed for."

"But that's the whole idea," said Dick. "The destination is kept a secret until you get there."

The Serviceman's expression took on an even more gloomy appearance "Well, let's hope," he remarked. morosely, "that the driver knows, anyway."

"Dash it all Smithy," protested Dick. "You *are* ungrateful. Here I am actually treating you to a coach tour, and all you do is moan about it."

A look of unbelieving wonder crept over Smithy's face.

"This," he remarked incredulously, "is *your* treat?"

"Nothing less," replied Dick. "You've just started your holiday and I'm on the last day of mine. It's so happened that we've both chosen the same holiday resort and I thought, therefore, that I'd plan a nice little surprise for you when you got here."

"That's very decent of you," said Smithy. "Although I must admit that I was a little shaken at first when you popped round to the hotel and told me about the trip. And I must say, also, that it's very pleasant to be driven around the countryside like this instead of being stuck in the Workshop, as I was yesterday."

"Don't talk about the Workshop," said Dick. "I'll be back in it tomorrow!"

Interference

The pair gazed contentedly through the window as the coach drove along its way. The seats were all occupied, and Smithy found himself becoming more and more appreciative of Dick's action as he realised that his assistant must have booked their places quite some time in advance.

A pastoral scene swung into view, complete with the regulation farmhouse, hay stacks, cows and sheep.

"Isn't that a lovely old cottage?" remarked Dick, pointing to the farmhouse. "And isn't it beautifully situated?"

Smithy focused his eyes on the building.

"I wouldn't say that," he remarked critically. "So far as I can see from their aerial they must be right on Channel 10 fringe."

"Corluvaduk," exclaimed Dick. "You're supposed to be looking at the countryside, not at TV aerials! For instance, take a dekko at that line of hills over there. Don't they look smashing?"

"I suppose so," said Smithy guardedly.

"And don't you think," continued Dick, carried away by his newly acquired love of nature, "that they're spoilt by all those pylons going over them?"

A gleam of intense interest shone in Smithy's eyes.

"Ah," he exclaimed enthusiastically. "Now I've been watching those pylons closely. The big fellows going right over the top of the hills must be nearly a hundred and fifty feet high and I should guess that they're part of the 275kV Super-grid. Just think of it, Dick my lad—275kV!"

Despite his previous championship of the rural scene, Dick was impressed.

"Gosh," he said, "that's over a quarter of a million volts."

"Those smaller jokers," continued Smithy, "will probably be part of an earlier line running at 132kV."

The pair studied the pylons, and the sagging wires strung between them.

"It makes you think, doesn't it?" said Dick eventually. "Especially when, tomorrow morning, I'll probably be trying to stop corona in some old telly or other at a mere 15kV."

"What you've said is not only probable," commented Smithy cheerfully, "but dead certain. "I've left you a telly with just that particular snag as your very first job."

Dick tore his eyes and thoughts away from the verdant scene outside the windows of the coach.

"It's nice to have friends," he remarked bitterly. "Is the corona obvious?"

"You can't see it," replied Smithy happily.

"Come off it, Smithy," protested Dick. "Doesn't it even cause flashes on the screen of the set?"

"Nope."

"Then what does it do?"

"It causes flashes," explained Smithy, "on the screen of the set next door!"

"Blimey," said Dick in disgust. "I've just about heard everything now. How on earth can you locate a fault when it only shows up on the set next door?"

"It's easy enough," chuckled Smithy. "But before I go into an explanation, I'd better tell you the history of the fault first. The initial complaint was from a customer who said that every now and again a vertical line composed of bright dots appeared on the screen. Sometimes the vertical line remained in position fairly steadily, but most of the time it kept moving to left or right. After doing a quick check I found that the receiver was using an indoor aerial and that it was O.K. in itself. I then told the customer that the interference was coming from a neighbour's set, and that it would be doubtful if it were more than two or three doors away."

"What happened next?" asked Dick, absorbed in Smithy's story. "Did you call in the Post Office to find the source of interference?"

"Nothing as official as that," grinned Smithy. "Fortunately, they're a matey bunch in the street concerned, and it needed only a little experiment to locate the set that was causing all the trouble. It so happened that it *was* next door, the interference clearing when it was switched off. And that's the set I've left for you to fix."

Dick looked baffled.

"All this is very well," he remarked helplessly. "But I just haven't got a clue where to start. I don't even understand how the interference is being caused."

"I suppose it is a little confusing at first," remarked Smithy, "although the process is actually quite simple. What is happening is that the faulty receiver has a snag in the line output stage which causes a pulse of r.f. to be radiated during each flyback period (Fig. 1(*a*)). Most probably there is a spark somewhere, and this takes place every time the line output transformer swings over to give the e.h.t. pulse at the end of the scan period. The radiated pulse given by the spark can be picked up on any other television receiver with the result that, under certain conditions, it shows up on the screen."

"But why," asked Dick, "isn't it picked up by the same receiver which generates the spark? After all, this is the nearest receiver *to* the spark!"

"It probably is picked up," replied Smithy, "but it still won't show up on its screen. You see, the spark appears during flyback when the spot is travelling rapidly back across the screen. The effect of the spark may be a slight brightening of the flyback line, but that will be about all. Also, the receiver may have line flyback suppression, and this will make the tube less sensitive to signals applied to it during flyback. Another point is that if the faulty receiver has a well-matched coaxial cable going up to an outdoor aerial its input circuits will be fairly well screened from the spark. Again, if the set is receiving a strong signal via that outside aerial, its a.g.c.

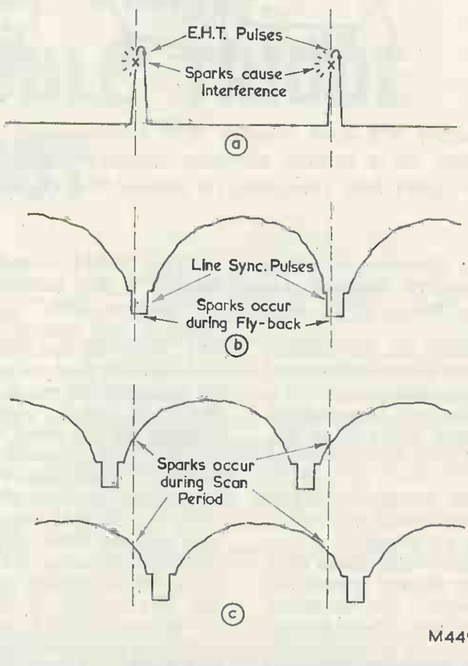


Fig. 1 (a). A pulse can be generated in the line output stage during flyback by a spark (or other source of interference)
(b). The spark occurs during flyback in a receiver locked to the signal that synchronises the faulty timebase
(c). The interference caused by the spark is visible on receivers locked to another programme

circuits will cause it to be in a relatively insensitive state."

"I see," remarked Dick. "It sounds to me as though the other receiver picked up the interference partly because it was using an indoor aerial."

"That's probably right," confirmed Smithy. "The second set was in a sensitive condition because it received a lowish signal from the indoor aerial. Also, this aerial was well in the field of the interference."

"I'm clear so far," said Dick. "What I don't yet understand is why the interference showed up as a vertical line moving from side to side."

"That," chuckled Smithy, "is the interesting bit! Since the spark appears during flyback, it also appears during the line sync pulse in the transmitted signal (Fig. 1(*b*)). If the second receiver were tuned to the same programme as the first, the sparks would then occur during *its* line flyback period as well, and they would similarly be unnoticeable on the screen."

"Hey?"

"That's right," grinned Smithy. "If, however, the second receiver is tuned to a different programme, the transmitted line sync pulses which control it will be out of step with those which control the interfering receiver, and the sparks will then cause interference on the screen" (Fig. 1(*c*)).

"Wait a minute," said Dick, excitedly. "Let's get this straight! First of all, am I correct in assuming that the line sync pulses transmitted by the B.B.C. and by I.T.V. are not synchronised with each other?"

Smithy nodded.

"You're perfectly correct," he said. "Each transmitter sets up its own line sync pulses. The two 405 line frequencies are *nominally* 10,125 c/s, of course, but there is always some discrepancy between them in frequency and phase. Incidentally, there is no tolerance on line frequency for the 405 line system quoted in the latest C.C.I.R. Report, although a figure of $\pm 0.1\%$ is given for line frequency in the 625 line system. If this figure were to apply to the 405 line system the B.B.C. and I.T.V. line frequencies could be 20 c/s away from each other and still be within tolerance."

"Right," said Dick. "That answers my first question. The next one is that, if the interference is to become noticeable, one receiver *must* be tuned to the B.B.C. and the other to I.T.V."

"That's right."

"Does it matter which is tuned to which?"

"That *could* have an effect," said Smithy. "The interference from the faulty set will be at constant level, whatever programme it is tuned to. The level of interference in the other receiver will then depend on its sensitivity for the two Bands, and on the frequency spectrum of the interference itself."

"I see," said Dick. "Now let's take it a stage further. If the line sync pulse arrives a little later at the interfering receiver than at the other receiver, can I assume that the spark will then appear on the left of the other receiver's screen?"

"That's right," said Smithy. "And, of course, it will appear on every line going down the picture, so that you get a vertical line made up of bright spots."

"And if," continued Dick, "the interfering pulse occurs just before the line sync pulse in the other receiver, will the vertical line then be on the right of the picture?"

"You've got it," said Smithy. "The vertical line moves from left to right according to the line frequency phase difference between B.B.C. and I.T.V. programmes."

"Well, I'm dashed," remarked Dick. "You learn something new every day! Incidentally, how were you able to diagnose the trouble so readily when you first encountered it?"

"Just experience," said Smithy. "We had a whole rash of this trouble when I.T.V. first started. Previously, television sets didn't cause interference with each other in this manner because they were all locked to the one B.B.C. programme. When I.T.V. came on the scene, receivers were tuned to different programmes and the faulty ones soon made their presence known."

"It seems to me," remarked Dick, "that the best thing to do is to live next door to people who always watch the same programme as you do!"

Sparking

Smithy laughed and looked at his watch. A sudden thought made him change the subject.

"These Mystery Tours are all right, I suppose," he remarked, "but I'm getting a little peckish. When do we get back to base?"

"We haven't even got to the *place* yet," replied Dick. "When we do we'll have something to eat there. The normal form is to stop at some tea-rooms for an hour or so."

"Are refreshments included with the ticket?" asked Smithy.

"Oh no," said Dick airily. "You buy your tea separately."

Smithy looked suspiciously at his assistant.

"Are you", he queried, "including tea in your treat?"

Dick looked a little uncomfortable.

"Well, no," he said reluctantly, "not exactly. I was rather hoping that we might be able to arrive at an amicable agreement concerning tea."

"What sort of amicable arrangement?"

"One in which you paid for both of us!"

Smithy sighed.

"I thought there would be a catch in it," he remarked resignedly.

Dick assumed a hurt expression.

"After all, Smithy," he pointed out reproachfully, "I did get the tickets, you know."

"Oh all right then," grumbled Smithy. "But I'm beginning to wonder whether I should have come in the first place. By rights, I should be down on the beach now, acquiring a glowing healthy tan to last me through the winter."

Having won his point Dick changed the subject abruptly.

"How will I cure this receiver which causes the interference?"

"What receiver?"

"The one", explained Dick, "which you've left in the Workshop for me."

"I'd forgotten," said Smithy, his complaints slipping from his mind, "about that! Well, the process of repair should be fairly easy. You'll need another set to pick up the interference, and you can run this from an indoor aerial."

"Any obvious things to look for?"

"The most obvious causes of the trouble," said Smithy, "are a missing line output cage screen, or bad valves. The trouble is very liable to happen if a previous service engineer has omitted to put the line output stage screen back on again after he has done a job on the set. Such a screen should be fitted correctly with all screws secured up tight. The next possibilities are the line output valve, the booster diode and the e.h.t. rectifier. Either of these could give rise to a spark during flyback. There is a slight possibility that the interference is caused by Barkhausen oscillations or a similar effect instead of sparks, and changing the line output valve should clear up that one also."

"Could corona be the cause?"

"I'm not certain about that," replied Smithy. "I know that corona can result in quite a few bright patches on the screen, and it could, I suppose, cause the trouble here. In any case it's worth looking for, and there's no harm done if you round off any spiky e.h.t. joints you run into. It's also worthwhile checking flexible e.h.t. leads. Frequently, one or more strands of these leads break off at connection points and cause quite a lot of corona. It's a good plan also to blow out any dust from the line output transformer cage. Dust reduces the ionisation path between e.h.t. points and chassis."

"Any other things to try?"

"Definitely," replied Smithy. "If there aren't any obvious points where corona or sparking occurs, check for poor solder joints. A dry joint can often cause the interference to occur, if it is directly in the line output transformer circuit. Some of the top cap connectors used for line output valves and booster diodes have a mechanical connection which can also cause trouble in this respect. (Fig. 2 (*a*).) The wires to these are

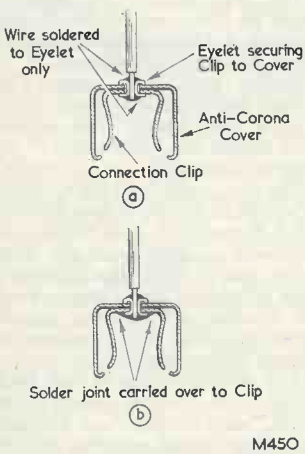


Fig. 2 (a). Cross-section through a top cap connector encountered in some television receivers. The wire is soldered only to the eyelet
(b). A better connection is made by continuing the solder joint to the connection clip. If desired, the joint may also be carried over to the anti-corona cover

soldered to an eyelet which exerts mechanical pressure only on the springy metal connector clip. If this mechanical joint is soldered over (Fig. 2 (*b*)) you may find that the interference ceases. It is worth suspecting the line deflection coils also, as these have fairly heavy voltages impressed on them during flyback."

"Take it easy," protested Dick. "You'll have me re-building the set next!"

"It does sound rather a tall order," agreed Smithy. "But you'll probably find the trouble will be of quite a simple nature. If you're unlucky, it could be something like the line output transformer, of course, so I'll keep my fingers crossed for you!"

"Thank you very much," said Dick, sardonically. "I know I'll be sweating it out whilst you're wallowing in the fleshpots here, but please don't rub it in as well."

"You'll be back amongst friends, at any rate," remarked Smithy, soothingly. "You'll be able to get back with your mates at 'Le Chat Noir' again."

" 'Le Chat Noir'?"

"Joe's Caff."

"Oh, we've gone off that place now," said Dick. "It was all right whilst Joe was going Expresso, but he's way out Beat now."

"Joe's a Beat?"

"All the way. The last I heard was that he's changed the name to 'Joe's Pad', and he never cleans it out at all."

"Very unhygienic."

"It is. It was the sauce bottles that finally made us leave."

"The sauce bottles?"

"That's right. In the old days the metal screw-on caps used to corrode on to the bottle tops, but Joe would at least change the bottle when the sauce came out *through* the cap."

"What happens now?"

"He just screws another metal cap down over the corroded one."

"It's only right and proper then," said Smithy, primly, "that you should leave."

Tuner Unit Interference

"One comfort," said Dick, his thoughts still occupied with his coming labours, "is that I've only got a single case of interference between one telly and another to clear up when I get back."

Smithy chuckled.

"Don't you be too certain of that," he grinned. "There's another one waiting for you as well. In this case the I.T.V. signal breaks through on B.B.C."

"Come again?"

"The I.T.V. signal breaks through on B.B.C." repeated Smithy. "I haven't had a chance of looking at it myself, but I can pass on the report that every now and again quite a clear I.T.V. signal appears behind the B.B.C. signal. The I.T.V. signal isn't properly synchronised and it goes from left to right in just the same way as the vertical line of bright spots we've just discussed. Also, the I.T.V. picture moves up and down vertically from time to time."

"What causes a snag of that nature?"

"Very probably another television installation," replied Smithy, blandly. "I would guess that the interfering installation almost certainly has one of those old Band III converters which changed the I.T.V. signal to the local channel and then applied it to the aerial input of the receiver. There are quite a few of those knocking around still. The fact that the interference only comes on now and again is a clue to the fault, because the times of interference will occur when the people using the converter switch over to Band III."

"Where does the radiation come from?"

"From the output of the converter," replied Smithy. "Converters of the type we're discussing had pretty simple Band I–Band III switching circuits. (Fig. 3.) On Band I, the Band I aerial switches straight over to the coaxial lead running to the receiver, and the signal goes straight in. On Band III the h.t. supply is applied to the converter valves, and the coaxial lead to the receiver is then switched to the secondary of the converter output coil. In consequence, the Band III signal goes into the converter from its separate aerial and comes out again as Band I. The only other job the switching circuits have to do is to ensure that the converted Band I signal isn't radiated from the Band I aerial so that it interferes with other receivers."

"Could the radiation come from anywhere else?"

"Oh yes," replied Smithy. "A likely spot consists of the coaxial cable to the receiver. Radiation from this cable is kept to a low level by ensuring that there is as good a match as possible at both ends. Radiation from the Band I aerial is killed by shorting it out when Band III is selected."

"Wouldn't it be better to terminate the Band I aerial feeder with a 75Ω resistor?" asked Dick. "That would prevent standing waves and things like that."

"It might seem so," said Smithy, "but in actual practice you get less radiation by shorting out the Band I aerial dead."

Dick considered for a minute.

"It seems that my first job", he remarked, "will be to locate the interfering installation. What do I do after that?"

"Check whether the radiation is coming from the Band I aerial," replied Smithy, "by disconnecting it and seeing if the interference disappears. If it does, it's possible that the short-circuiting contacts on the

Band I–Band III switch in the converter aren't doing their job properly. They will then need cleaning up and the wiring checked. When there is radiation from the Band I aerial it may help also if you reduce converter gain and increase receiver gain to make up for it. The Band I aerial can then be attenuated before it goes into the converter.

"If", continued Smithy, "your radiation is coming from the lead between the converter and the receiver you want to check that the coaxial outer conductor is reliably earthed at both ends. Surprising as it may seem, you may also be able to reduce radiation from this cable by popping in a 6dB attenuator at one end or the other. The attenuator irons out any bad mis-matches which may exist, even though it does give you a loss in gain. Another dodge is to change the length of the coaxial cable by lengthening it, or shortening it, by half a wavelength at the Band I frequency. Even moving it to a new position reduces the radiation in some cases."

"Well, I'm dashed," said Dick. "You're certainly introducing me to some new snags today, Smithy."

"Actually", admitted Smithy, "interference from converters is rather an oldie. However, it's rearing it's ugly head again these days because some of the converters which are still in use require attention and because more and more people are using indoor aerials and portable receivers. The latter are more likely to pick up local radiation from a Band III–Band I converter than is the case when an outdoor aerial is employed."

Smithy paused, as a thought struck him.

"Turning away from technical matters," he remarked, "I've just realised something. Haven't you had any feminine company on this holiday?"

"Oh yes," replied Dick enthusiastically. "I met a real smasher the first night. At the Roller Skating and Bingo Festival."

"At the *what*?"

"Roller Skating and Bingo," repeated Dick. "Actually, we'd intended to go on today's Mystery Tour ourselves."

Smithy frowned.

"Am I to understand," he remarked somewhat heavily, "that the only reason you've invited me on this trip is because your girl has stood you up?"

"She has *not* stood me up," snorted Dick indignantly. "She's had to put off the trip because she's got an aunt coming down. We'll be meeting later on tonight for the Trad and Twist Dance. Care to come?"

Smithy swallowed.

"No, thanks," he replied. "I don't thank that would be quite in my line."

"As you like," said Dick, in a relieved tone of voice. "Anyway, as I said, she's a smasher. Her father's got stacks of lolly, too."

"Not", remarked Smithy, "a disadvantage."

"He's rolling in it," continued Dick enthusiastically. "For instance, he owns the coach we're riding in now."

A suspicion no larger than a man's hand suddenly appeared in Smithy's mind. Broodingly he looked out at the rustic scene rolling past the windows of the coach.

stage. It is a well-known fact, for instance, that the line output stages of badly screened receivers cause a lot of interference with the Light Programme on 200 kc/s. The nominal line frequency for 400 lines is 10,125 c/s, as I said just now, which means that the 20th harmonic comes up at 202.5 kc/s. This is only 2.5 kc/s away from 200 kc/s, and it gives you a nice whistle at this frequency, modulated by line frequency! You'd be surprised how much trouble is caused, even nowadays, by interference from line output stages in areas where the long-wave Light Programme is at low strength. Fortunately, the effect seems to be worst when aerial pick-up is largely capacitive and it doesn't cause too much trouble if the receiver is fitted with a ferrite frame."

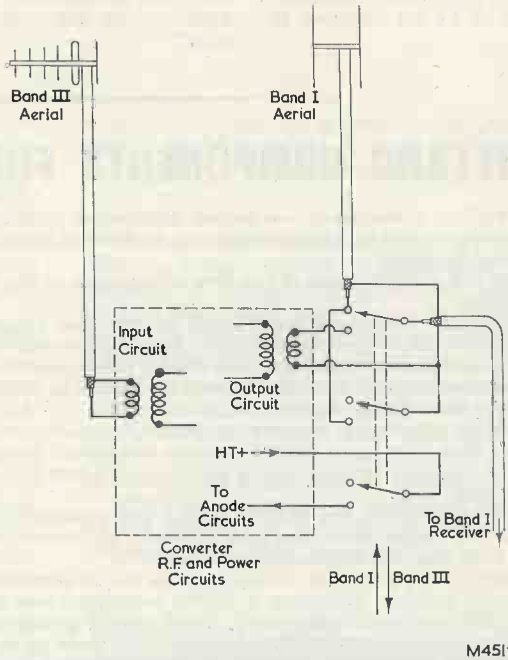


Fig. 3. Switching arrangements for a typical Band III–Band I converter. The 3-pole switch would, in practice, be housed in the converter case

Other Interference

But Dick had returned to their main topic of conversation.

"I hadn't realised", he remarked, "that television sets could cause so much interference."

Smithy came out of his reverie and concentrated on the matter in hand.

"What you have to remember," he stated, "is that there are some circuits in television receivers which handle quite a lot of power. This is particularly true of the line output

"Any other sorts of radiation?"

"Not of similar importance," said Smithy. "You occasionally hear of f.m. or short-wave radios picking up the television sound signal via a TV receiver. Such a signal is probably being radiated by the sound detector circuits in the TV set, as these work at fairly high level and aren't usually screened as efficiently as the video detector circuits. However, the effect is not of great importance, and normally occurs only when the two sets of equipment are close together. Then, of course, you get X-ray radiation."

"From a television set?"

"That's right," said Smithy. "There are relatively very high voltages across the e.h.t. rectifier and these may cause the radiation of X-rays for tube voltages above 16kV or so. And, finally, there's light radiation."

"*Light* radiation?"

"From the screen, you twirp," chuckled Smithy. "Which is the sole function of the television set!"

Mystery Solved

"Well, you caught me that time," laughed Dick. "And it looks as though we've pretty well exhausted the mysteries of TV set radiation as well."

But Smithy's thoughts had returned to his earlier suspicion. This was, by now, almost completely filling his mind.

"Tell me, Dick," he asked tentatively. "If your girl friend's father owns this coach, how did you get the tickets for this trip?"

Dick looked somewhat embarrassed.

"Well, to tell you the truth," he said unwillingly, "he sort of rather *gave* them to me."

"With the result," exploded Smithy, "that not only have you talked me into going on this tour, because your girl couldn't come, but you've also shanghaid me into standing you a free tea as well! You, Dick, are the tightest man I know."

"Now, don't be like that, Smithy," said Dick persuasively. "You must admit you've had a pleasant coach ride."

"I suppose so," grunted Smithy. "Although I've hardly looked out of the windows once. Hallo, we seem to be stopping."

"So we are," said Dick. "Well, at any rate, we'll now find out where the Mystery Tour *was* going to. Come on, Smithy, let's pop out and find out where we are."

The pair rose from their seats and made their way, in company with the rest of the passengers, to the door of the coach. In front of them they found a wooden establishment carrying a very large sign which proclaimed to the world:

THE IMPERIAL TEA ROOMS

Smithy blinked short-sightedly around him in the strong sunlight.

"That place", he remarked suspiciously, "seems to look very familiar."

Dick gave a groan of utter misery.

"Don't you know what it is," he wailed. "It's Joe's Caff!"

MULLARD COMPONENTS FOR SERVICE ENGINEERS

Ranges of Mullard components—consisting of polyester, miniature foil, and miniature electrolytic capacitors—already introduced to the setmaker industry, are now available through Mullard wholesalers to dealers' service organisations for maintenance purposes.

This follows the increasing use of the new components in the latest radio and TV sets and audio equipment coming on to the market.

Several important advantages are claimed for the new ranges: greater reliability, improved performance, closer tolerances, smaller size, robust construction, exacting electrical specification and highly competitive prices.

Polyester Capacitors. These are made from a non-inductive winding of thin polyester and aluminium, coated with a special protective lacquer. Both lead wires are soldered to the metal foils in a way which eliminates contact resistance and ensures the lowest possible self-inductance.

Compared with paper types they are claimed to be smaller, more resistant to moisture and able to withstand higher temperature. They have lower dielectric losses and higher insulation resistance.

A feature of particular interest to the service man is that the outer casing is proof against accidental contact with a hot soldering iron.

Close tolerance is $\pm10\%$ and stability is such that capacitance change will not exceed $\pm5\%$ over working life.

Miniature Foil Capacitors. Designed primarily for transistorised circuits where their rectangular shape, insulated coating and small size are of greatest advantage.

The loss factor, say the makers, is less than half that of ceramic disc capacitors and the variation with temperature is also considerably smaller. Tolerance is $\pm20\%$ and capacitance change over working life will not exceed $\pm10\%$.

Miniature Electrolytic Capacitors. These have a greatly increased voltage-capacitance product for a given can size. Small dimensions and an insulating sleeve allow them to be mounted together or against a metal plate.

It is these properties which make them eminently suitable for use in modern personal portable radio receivers.

Brochure. Mullard have prepared a special brochure, giving full technical and marketing information, and price lists of the available types. Both will automatically be sent to those dealers, special buyers, etc., who return the reply-paid postcard sent with the company's mailing shot on 2nd July.

S.T.C. Selenium Stacks to Protect Silicon Rectifiers

A range of selenium semi-conductor units has been introduced by Standard Telephones and Cables Limited for the protection of silicon rectifiers against transient voltages These selenium stack assemblies are called Safe-T-staCs, being manufactured and marketed by the S.T.C. Rectifier Division, Edinburgh Way, Harlow, Essex (Harlow 26811).

Unlike selenium plates, silicon rectifiers and controlled rectifiers have a low thermal capacity which leads to rapid overheating in the presence of voltage transients. This overheating can destroy the rectifying junction if left unprotected, resulting in equipment breakdown.

Safe-T-staCs have the ability to absorb substantial current overloads of short duration and may be applied to any silicon rectifier circuit to protect it from damage and to enable the equipment in which it is used to give reliable, uninterrupted service.

The application of the new units generally allows the use of silicon rectifiers of lower ratings than would otherwise be necessary.

Full details of the application of Safe-T-staC units, including suggested circuits, are available from S.T.C.'s Rectifier Division.

Cover Feature

A TRANSISTORISED ELECTRONIC ORGAN

Part 1

By S. ASTLEY

This is the first in a series of four articles describing a transistorised electronic organ. Apart from the fact that transistors are employed, thereby reducing heat dissipation and assembly time, the organ has the further advantages that it is fully polyphonic on both manuals and pedals, that it employs no elaborate solenoid switches, and that all pitches and voicing are selected by electronic means

THE ORGAN DESCRIBED IN THIS AND THE SUCceeding articles uses some 72 transistors or more. It has two 61-note keyboards and a standard pedal board. There are approximately 30 stops and a crescendo pedal (volume). Also, it is fully polyphonic on both keyboards and pedals, and no elaborate electro-magnetic switches are used to provide 16, 4, 2 and 2⅔ft pitches, all selection being achieved electronically.

Perhaps the most important feature of the organ is the use of transistors, since this fact at once brings about the consequent advantages that negligible heat is dissipated, that space is saved, and that power supply problems are reduced by a considerable extent. There are no heaters to feed and the only h.t. requirement is 9 volts at a maximum current of 35mA. A final, and not unimportant, point is that the use of transistors also reduces the time spent in construction: not only is there no heater wiring to install but there is also no need to mount valveholders. The transistors employed may be connected directly into circuit by way of their lead-out wires.

It cannot be over-emphasised that the highest quality components and workmanship should be incorporated into the construction of this organ, otherwise much disappointment will be caused due to frequency drift and similar faults.

The writer does not intend to give working practical layouts for the organ although, as far as is possible, full information will be given to allow the amateur with a good knowledge of radio to tackle the project. The constructor new to this field of electronics is strongly advised to examine an organ console, perhaps getting an organist to explain the various operations of the stops, etc. The writer realises that there are many readers who can play the piano or accordion a little, and who would attempt the construction of an organ if they more fully understood the general layout of the instrument. For this reason a short description will be given before construction is described.

The Pipe Organ

The pipe organ was, originally, no more than an effort to bring a number of flutes under mechanical control. A penny whistle is very similar to the present-day "flue" pipe (wood or metal) organ in which air is forced against the sharp lip of the pipe. The air in the column is set into vibration, the length of the pipe determining the pitch of the note. There are, also, "reed" pipes which have a reed similar to that of the mouthorgan placed in the pipe in such a position that, as its tongue beats, the air in the column is again set in motion.

When an organ key is depressed air is admitted to the pipe via a valve which is operated by an electromagnet or by pneumatic means. This same

A view of the completed instrument

key can actuate many more pipes, these being reed or flue and having different diameters and shapes, whereupon different tones can be given to the initial note or frequency. The additional pipes are controlled by stops. Stops select the particular rank of pipes required, or cut off the wind supply to the pipes not wanted. (See Fig. 1.)

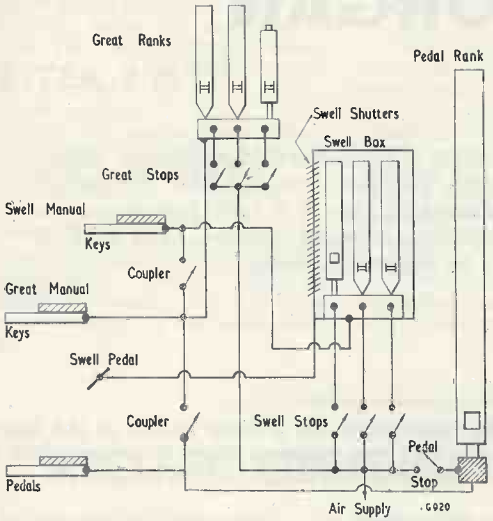


Fig. 1. Block diagram of a simple pipe organ

In a two-manual[1] church organ the lower keyboard is known as the Great manual. The upper keyboard is the Swell, and controls pipes enclosed in a large box (the Swell box) fitted with hinged shutters. The latter are adjustable and may be set so that they completely enclose the Swell box or leave one side almost fully open. The position of the shutters is controlled by a foot pedal, with the result that the volume of sound from the Swell pipes is adjustable. A third keyboard could be fitted below the Great manual. This would be known as the Choir manual, and would produce tones principally of a soft nature, suitable for choir accompaniment. A fourth keyboard, above the Swell and known as the Solo manual, would, as the name implies, have on it stops of a solo character, such as Trumpet, Oboe and Flute, etc. A fifth manual may provide an Echo, whereby the associated pipes are positioned a distance away from the main instrument.

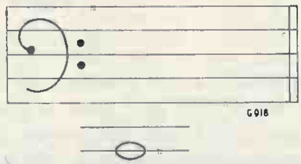
The pedals of the organ have "black" and "white" keys, as with the manuals, and are played with the feet. They control very large pipes which can be 32ft in length, and which give a ground bass of great depth, reinforcing and giving support to the harmonics produced by the manuals.

By means of couplers it is possible to couple say, a lower manual to an upper, allowing pipes belonging to the upper to be controlled by, or added to, the lower. Also, the pedals may be coupled to the manuals. Typical stop functions could, therefore, be Swell to Great, or Great to Pedal.

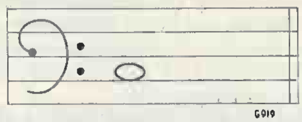
Another stop, Tremulant, or Vibrato, provides a means of modulating the air supply, so causing a pathetic trembling of the note.

Stops

Assuming that only one of a rank of pipes is actuated, if the lowest note on the manual, C^2, is played, the note heard will be



and the pipe would be physically 8ft long. The corresponding stop could be of any name or tone colour, but underneath its name will be seen the legend "8 ft." A pipe 4ft in length and stopped at one end will give the same note. One pipe might for instance be an Open Diapason 8ft or a Stopped Diapason 8ft (tone).[2] Now if, instead of the 8ft stop, another stop of 4ft was drawn, then when the *same key* was depressed one would hear C^3, an octave above:



A 2ft stop would give an octave above this, i.e. C^4, whilst a 16ft stop would give an octave below C^2, i.e. C^1. Thus, all these pipes can be made to sound in octaves when the stop for the appropriate footage is drawn, but we are still only pressing down one key—C^2. Other stops will add intermediate notes such as a Twelfth ($2\frac{2}{3}$ft) which, for the same note, C^2, would give not C but G^3. This addition of harmonics gives improved tone colouring, and some electronic organs rely on this system to give the tones required, this being done by the addition of 2nd, 3rd, 4th, 5th, etc., harmonics to the fundamental.

Other stops have many pipes to each note and are known as compound stops. Often, and in cinema organs in particular, a separate rank of pipes is installed. These are not used for each stop; instead, borrowing takes place so that several stops may use the same rank to obtain say, a 16ft, 8ft or 4ft note.

Fig. 2 illustrates the standard keyboard showing approximate frequencies at each C. Also shown are the ranges for 16ft, 8ft, 4ft, and $2\frac{2}{3}$ft tones which are employed in the transistorised electronic organ.[3]

[1] A manual is a keyboard.

[2] Diapason is the foundation-tone of an organ, and has the characteristic sound of the church (pipe) organ.

[3] The notation C^1, C^2, etc., used in Fig. 2 and in the preceding text is a common one, the suffix number applying to all notes in the octave up to the next C. Thus, the B below C^2 is B^1.

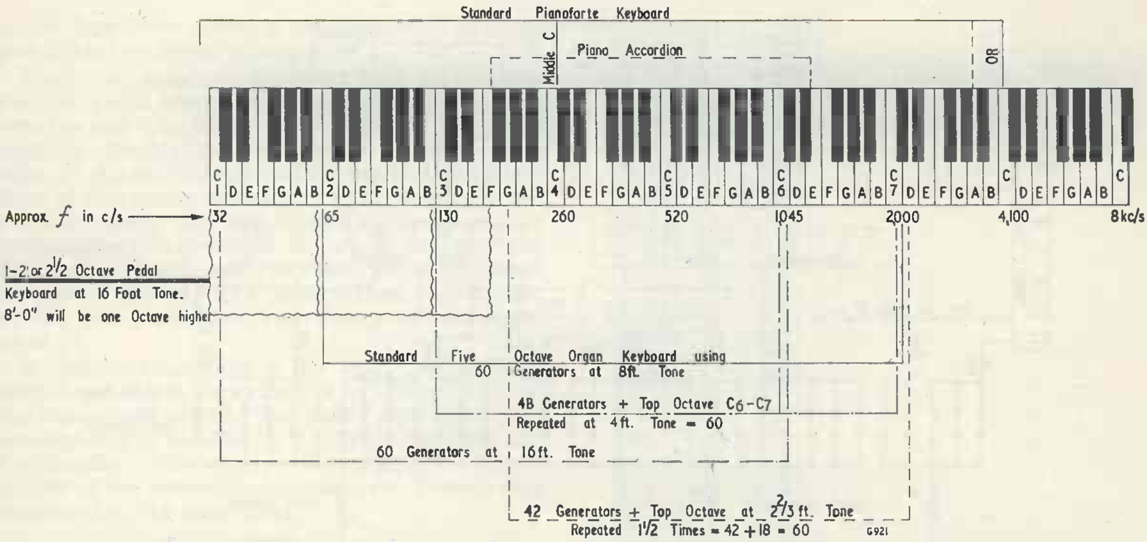


Fig. 2. Keyboard layout, showing approximate frequencies together with ranges for 16ft, 8ft, 4ft and 2⅔ft tones

It is hoped that these brief notes will assist the constructor to realise the electrical problems as we approach them later. Further reference should be made to the excellent books which have been published on the subject, including those listed at the end of this article.

Pipe versus Electronic

The differences of opinion which have arisen over the years concerning the respective merits of electronic and pipe organs would fill volumes. The writer is of the opinion that the pipe organ is supreme, but that some electronic types are a very close imitation. Electronic organs are certainly very useful where portability is required or where confined space considerations have to be met, these points applying especially in the home.

In electronic organs, much work has gone into obtaining the correct starting tone when a key is depressed, and the elimination of clicks due to contact make or break. Also, the chorus effect of many ranks of pipes sounding together is hard to imitate with one set of generators and a single amplifier and speaker system. Here, reverberation helps.

With regard to tone there are two basic types of electronic organ on the market. One of these endeavours to imitate the traditional instrument; whilst the other, the Entertainment type, has its own characteristic tone (as the Hammond) but can still produce a reasonable church, or diapason, tone. The writer's organ is of the latter type, and will be found to give a good all-round tone. Also, the voicing, or tone colour, can be altered to the constructor's own wishes.

The waveform generated in the writer's organ is sawtooth which, as is known, is very rich in harmonics. By arranging suitable filters the waveform is modified to the tone colour required.

If there were a separate oscillator for each note, the organ would produce a much better chorus effect, as discussed earlier. Unfortunately, it is difficult for the amateur to tune an organ of this nature and, in our model, it is necessary to set up, by means of pre-set potentiometers, *the* 12 *notes of one octave only*, the other octaves (sub-multiples of frequency) being automatically locked in to the master octave by means of frequency dividers.[4] Some purists do not like the locked-in system because the octaves are absolutely related in frequency and phase, but the writer—whilst agreeing to some extent—prefers the system to be described because of its ease of tuning by the amateur and

[4] A thirteenth oscillator—for C^1—has also to be tuned, this being a simple operation which can be carried out after the main oscillators and dividers have been set up.

Side view of the manual and stops

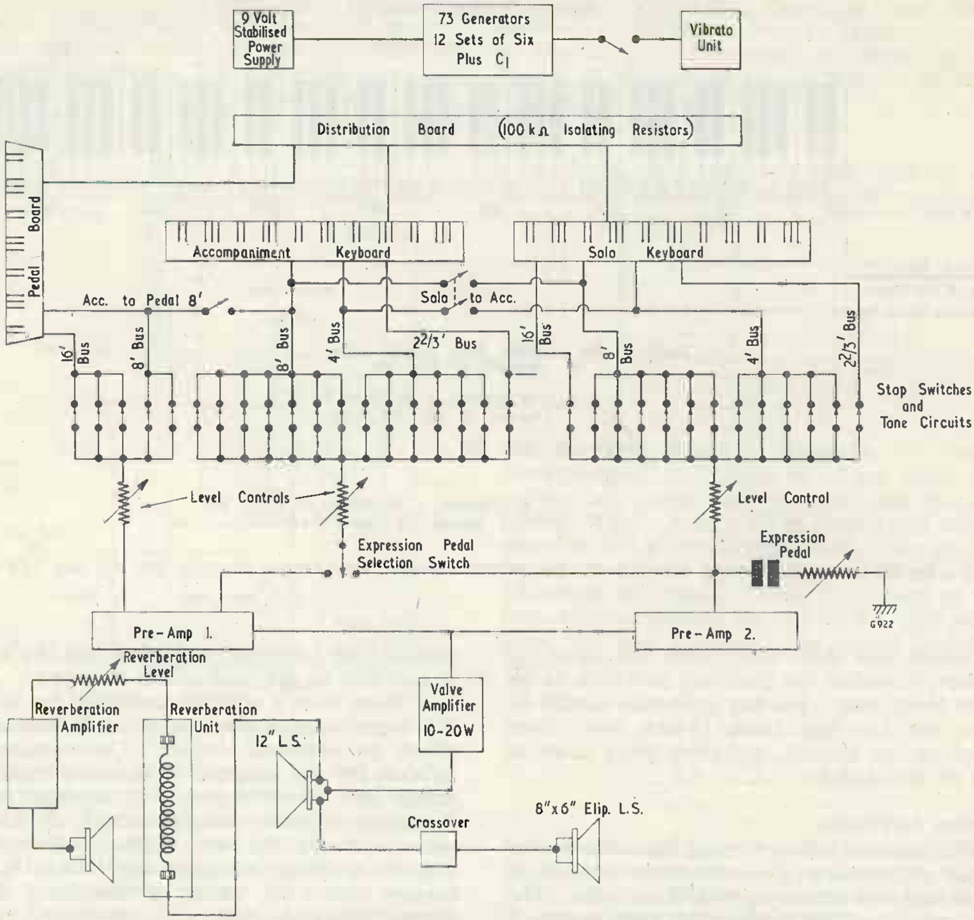


Fig. 3. The basic layout of the transistorised electronic organ

because of other factors which will become evident later.

In the writer's organ, the use of transistors raises the question of stability due to temperature changes, and by careful design no troubles in this direction have been experienced. Even in the hottest weather the instrument has not required attention, and there is, of course, negligible dissipation of heat from the transistors themselves. When silicon types are cheaper, no worries in this direction will be necessary.

The writer has tried to put the pros and cons forward without bias and believes that, with care, the circuitry to be described should produce an instrument giving lasting pleasure and a grand hobby.

The Basic Instrument

Fig. 3 gives a block diagram for the instrument. Apart from the C^1 generator, the generators consist of 12 units, each comprising a master oscillator and five frequency dividers. These feed into a distribution board in which a 100kΩ isolating resistor is inserted in series with the feed to each key switch, or pedal board contact.

As this is an Entertainment organ, the upper of the two keyboards is known as the Solo manual, and the lower as the Accompaniment manual (unlike the names given to the pipe organ manuals of Fig. 1). The right hand then usually plays the Solo manual. In Fig. 3 the Solo keyboard is shown on the right and the Accompaniment keyboard on the left. As we shall see in more detail later, each key when depressed couples a note from a particular footage range to a corresponding busbar (or bus). Thus, when C^4 key on the Solo manual is pressed, C^3 generator is coupled to the 16ft bus, C^4 generator is coupled to the 8ft bus, C^5 generator is coupled to the 4ft bus, and G^5 generator is coupled to the $2\frac{2}{3}$ft bus. Fig. 2 illustrates the ranges for 16ft, 8ft, 4ft and $2\frac{2}{3}$ft tones as applied to the keys.

Each key on the Solo manual of Fig. 3 has four contact sets, these coupling to the four buses leaving the manual. Similarly, each key on the Accompaniment manual has three contact sets, these coupling to the three buses shown in the diagram. The pedal board has two buses leaving it.

The keyed signals on the buses from the manuals and the pedal board are next passed to the stop switches and tone filters. Also shown in Fig. 3 are couplers offering Accompaniment to Pedal, and Solo to Accompaniment. The required combinations of tone colour are selected by the stop switches, and the signals are then routed to the respective pre-amplifiers. Provision is made to cut the Expression pedal out on the Accompaniment manual, if desired. The pre-amplifiers then couple to the main amplifier and thence to the loudspeakers.

A reverberation unit is fed from the amplifier output and this is very effective in adding "life" to the reproduced sound. The signal from the reverberation unit is handled by a separate amplifier and loudspeaker. Also capable of changing the overall quality of the reproduced sound is the Vibrato unit connected to the generators.

Key Connections

Tables 1 and 2 augment the information given in Fig. 2 and show clearly which generator couples to each key and, thence, to the appropriate bus. The master oscillator numbers are 61–72, numbering then proceeding downwards through the frequency dividers. A separate oscillator is used for C^1, and this is indicated by the letter X in the tables.

Table 1 is applicable to both the Solo and Accompaniment manuals. The Solo manual has four buses and the corresponding generator numbers for these appear at the appropriate parts of the Table. Thus, when key No. 27 (D^4) is pressed, generator No. 58 is applied to the 2⅔ft bus, generator No. 50 to the 4ft bus, generator No. 38 to the 8ft bus, and generator No. 26 to the 16ft bus. The Accompaniment manual has three buses and, in the writer's organ, these are 8ft, 4ft and 2⅔ft as shown in Fig. 3. some constructors may prefer to delete the 2⅔ft bus from the Accompaniment manual, and make this 16ft instead.

Table 2 gives the corresponding generator numbers for the pedal board, this having two buses at 8ft and 16ft.

Fig. 4 illustrates the contact arrangements at one key (C^4) on the Solo manual. The lines inclined at 45° represent the contact sets and the straight lines indicate the contacts which are pressed down when the key is depressed. These then connect to the lower angled contacts (shown dotted) and pass the output of each generator to the corresponding bus. When the key is at rest the straight line contacts connect to the earthed rhodium bar, thereby short-circuiting the generator output (after its 100kΩ isolating resistor) to chassis. The key contacts are described in detail later.

Harmonics and Tone

Now that we have seen the basic form of the transistorised organ, it might be advisable at this stage to briefly reconsider the question of harmonics

LOW — GENERATOR No. — HIGH

STOP BUS 2⅔'	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
4'	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
8'	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
16'	X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	C^2												C^3												C^4						
NAME OF NOTE	C	#	D	#	E	F	#	G	#	A	#	B	C	#	D	#	E	F	#	G	#	A	#	B	C	#	D	#	E	F	#
MANUAL KEY No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

STOP BUS 2⅔'	62	63	64	65	66	67	68	69	70	71	72	61	62	63	64	65	66	67	68	69	70	71	72	61	62	63	64	65	66	67
4'	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	61	62	63	64	65	66	67	68	69	70	71	72
8'	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
16'	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
						C^5												C^6												C^7
NAME OF NOTE	G	#	A	#	B	C	#	D	#	E	F	#	G	#	A	#	B	C	#	D	#	E	F	#	G	#	A	#	B	C
MANUAL KEY No.	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61

X DENOTES SEPARATE GENERATOR

MIDDLE C

G926

GENERATORS FOR SOLO AND ACCOMPANIMENT MANUALS

MASTER OSCILLATOR Nos. ARE 61–72
ASSUMING THAT M.O. AND IT'S 5 DIVIDERS ARE BUILT ON ONE UNIT. A 'C' UNIT THUS WOULD BE 72-60-48-36-24-12 RESPECTIVELY.
THIS CHART IS IDENTICAL FOR EACH MANUAL DEPENDENT ON NUMBER OF BUSES REQUIRED

TABLE 1

GENERATOR No.

STOP BUS 8′	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
STOP BUS 16′	X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	C^1												C^2												C^3						
NAME OF NOTE	C	#	D	#	E	F	#	G	#	A	#	B	C	#	D	#	E	F	#	G	#	A	#	B	C	#	D	#	E	F	#
PEDAL KEY No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

1 OCTAVE STUB BOARD

COMPLETE R.C.O. PEDAL BOARD

G927

GENERATOR FOR PEDAL BOARD

TABLE 2

and tone, and in particular its application to the present instrument.

Let us imagine that the note "la" is sung. As we know, if a trumpet sounds the same "la", followed by a fiddle, oboe, clarinet, etc., the pitch or frequency will be exactly the same, but the tone will obviously be entirely different. This is due to the harmonic content of the note or its *formant range* (or frequency spectrum). In the present instrument the $2\frac{2}{3}$ft stop would not be used on its own but only in combination with others to provide a harmonic. A sawtooth wave, which is rich in harmonics, is used in the organ and this is useful in tone forming with suitable filters. Some organs (such as the Hammond) which use sine wave generators have a multitude of contacts under the keys and, by borrowing from other notes, the harmonics so produced are combined in correct proportions with the fundamental to give the imitative tone desired. The present instrument has its harmonics initially, and we limit our contacts under the keys to three pairs on the Accompaniment manual and four pairs on the Solo manual.

If C^4 key is depressed it will sound Middle C as heard on the pianoforte, and this is equivalent to 8ft tones. The output would sound monotonous and dead if we only had this one 8ft facility and, by drawing a 4ft stop, the second harmonic is added, i.e. the C^5 an octave above. 2ft would be the fourth harmonic two octaves above (C^6). The 2ft facility is not available on the present instrument as the generators do not go high enough in frequency, but it *is* obtained synthetically.

The 16ft stop gives the *sub*-fundamental, C^3. The $2\frac{2}{3}$ft stop will sound G^5, the third harmonic. The particular tone will be decided by the appropriate 4ft or 8ft stop drawn. There may be many 4ft or 8ft stops working from their respective buses, giving thereby many different tone colours.

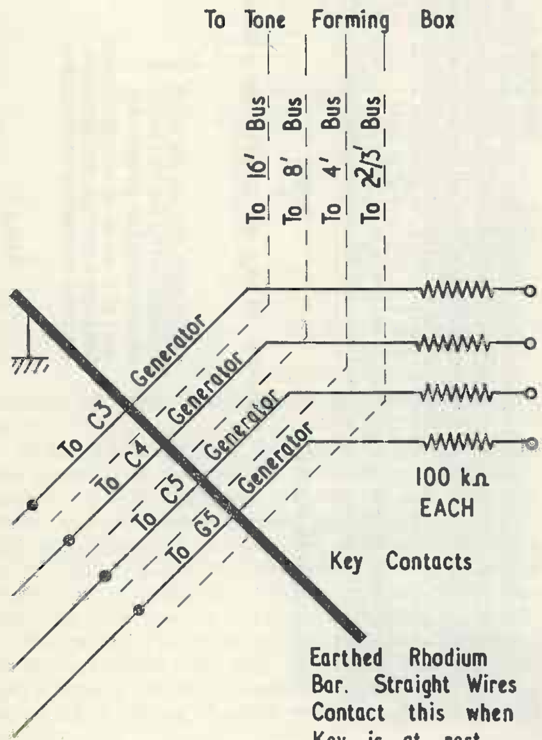
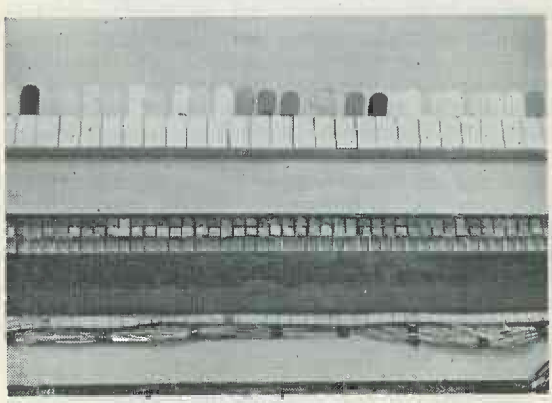


Fig. 4. Keying contacts. This diagram shows C^4 contact block and routing. All others are identical and can be easily found by referring to Fig. 2 and Tables 1 and 2



Underside of the Solo manual raised for inspection

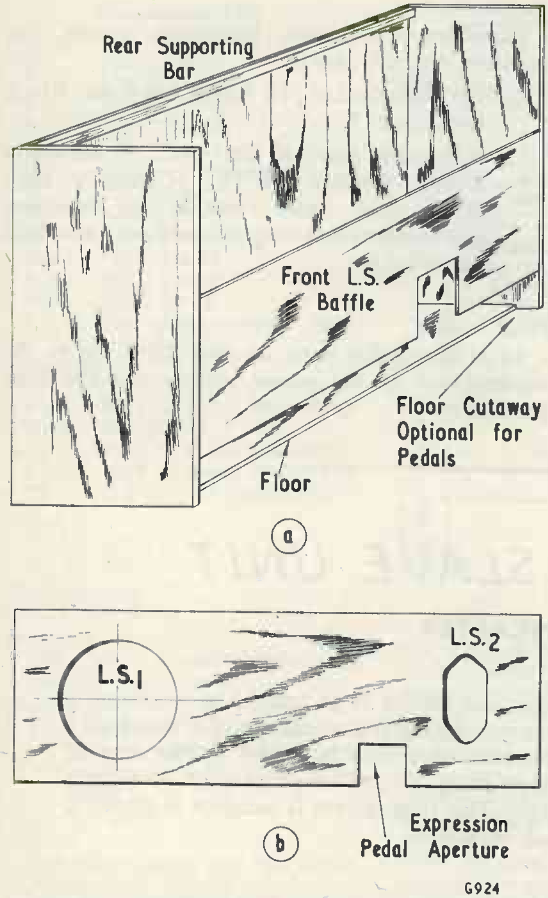


Fig. 5 (a). A suitable method of constructing the case

(b). Front view of the baffle, showing the position of the apertures for the pedal board and the Expression pedal

The Case

A case for the organ may be made, or it can be purchased.[5] The design will be greatly influenced by the builder's domestic circumstances, and by the pedal board size. The pedal board should be made detachable. Manufacturers' literature should be studied and this can give rise, also, to quite some good ideas. If the constructor wants to go the whole hog there are plenty of old Wurlitzers in the cinemas these days, whose consoles could be easily adapted! Fig. 5 shows a suitable framework that can be quite simply constructed. It would be advantageous to fit Sheppard's Castors to such a framework.

Whatever the decision on case design, the use of transistors makes it possible to get the case down practically to Mini-Piano size, provided, of course, that adequate room is available for the knees under the keyboards and for ease of pedalling. The right foot should also be able to move above the pedals to reach the Expression pedal without cramping. The aperture for the Expression pedal should be approximately two-thirds of console width from the left. The pedal board recess in the front baffle is only necessary if the contacts are placed on the console floor.

If the instrument is not required to be self-contained, the constructor is advised to use a separate loudspeaker enclosure. The pedal notes, which run down to 30 c/s and are of large amplitude will soon find any resonances, and they will, of course, be better reproduced by a speaker in a properly designed cabinet.

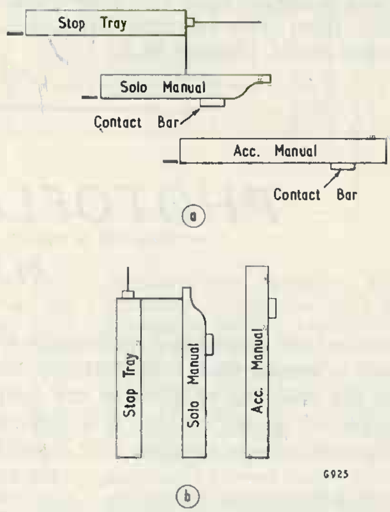


Fig. 6 (a). The stop tray, Solo manual and Accompaniment manual in their normal positions

(b). The tray and the two manuals may be hinged back, as shown here, for adjustments and maintenance

Keyboards and Pedals

Keyboards and pedals are available from the suppliers listed at the end of this article. Alternatively, it is possible to obtain redundant units from organ builders. Pipe organ builders often advertise surplus units in the magazine *Musical Opinion*, and offer pedals and keyboards for sale at very low prices. Although the contacts for these are often silver wire (for electro-magnetic current keying) and are not suitable for a.f. keying, as is used in the present model, the units may still be capable of modification. The writer recently saw three manuals complete in frames offered for £10, with pedals at £5.

Components and Keyboard Mounting

The rest of the components required for the organ are familiar radio types. The stops use telephone jack switches. The Expression pedal potentiometer is operated by a rack and pinion. In the writer's organ the stop switches and tone filters are com-

[5] Suppliers of cases, keyboards, pedal boards and organ components are listed at the end of this article.

pletely contained in a 16 s.w.g. mild steel tray 3ft long by 1ft wide, and 2½in deep. This tray and the two keyboards are hinged so that they may be lifted up through 90°. This is a desirable feature as it readily enables contacts, etc., to be examined or adjusted. Fig. 6 shows the two manuals and the stop tray in the normal, and in the folded back positions.

Recommended Books

Recommended books for the constructor are:

(1) *The Electronic Musical Instrument Manual*, Fourth Edition, by Alan Douglas, M.I.R.E., M.A.I.E.E. (Pitman).

(2) *Electronic Musical Instruments*, by Richard Dorf, Schober Organ Co., New York. (Available from The Modern Book Co., 19–21 Praed Street, London W.2.)

Suppliers

Suppliers of consoles, keyboards, pedals, key contacts, etc., etc., are:

(1) Clyne Radio Ltd., 18 Tottenham Court Road, London, N.7.

(2) Copeman Hart & Co. Ltd., 3 Barandon Street, London, W.11. (Copeman Hart & Co. Ltd. make consoles to individual requirements and designs, and have a standard keyboard.)

Next Month

In next month's issue we shall carry on to the construction of the power supply and the tone generators.

PHOTOFLASH SLAVE UNIT

By B. S. MUNCASTER

This article describes a unit which enables two electronic flashes to be tripped in synchronism with a master flash. Alternatively, the slave flashes may be tripped on receipt of a sound such as the breaking of glass or the bursting of a balloon. More than two slave flashes may be employed, if desired, and it is only required that their firing circuits should present an isolated negative voltage together with a positive trip voltage. This requirement is satisfied in standard electronic photoflash equipment

The circuit of the photoflash slave unit to be described was developed to enable the writer to utilise several electronic flash units together in pursuance of his hobby of colour photography. As most photographers know, electronic flash is balanced for use with daylight type colour film and its use indoors enables the photographer to mix indoor and outdoor shots on the same roll of film without recourse to filters. An additional advantage of flash is its high intensity when compared with photoflood or other tungsten lighting, and the absence of heat which invariably accompanies such lighting. This makes for greater comfort for both photographer and subject.

Good colour photography usually demands the use of more than one light source; in portraiture, for example, at least three lights are needed. When the writer tried to synchronise two or three electronic flash units together it became obvious that this was not just a matter of connecting the flash leads in parallel to the camera shutter. Over the years the writer has acquired four electronic flash units, all of different types, and when attempts were made to couple them together the snags became apparent. Sometimes, when the flash leads were paralleled it was not possible to get any unit to flash, at other times one would flash but not the others. With two of the units coupled together an interaction took place between the triggering circuits which resulted in one flash continuing to trigger off as soon as there was a sufficient charge in the capacitors.

Photography under these circumstances was hardly possible and the only way out was to couple all the flash leads to a four-way push button and use "open flash" technique. This meant that the ambient room lighting had to be kept at a fairly low level, the subject made ready, then the camera shutter set at "B" (bulb or brief time), and the shutter opened. The flashes were then fired and the shutter closed again. With some practice this became quite a speedy operation but it was difficult to capture just that right moment which makes the difference between the mediocre and the good photograph. It became necessary to find some way of tripping all the flash units from the camera shutter, and the circuit to be described was evolved.

Thyraton Valve Control

Since the use of multiple flash was confined to indoor work, the fact that the slave unit developed by the writer is mains operated presents no great disadvantage. All the flash guns used will operate either from the mains or from their own batteries, although they are invariably used from a mains source if this is possible. An evening's photographic session keeps the capacitors well formed, re-charging of the flash unit capacitors is quite automatic, and all flashes are available again about half a minute after an exposure has been made. If the flash units were used on their own batteries it would be necessary to switch them all off after

Components List

Resistors
- R_1 10kΩ ¼ watt
- R_2 100kΩ ¼ watt
- R_3 2.2MΩ ¼ watt
- R_4 22kΩ ½ watt
- R_5 470Ω ¼ watt
- R_6 500kΩ potentiometer
- R_7 27kΩ ½ watt
- R_8 100kΩ ¼ watt
- R_9 470Ω ¼ watt
- R_{10} 1MΩ ¼ watt
- R_{11} 10kΩ ½ watt
- R_{12} 50kΩ 2 watt
- R_{13} 3kΩ potentiometer, wire-wound

Capacitors
- C_1 0.002μF
- C_2 32μF 275 w.v. electrolytic
- C_3 0.002μF
- C_4 16μF 275 w.v. electrolytic
- C_5 16μF 275 w.v. electrolytic
- C_6 8μF 275 w.v. electrolytic

Valves
- V_1, V_2 EF91
- V_3, V_4 2D21

Phototransistor
- OC71 (see text)

Rectifiers
- MR_1, MR_2 Contact cooled (see text)

Transformers
- T_1 "Converter" mains transformer secondaries: 220V 11mA minimum, 6.3V 1.8A minimum
- T_2 See text

Sockets
- Jack with contact leaf (see circuit diagram)
- Non-reversible flash lead sockets

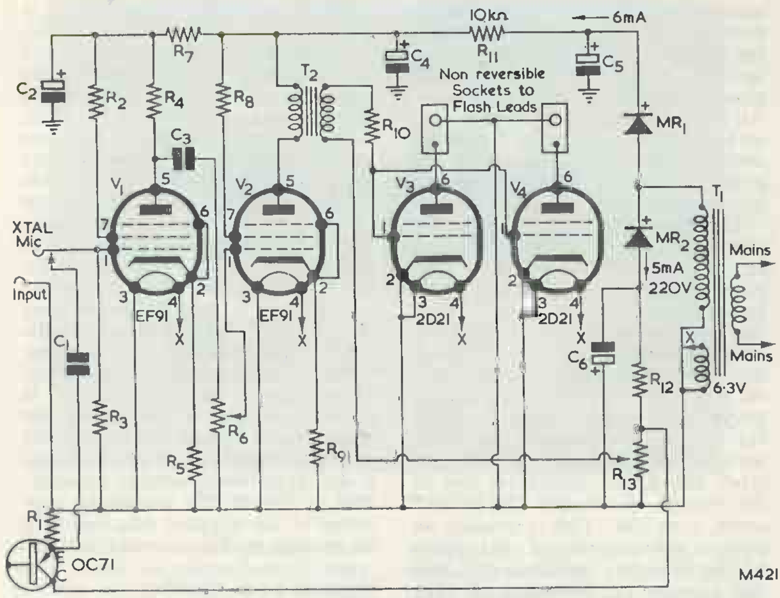


Fig. 1. Circuit of the slave unit

an exposure then switch them on again after the next shot was set up, a time-wasting procedure, indeed, for the amateur working on his own.

The unit described here triggers the slave flash units by the use of an electronic switch, a thyratron valve. In early experiments to find a way of triggering several flashes the writer used a high speed relay to make the flash contacts, and whilst this arrangement was reliable when employing expendable flash bulbs, it was not so with electronic flash. This was due in the main to the very high speed of the flash; the whole energy of the flash unit is expended in about 1.2 milliseconds and the relay took about 2 milliseconds to pull in. Whilst this delay is of no consequence photographically, the fraction of a millisecond difference between the speed of the flash and the speed of operation of the relay was enough to cause failure of synchronisation.

The thyratron valve was the answer. This is a triode valve which has a gas filling and behaves in a slightly different manner to the normal hard vacuum valve. If a negative voltage is applied to the grid before any potential is applied to the anode, the valve will not conduct. If the grid bias is reduced in value or made to swing positive, even momentarily, anode current will flow and the gas filling of the valve becomes ionised. Once this happens the grid has no further control over the current through the valve, and in order to stop the thyratron conducting either the anode circuit must be broken or the voltage on the anode reduced to the point where de-ionisation takes place, this being somewhere in the region of 8 to 10 volts. In the circuit shown de-ionisation is quite automatic since the voltage applied to the thyratron is taken from the controlled flash gun itself. When the flash takes place the flash trigger capacitors are discharged and the anode voltage is at once removed. The negatively biased grid can then resume control and the thyratron ceases to conduct even though the anode voltage is gradually built up again as the flash gun re-charges. The circuit shown is extremely sensitive, it will work at great distances from the primary flash (operated by the camera shutter) and it will trigger the slave units when used in bright room lighting or even in daylight.

Phototransistor

As will be seen from the accompanying circuit diagram (Fig. 1) the light-sensitive device is a phototransistor, in fact an OC71 with the protective paint scraped off.[1] The impulse from this transistor is coupled into the grid of the first valve through the low value capacitor C_1. The value of C_1 is deliberately made low in order that large signal voltages are not passed when the slave unit is used in the presence of a.c. mains lighting. If a component of larger capacity were used the hum voltages from the lighting may be sufficiently high to trigger the thyratron and lead to spurious flashing of the slave unit. The input circuit is broken by the introduction of a

[1] The OC71 is, theoretically, operated outside maximum ratings here, by reason of the 15 volts applied to it from R_{13}. An OCP71 phototransistor would, alternatively be within ratings and should function as well as the OC71.—*Editor*.

microphone jack plug, of which more later. The amplifier section of the slave unit is very simple, we are not after hi-fi reproduction and the circuit is bereft of any trimmings. All the amplifier has to do is to step up the voltage pulse from the photo-transistor (or microphone) to the point where it will trigger the thyratrons.

The main item which calls for comment is transformer T_2. Almost any transformer will work in this position but some, of course, work better than others. It will be realised that the final sensitivity of the slave unit is dependant upon the relationship between the negative grid bias on the thyratron, and the positive-going pulse which arrives from V_2 via T_2. In the prototype the writer tried several transformers of different types and finallv settled on one of the Wright & Weaire "Hyperloy" series, type 208. This is actually an output transformer of 8:1 ratio having a primary resistance of 2.2kΩ and a secondary resistance of 64Ω. It is connected into the circuit "about face", the low resistance winding being in the anode circuit of V_2. This is an obvious mis-match of course, but the arrangement does give a large voltage swing. Other transformers tried include a blocking oscillator transformer, and the junk box should be explored before purchasing a new component. If, however, one must be bought, the Radiospares "Midget" L.F. transformer of 5:1 ratio serves very well in this position. If a normal output transformer is used, the difference between the negative bias voltage and the signal voltage may be very small and the adjustment of the bias potentiometer R_{13} will be quite critical.[2]

With a suitable transformer the voltage swing to the thyratron grid is so great that the potentiometer R_{13} may be exchanged for a fixed resistor of the same value. The grid bias tap is then made at the same point as the supply for the OC71. This results in a negative grid voltage of about 15 being applied, and is sufficiently high to ensure that any hum present in the amplifier does not trigger the slave flashes in the absence of a primary flash. The 1MΩ resistor, R_{10}, in the grid circuit of the thyratron prevents excessive grid current flow when the grids are made positive.

The power supply is quite conventional and the mains transformer is a small "converter" type having a single h.t. winding and a heater winding. If the heater winding will take the load, there is no reason why other thyratrons should not be added to the circuit to control as many flashes as are required. The two metal rectifiers are of the contact cooled type and may be of very low current rating. The actual current consumption is 6mA to the amplifier and 5mA through the negative bias bleeder circuit. The only essential is that a double-wound mains transformer is used to ensure that no mains voltages are present in the external flash circuits. If a transformer is used which has the usual centre-tapped h.t. winding it is merely a matter of connecting the centre-tap to chassis and putting the rectifiers in each leg of the windings. It should be remembered in construction to connect the smoothing capacitor of the negative bias line with its positive lead to chassis.

External Flash Circuits

As far as the external flash circuits are concerned it will be realised that the anode of the thyratron must be connected to the positive side of the flash lead. For this reason non-reversible connectors should be used and a check made on the flash gun to ascertain which of the trigger leads is positive. Usually the centre pin of the coaxial flash lead is positive, but this is not an invariable rule. It is quite easy to determine the polarity of the flash lead if it is connected to a voltmeter. It will not of course be possible to actually measure the voltage on the flash lead by this means as the triggering circuits of electronic flash units are usually fed through resistors of several MΩ. However, on connection of the flash lead to the voltmeter the needle will give a slight kick and from the direction of its movement it is quite apparent which of the leads is positive. The trigger voltage presented at the flash leads of most electronic flash units is between 100 and 200 and this is well within the limits of the thyratron used. Incidentally, the 2D21 thyratron also has a screen-grid in its construction. For this particular application the screen-grid was not used and the appropriate valve pins were simply left unconnected.

It will also be seen that no mains switch is fitted. Since the unit is connected to the mains only when it is required for use there seemed little point in including this extra component. The unit was built with economy in view as well as absolute reliability. The writer has seen 2D21 valves advertised in the columns of *The Radio Constructor* for as little as 5s. 6d. and most of the other components can be obtained quite cheaply from the surplus stores.

Construction and Setting Up

The construction of the unit is quite straightforward and in no way critical as regards layout. Everything fits quite easily into a 6 x 4in chassis. As will be seen from the accompanying photograph, the phototransistor is mounted in a glass tube so that when the unit is put into its case the phototransistor projects from the top where it can receive the light from the primary flash. There is no particular merit in this form of mounting, of course, and the constructor may have his own ideas on the matter. When scraping the paint from the OC71 be sure to leave the spot on the side for identification of the leads. The photo-sensitive side of the transistor junction was found to be towards the observer when the spot was on the left of the transistor (see Fig. 2).

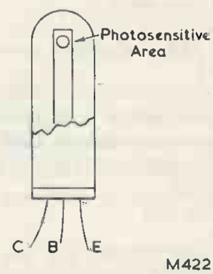


Fig. 2. Photo-sensitive area of the OC71

There is very little to the setting up of the unit, and the procedure is as follows. Ensure that the flash gun to be used as a slave presents its positive trigger lead to the anode of the thyratron, plug in the unit to the mains and allow the heaters to run for at least half a minute before connecting the slave flash gun. This is to ensure that the cathode of the thyratron is at the correct working temperature before any h.t. voltage is applied. Set the gain control R_6 to minimum and switch on the flash gun. Set the bias control R_{13} to maximum and when the neon of the flash gun shows that it is fully charged back off R_{13} until the unit flashes. This indicates the critical point of balance between the anode and grid voltages. If the flash gun is re-charged the bias control should be advanced slightly and the gain control of the amplifier also advanced. If at any point below the maximum

[2] The pulse at the anode of V_2 is negative-going, and the transformer should be so connected that a positive pulse is applied to the thyratrons. If in doubt, connections to the primary or secondary may be reversed experimentally.—*Editor*.

setting the flash triggers, the bias control should be advanced further. R_{13} should finally be set at a point where the flash just fails to trigger when the amplifier gain control is set at maximum. This will then ensure that sufficient bias is applied to the thyratron grid to prevent spurious triggering from hum voltages, etc., and the unit is now ready for use. R_{13} should not require any further adjustment. If another flash is now used anywhere in the same room as the slave unit, the slaved flash will trigger.

The Microphone Jack

The microphone jack is an optional feature of the unit, but it will enable the photographer to photograph any action which makes a noise, and it also enables a sequence of photographs to be taken with very accurate timing. The drill for using the microphone to take a photograph is quite simple. Open flash technique is used in a darkened room. The distance between the source of noise and the microphone will give a varying time delay and can be easily calculated. Since the speed of sound in air is 1,100 feet per second, the delay works out roughly at 1/1000th of a second per foot of distance between the microphone and the source of sound. Typical subjects include bursting balloons, breaking light bulbs, crockery, etc. It will be realised that for this sort of photography one subject, one sound, and one flash is the rule. For a sequence of photographs one must have available several balloons or bulbs, etc. A point to remember when using the microphone is that it is non-selective and any sound may trigger the flash. Judicious use of the gain control is necessary to ensure that the flash is not triggered by accident from another source of noise. With the gain control at maximum the flash will trigger from a snap of the fingers or a mere whisper into the microphone.

Above—chassis view of the completed unit

Conclusion

In conclusion the writer would like to say that this unit has been invaluable to him in following his hobby. It has proved absolutely reliable and provides positive synchronisation every time. With so many types of electronic flash on the market a slave unit as described would be an asset to any serious colour user and its use at a photographic club would enable members to pool their equipment for use on practical nights, etc. There is no fear of damage to any flash gun used with it as no external voltages are applied to the slave units to trigger them. All the external flash circuits, although with a common negative line, are quite independently switched, each thyratron acting as a separate switch for each slaved flash unit.

British Monitors for Italy's First Nuclear Power Station

When the reactor at Italy's first nuclear power station, at Latina, near Rome, goes critical in about a year's time, employees whose duties bring them into contact with radioactive materials will be checked for contamination on the latest type hand and clothing monitors. Four of these instruments have been ordered from E.M.I. Electronics Ltd., through Bay & Co. of Milan, by Societa Italiana Meridionale Energia Atomica, the Italian operating company for the new power station.

It is an important consideration at the vast Latina power station that a large number of personnel be checked for contamination as quickly as possible. The E.M.I. hand and clothing monitor checks both hands of personnel simultaneously for alpha and beta contamination, and at the same time it checks two other people's clothing and footwear.

The count time for checking hands is five seconds. Visible and audible alarms operate immediately the maximum permissible level of contamination has been reached or if personnel remove their hands before the end of the count period.

A special dual-phosphor technique is used when checking the hands and two independent probes check clothing —a scintillation counter for alpha contamination and a Geiger-Muller counter for beta-gamma contamination.

The power station authorities need not take special care to avoid background radiation when siting the four hand and clothing monitors, as a detector continuously monitors any background radiation—up to 0.5 mR/Hr—and makes any necessary subtraction from the total measured count.

This order, valued at over £8,000, is the most recent of many contracts placed with E.M.I. by nuclear establishments in the United Kingdom and throughout the world.

High-Low Impedance Microphone Pre-amplifier

By K. BERRY

In this article our contributor describes a three transistor pre-amplifier, originally designed for use with a crystal microphone, which is capable of accepting a high impedance input signal and of offering a low impedance output with a gain of some 20dB. It should be pointed out that, for speech and music applications, the input impedance is really too low to allow direct connection of a crystal microphone, as bass attenuation will result. Nevertheless, a crystal microphone can be employed for the recording of bird song, and this has been successfully achieved by the author. The input impedance may be increased to allow for normal applications with a crystal microphone by the addition of a series input resistor, this reducing the gain to zero dB. In this instance the pre-amplifier still retains the advantage of enabling the microphone to be positioned a considerable distance away from the main amplifier, since the inter-connecting cable can then carry the low impedance output from the pre-amplifier. Losses due to cable capacitance are thereby very considerably reduced.

The pre-amplifier can, of course, accept most other low-level high impedance inputs directly. —Editor.

This pre-amplifier was designed to enable a crystal microphone to be used some distance from a tape recorder. Long distances are not normally possible as a crystal microphone requires to work into a high impedance, and the use of a long screened microphone lead will result in such a large shunt capacitance being connected across the microphone that heavy attenuation may occur. Also, due to the fact that both the microphone and its load are at high impedance, the use of a long lead would result in difficulties with hum.

The unit which was evolved is small, light, and self-powered. It is fully transistorised and employs a 9 volt layer type battery which has a long shelf life.

Circuit Description

The circuit diagram is shown in Fig. 1. The first stage is an emitter follower giving a high input impedance, the transistor recommended being an OC45. This transistor was selected because of its low leakage current, and the fact that the OC45 tends to be less noisy than the lower frequency OC71.

The second stage employs an OC71 as a common emitter amplifier giving about 20dB of gain. This feeds the third and last stage, which is another OC71 connected as a further emitter follower. The third stage ensures that a low output impedance is obtained and allows a long coaxial cable to be used between the pre-amplifier and the load without losses or the introduction of hum.

Technical Considerations

When the requirement for the pre-amplifier arose the circuit described was designed and the unit made and found to be satisfactory. However, at a later date, some thought was given to seeing whether the performance could be improved. Instead of using an emitter follower input stage to give a high impedance, a pre-amplifier was made with a common emitter input stage. The input impedance of such a stage is typically about 2 or 3kΩ, and this was increased to 200kΩ by means of a 200kΩ series resistor. This version was, however, found to be considerably noisier than the circuit described.

It will be seen that the values of resistance used in Fig. 1 are much higher than those normally encountered in transistor circuits operating at the supply voltage shown. The reason for this is that the stages run at low collector current, this being 0.4mA approximately for all three stages. These low values of collector current have been chosen to obtain the lowest possible noise figure Whilst the original unit was made with 10% grade 2 resistors, some reduction in noise may be obtained if grade 1 high stability resistors are employed, since these should be inherently less noisy than ordinary composition resistors.* A further reduction in noise might be obtained by using silicon transistors such as the OC202, but since these are rather expensive the question of employing such transistors will not be pursued further.

In case it should be wondered who so much attention has been paid to the question of noise, it must be pointed out that the input to the pre-amplifier may be less than 1mV. Thus, any noise generated by the pre-amplifier is of importance.

Low Frequency Response

The input impedance of this pre-amplifier is

* Grade 1 resistors are high stability (cracked-carbon) types; Grade 2 resistors are normal composition types, as are employed generally in radio work.—Editor

Components List

Resistors

$\frac{1}{4}$ watt, Grade 1 or Grade 2 10% (see text).

R_1	470kΩ
R_2	10kΩ
R_3	18kΩ
R_4	22kΩ
R_5	4.7kΩ
R_6	10kΩ
R_7	18kΩ
R_8	22kΩ
R_9	10kΩ

Capacitors

C_1	0.25μF 150 w.v.
$C_{2,3,4}$	8μF 6 w.v. Electrolytic
C_5	0.25μF 150 w.v.

Transistors

TR_1	OC45, Mullard
$TR_{2,3}$	OC71, Mullard

Miscellaneous

2 Jacks, (see text)
1 Die-cast box, $4\frac{5}{8}$in by $2\frac{1}{2}$in by $3\frac{5}{8}$in, Eddystone
1 Battery, type PP3, Every Ready

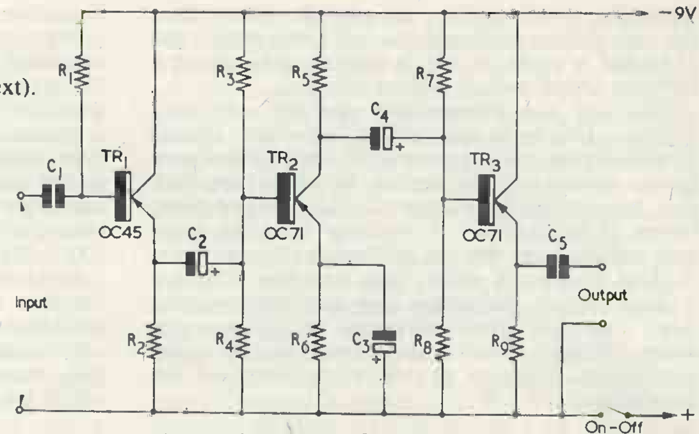


Fig. 1. The circuit of the pre-amplifier

only 150kΩ, and its use with a crystal microphone will lead to a fall-off of output below about 500 c/s.

For the original application for which the unit was intended (i.e. the recording of bird song) this was no disadvantage, although it would be so if other purposes were intended. Fortunately, the difficulty can be largely overcome by artificially increasing the input impedance to 1.5MΩ approximately, this being effected by connecting a 1.5MΩ resistor in series with the 0.25μF input capacitor. It should be noted that if this modification is made, the unit will then have an overall gain of one—i.e. no gain at all. It will still, nevertheless, enable the microphone to be connected to the recorder or main amplifier by long leads at low impedance, thereby considerably reducing cable losses and hum pick-up.

Electrical Performance

The frequency response of the pre-amplifier is shown in Fig. 2. It was measured with a source impedance of 600Ω, and a load impedance of 100kΩ. The gain of the pre-amplifier (when used with the crystal microphone) into a load impedance of 100kΩ is approximately 20dB or ten times.

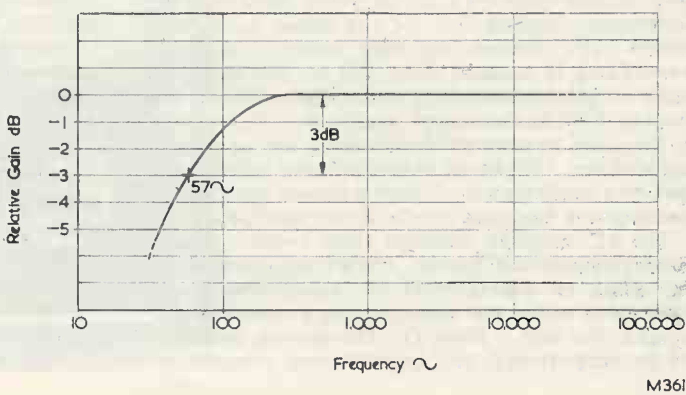
The noise output voltage measured across a 100kΩ load is 1/3 millivolt.

Input Impedance	=150kΩ
Output Impedance	=300Ω
Current Consumption	=2mA

Construction and Components

The pre-amplifier was made in an Eddystone die-cast box, of size $4\frac{5}{8}$in by $2\frac{1}{2}$in by $3\frac{5}{8}$in approximately. The input and output connections are made by means of Igranic jack sockets. The input socket has a "make" contact which connects to the outer of the jack plug when it is inserted in the socket, this contact is connected in series with the positive lead from the battery and auto-

Fig. 2. The frequency response of the pre-amplifier for a source impedance of 600Ω and a load of 100kΩ



matically switches the pre-amplifier on when the microphone is plugged in. If some other type of socket is preferred, e.g. a coaxial socket, then a separate on-off switch will be required.

None of the components specified are very critical. The input and output capacitors should be paper types and not electrolytic, whilst transistors having characteristics similar to those specified may be used as alternatives to the Mullard transistors if so desired. A warning must be given with reference to the use of "surplus" transistors. If these transistors suffer from excessive collector leakage current, the circuit may not function well. Also, "surplus" transistors may introduce extra noise. Whilst neither of these troubles may occur in practice, it is just as well to be aware of the possibility.

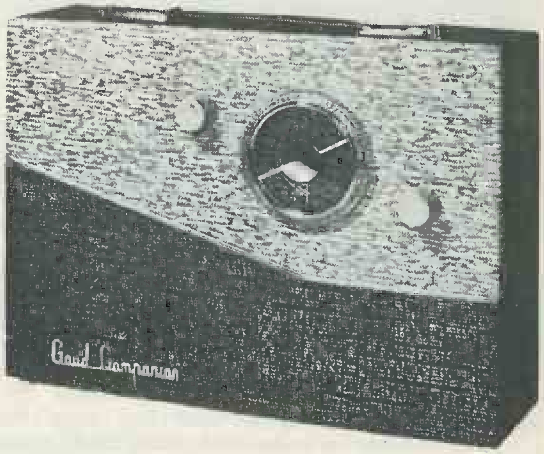
Operation

Once the pre-amplifier has been wired and assembled, no trouble should be experienced. If coaxial cable is used for the lead from the pre-amplifier to the tape recorder or main amplifier, a maximum lead length of 1,000 feet is suggested from calculations. Small diameter screened lead is not recommended as it has a much higher capacitance per foot than coaxial cable; nevertheless, even this type of lead should suffice for leads of 100 to 200 feet long.

It should be noted that this pre-amplifier is only intended to handle small input voltages, such as are obtained from a crystal microphone. It will not handle large signal voltages and, because of this, may prove unsuitable for other purposes where amplification is desired.

The Good Companion Mk. II Transfilter Portable

Described by W. HOLMES



A 6-transistor medium and long wave portable receiver featuring singled-ended a.f. output together with resonant ceramic i.f. transformers

THE "GOOD COMPANION" MK. II RECEIVER COMBINES a number of design features which not only cause it to be an attractive proposition for the home constructor but which also make it of interest to readers concerned with new developments. The receiver employs a ferrite frame fitted with an additional coupling coil for car aerial input, and covers both medium and long waves. The long-wave band is tunable from 160 to 280 kc/s. A single-ended a.f. output circuit is used, enabling the push-pull OC81 transistors to deliver a high power to the speaker without the necessity for an output transformer. A pre-set potentiometer adjusts a.f. gain by a combination of varying bypass capacitance and negative feedback for the driver transistor.

The i.f. amplifier employs three ceramic transfilters resonant at 470 kc/s. These components take the place of conventional i.f. transformers and function in rather the same manner as piezoelectric crystals, but with a lower Q. The ceramic elements are so dimensioned, and have silvered connections fired on them in such a manner, that they offer a passband at 470 kc/s which is equivalent to that offered by high grade i.f. transformers. In consequence, not only do they replace comparatively expensive wound components, but they also reduce alignment problems in the receiver in which they are installed. In the Good Companion Mk. II the only i.f. transformer employed is that which provides a low impedance feed for the detector. This transformer is the only component in the i.f. amplifier which has to be aligned.

The Good Companion Mk. II has a sensitivity, for 50mW output, of approximately 25µV/metre on medium waves and approximately 35µV/metre on long waves. A 9 volt battery provides power, consumption under quiescent conditions being 8 to 10mA and, at average volume level, 10 to 20mA. The panel controls are combined volume and on-off switch, wave-change and tuning. The tuning control has an integral slow-motion drive.

The Circuit

The circuit of the receiver appears in Fig. 1. In this diagram L_1 to L_5 are the windings on the ferrite rod aerial. L_1 is the medium wave tuned coil and L_3 the long wave tuned coil, coupling to TR_1 being effected by L_2 and L_4 respectively. Trimmer C_4 is permanently in circuit across tuning capacitor C_3, additional fixed and trimming capacitance being provided on long waves by C_5 and C_6. L_5 is the coupling coil for the car aerial socket, and it allows the car aerial to be inductively coupled into the rod, thereby obviating any excessive capacitive loading on the tuned circuits.

The signal frequency from the ferrite rod assembly is fed into the base of TR_1 in normal manner. TR_1 functions as a self-oscillating mixer, feedback being effected via the central tuned coil of the oscillator transformer OT_1. On medium waves this coil is tuned by the parallel combination of tuning capacitor C_9 and trimmer C_{10}, additional trimming and fixed capacitance (C_{11} and C_{12}) being connected into circuit on long waves.

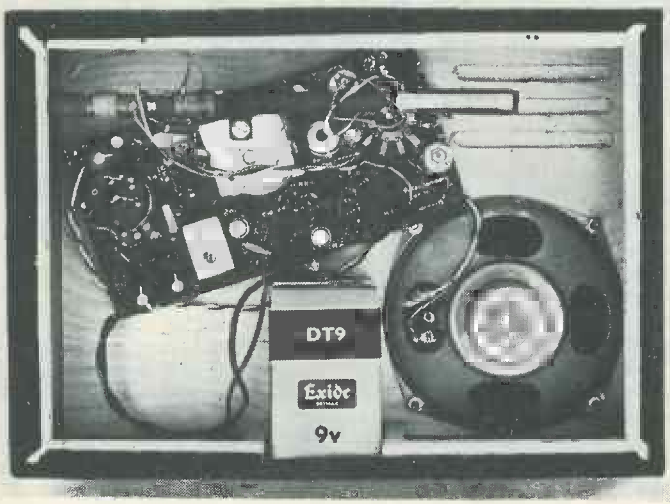
The intermediate frequency appears at the collector of TR_1, and this is applied directly to transfilter TF_1. The remaining non-earthy electrode of TF_1 then couples directly to the base of TR_2. The transfilter requires a polarising voltage and this is offered automatically by R_{24} and R_5, these being the resistors which provide h.t. feed to the collector of TR_1 and bias to the base of TR_2 respectively. It will be noted that the components associated with TF_1 are no greater in number than would be required in a simple cascade a.f. coupling circuit.

The emitter of TR_2 is coupled to the positive supply line via R_7 in parallel with the two-electrode transfilter TF_2. This transfilter functions rather as a series resonant circuit, offering a low impedance at resonant frequency. Emitter degeneration is therefore at a minimum at the desired frequency, with the result that the overall i.f. response is further improved. The collector of TR_2 couples into the base of TR_3 by way of transfilter TF_3, employing the same basic circuitry as appears between TR_1 and TR_2. The relatively low value resistors R_{24} and R_{26} provide a small, and acceptable, level of loading on transfilters TF_1 and TF_3. Nevertheless, this loading is of a sufficient order to ensure that neutralising components are not, in practice, required for either TR_2 or TR_3. Use of transfilters, therefore, brings about the deletion of these components from the i.f. amplifier.

The single i.f. transformer $1FT_1$ has a low impedance winding feeding diode D_1. The detected output from D_1 passes through the filter C_{20}, R_{12}, C_{27} and appears across the diode load VR_1. The diode is connected such that the rectified voltage on the upper terminal of VR_1 is positive, and this positive voltage is applied, via R_8, C_{17} and R_{25}, to the base of TR_2. As a result, an a.g.c. loop is set up: increasing signal voltage at the diode causes an increased positive bias at the base of TR_2, with consequent reduction in i.f. amplification.

The diode load VR_1 is also the volume control, the desired volume level being tapped off by its slider and applied to the base of the driver transistor TR_4. This couples into transformer T_1, the latter having two separate secondary windings feeding, in anti-phase, the bases of TR_5 and TR_6. TR_5 and TR_6 form a single-ended Class B push-pull output stage, the a.f. voltage at their junction being coupled to the speaker via C_{24}. The speaker has an impedance of 25–35Ω to permit adequate matching to be achieved.

A proportion of the voltage across the speaker is fed, by way of R_{23} and VR_2, to the emitter of TR_4. VR_2 is a pre-set component. When the slider of VR_2 is at the top end of its track C_{23} is short-circuited, and maximum negative feedback from the speaker is applied to TR_4. When the slider of VR_2 is at the lower end of its track the negative feedback voltage from the loudspeaker is short-circuited, and C_{23} functions as a bypass component. Intermediate



Inside the cabinet. The three transfilters appear immediately above the battery and are grouped around TR_2

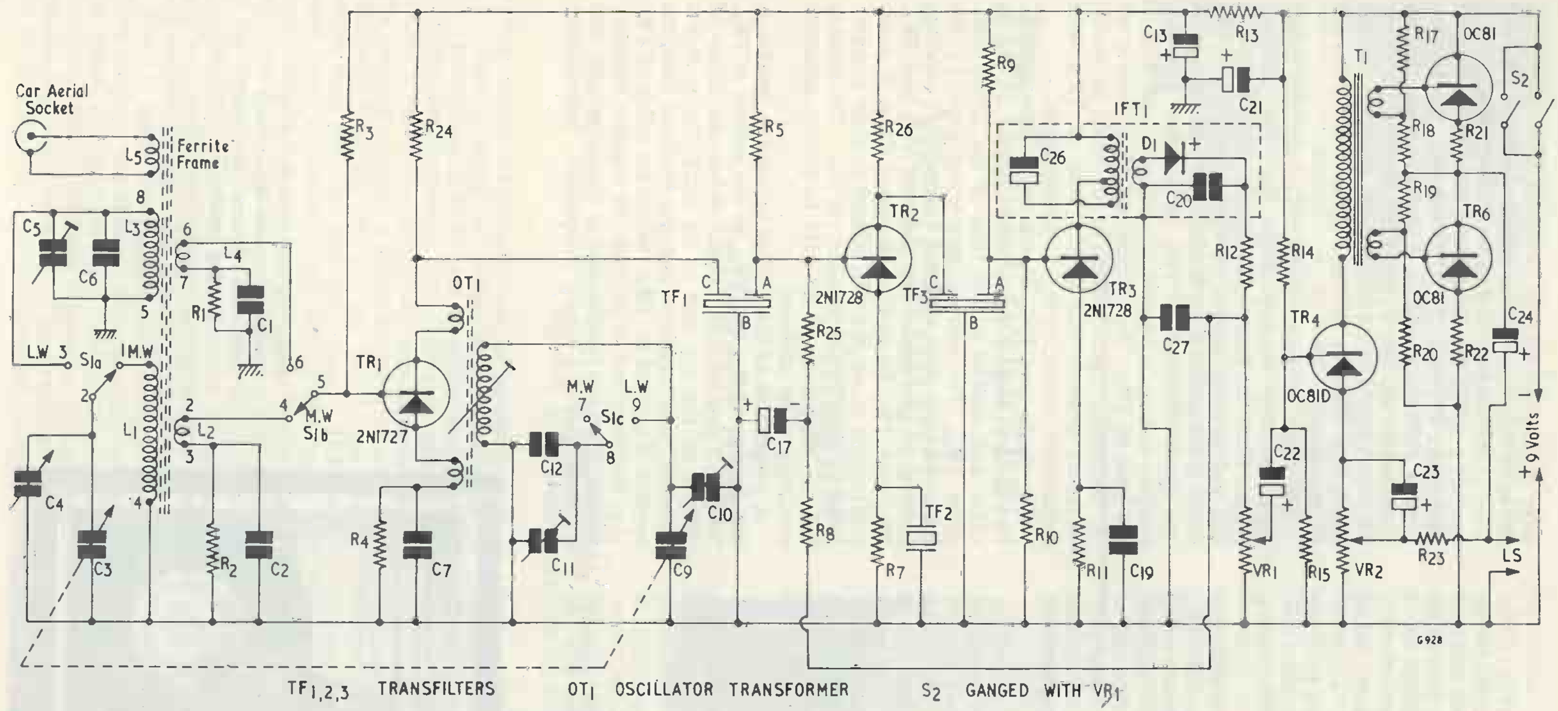


Fig. 1. The circuit of the Good Companion Mk. II Transfilter Portable

Components List

Resistors (all ¼W, 20% unless otherwise stated)

R_1	12kΩ
R_2	8.2kΩ
R_3	39kΩ
R_4	1.8kΩ 5%
R_5	39kΩ
R_7	680Ω
R_8	3.9kΩ
R_9	22kΩ
R_{10}	4.7kΩ
R_{11}	1kΩ 10%
R_{12}	560Ω
R_{13}	560Ω
R_{14}	33kΩ

C_9	174pF, variable, part of 2-gang
C_{10}	Trimmer on C_9
C_{11}	3–30pF, trimmer
C_{12}	330pF
C_{13}	100μF electrolytic
C_{17}	8–10μF electrolytic
C_{19}	0.05μF
C_{20}	Fitted in IFT_1
C_{21}	100μF electrolytic
C_{22}	10–30μF electrolytic
C_{23}	50μF electrolytic
C_{24}	100μF electrolytic
C_{26}	Fitted in IFT_1
C_{27}	0.01μF

Semiconductors

TR_1	2N1727 Philco
TR_2	2N1728 Philco
TR_3	2N1728 Philco
TR_4	OC81D Mullard
TR_5	OC81 Mullard
TR_6	OC81 Mullard
D_1	Fitted in IFT_1

Note: TR_5 and TR_6 should be matched. TR_4, TR_5 and TR_6 may be in audio package LFH3

Transfilters

TF_1	*Clevite TOO2D
TF_2	*Clevite TFO1D
TF_3	*Clevite TOO2D

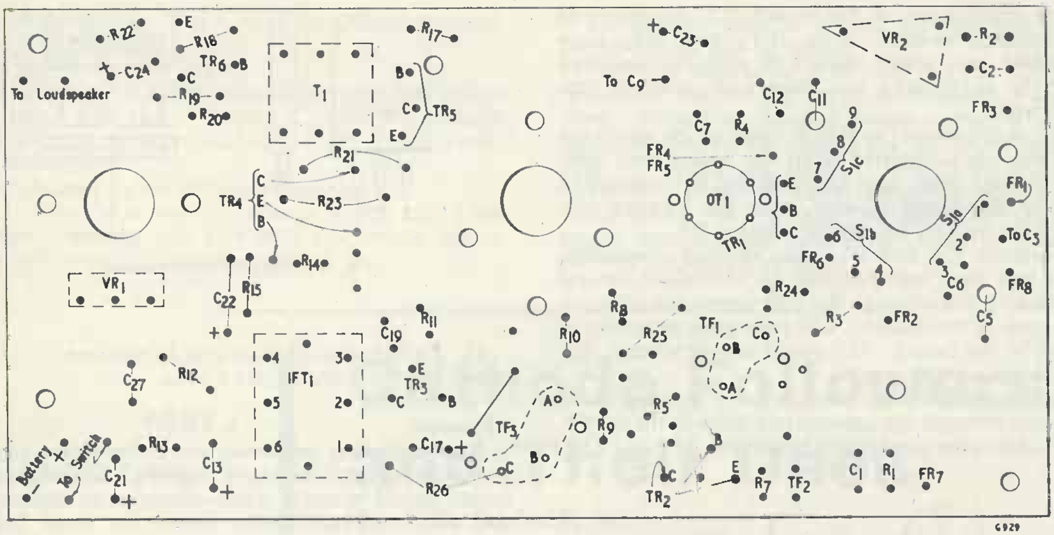


Fig. 2. Component connections to the printed circuit board

R_{15}	10kΩ
R_{17}	2.7kΩ
R_{18}	100Ω
R_{19}	2.7kΩ
R_{20}	100Ω
R_{21}	3.3Ω
R_{22}	3.3Ω
R_{23}	3.3kΩ
R_{24}	3.9kΩ
R_{25}	3.9kΩ
R_{26}	2.7kΩ
VR_1	10kΩ potentiometer log
VR_2	500Ω potentiometer lin. pre-set
Capacitors	
C_1	0.05µF
C_2	0.05µF
C_3	343pF, variable, part of 2-gang
C_4	Trimmer on C_3
C_5	3–30pF, trimmer
C_6	100pF
C_7	0.01µF

Inductors	
L_1 to L_5	*Ferrite rod aerial JB128/1
OT_1	*Oscillator transformer JB285
IFT_1	*IF transformer and diode assembly JB139
T_1	*Driver transformer
Switches	
S_1	*3-pole, 2-way
S_2	2-pole, 1-way. Ganged with VR_1
Speaker	
	5in round, 25–35Ω impedance
Battery	
	9 volts, EverReady PP9, Exide DT9 or Vidor equivalent
Miscellaneous	
	*Printed circuit board
	*Knobs, dial, drive
	*Cabinet
	*Car aerial socket
	Wire, nuts, bolts, etc.
	*Electronic Precision Equipment Ltd.

settings of VR_2 give results lying between these two conditions, and VR_2 may be set up to give whatever degree of negative feedback is desired by the user.

The power supply circuit follows conventional practice. A 9 volt battery is employed, this being bypassed by C_{21} to ensure that there is no falling-off in performance due to increase of battery internal resistance with age. The supply for TR_1, TR_2 and TR_3 is decoupled by R_{13} and C_{13}.

Construction

The construction of the receiver is considerably simplified due to the use of a printed circuit board, and components are inserted as indicated in Fig. 2. It is important to note that the board supplied is pre-fluxed and that no attempt should be made to clean this in any way. All connections must be made with high-grade resin cored solder.

A heat shunt is essential when soldering transistors, and TR_1, TR_2 and TR_3 should be wired into position with approximately ½in of lead-out between the body of the transistor and the printed circuit board. Transistors TR_4, TR_5 and TR_6 require lead-out wires of at least 1in. It is recommended that all transistor lead-out wires be sleeved, employing white sleeving for the collector, green for the base and red for the emitter in order to prevent mistakes. Fig. 3 shows the layout of lead-outs for the transistors employed in the receiver.

When fitting electrolytic capacitors to the board it is necessary to ensure that correct polarity is observed. Driver transformer T_1 is mounted with its blue spot facing the adjacent edge of the chassis. Transformer IFT_1 has an orange spot and this also faces the adjacent edge of the board. Pins 3 and 6 of this transformer are not soldered into circuit. The oscillator transformer OT_1 is colour coded violet-red, and this coding must be towards the nearer short edge of the board, i.e. towards the wave-change switch. Both IFT_1 and OT_1 have mounting lugs which should be carefully soldered after the component has been fully inserted into the board.

The wavechange switch S_1 has to be mounted carefully. It is inserted from the non-copper side, and all tags must pass through the corresponding holes in the board as, also, must the locating lug. The same applies to volume control VR_1.

Trimmers C_5 and C_{11} are Mullard concentric types and they are mounted so that their central conductors pass through the hole nearer the adjacent long edge of the board. The twin-gang capacitor is bolted to the board. The aerial tuning section, C_3, is that nearer the spindle.

The transfilters are mounted by passing their lead-outs through the appropriate holes in the board. Fig. 4 shows the connection layout for TF_1 and TF_3.

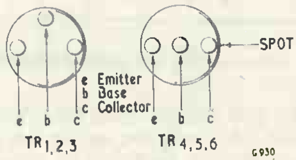


Fig. 3. Transistor lead-outs

It should be noted that the centre lead-outs of these two transfilters must be bent over and soldered to an earthy section of the copper foil.

The order of assembly is as follows:

1. Fit all fixed resistors, fixed capacitors, VR_2, C_5, and C_{11}, to the board.
2. Fit IFT_1, OT_1 and T_1 to the board.
3. Fit S_1 and VR_1/S_2 to the board.
4. Fit transistors and transfilters to the board.
5. Fit and wire the two-gang capacitor to the board.
6. Fit and wire the ferrite rod. The rod is secured by a plastic clamp bolted to the rear of the two-gang capacitor. The connections to the ferrite frame coils are shown in Fig. 5, the numbered tags corresponding to the similarly numbered points (preceded by the letters "FR") in Fig. 2. The car aerial coupling coil is not wired at this stage.
7. Complete the wiring to S_2 and fit leads for the battery and the speaker.

All connections should be thoroughly checked at this stage. If desired, the receiver may be switched on and tested, the knobs being temporarily fitted and the speaker connected for this purpose. The following steps cover installation in the cabinet.

8. Mount the speaker.
9. Attach leads to the car aerial socket and mount this socket to the cabinet.
10. Mount the board with 6BA ¼in bolts using the pillars provided.
11. Connect the car aerial socket to the car aerial coupling coil.
12. Connect up the speaker.

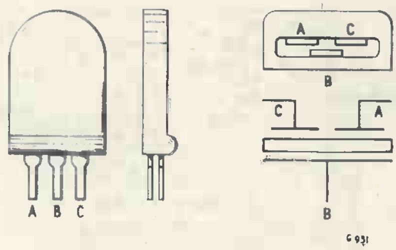


Fig. 4. Transfilter connections

13. Fit the self-adhesive dial in position.
14. Fit the pointer and knobs.

Alignment

Alignment may be carried out either with a signal generator or on broadcast signals. Final adjustments should be made with volume set to maximum and with minimum input signal, the latter being achieved when using broadcast signals by suitably rotating the set. The signal generator may be coupled to the ferrite frame by a 4 turn loop of 6in diameter positioned several feet away.

1. Align pointer so that it is vertical when C_3C_9 is fully closed or open.
2. Tune in a local station (or select medium waves, fully close C_3C_9, and inject 470 kc/s from the signal generator) and align IFT_1.
3. Tune in a station on medium waves between 475 and 550 metres, and as close to 550 metres as possible (or inject 540 kc/s). Adjust OT_1 so that pointer indicates correct wavelength (or C_3C_9 is fully closed for 540 kc/s).
4. Adjust L_1 along the ferrite rod for maximum output.
5. Tune in a station on medium waves between 200 and 225 metres, and as near as possible to 200 metres (or inject 1640 kc/s). Adjust C_{10} so that pointer indicates correct wavelength (or C_3C_9 is fully open for 1640 kc/s).
6. Adjust C_4 for maximum output.

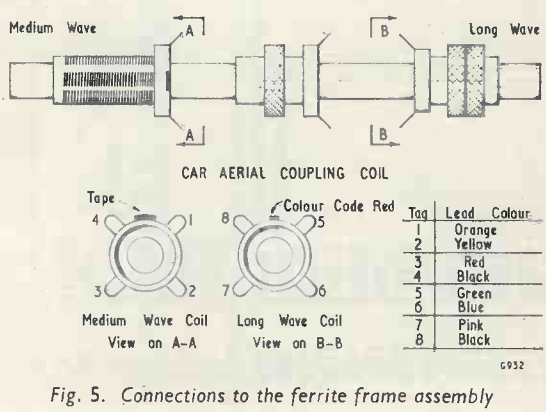


Fig. 5. Connections to the ferrite frame assembly

7. Repeat steps 3 to 6 until no further improvement can be made.

8. Switch to long waves.

9. Tune in the Light Programme on 1,500 metres (or inject 160 kc/s). Adjust C_{11} so that pointer indicates correct wavelength (or C_3C_9 is fully closed for 160 kc/s).

10. Adjust L_3 for maximum output.

11. Tune in a station between 1,300 and 1,100 metres (or inject 280 kc/s with C_3C_9 fully open). Adjust C_5 for maximum output.

12. Repeat steps 9, 10 and 11 until no further improvement can be made.

13. If the receiver is to be used in a car, couple it, inside the car, to the aerial with which it will be used. Switch to medium waves, select a station near 200 metres, and adjust the car aerial coupling coil for maximum output. Alternatively, inject 1,500 kc/s from the signal generator into the car aerial socket, tune around 200 metres for optimum signal strength, and adjust the car aerial coupling coil for maximum output.

PART I

BASIC THEORY

Cathode Followers and Their Uses

By J. B. DANCE, *M.Sc.*

A CATHODE FOLLOWER IS A VALVE circuit with connections which are somewhat different from those of a conventional valve amplifier. The performance of the valve circuit is very much modified by the negative feedback which occurs in the cathode follower circuit. One of the three electrodes of a triode valve is normally operated at chassis potential with respect to a.c. signal voltages. In most conventional amplifiers this electrode is the cathode, but in grounded grid amplifiers, it is the grid and in cathode followers it is the anode.

The basic cathode follower circuit is shown in Fig. 1. The anode is bypassed to earth by the capacitor and the input voltage is applied between the grid and the lower end of the cathode resistor. This is not the same as between grid and cathode, as the cathode is not bypassed to earth. The output is taken from across the cathode resistor; this resistor is the load resistor and in most simple cathode follower circuits it is also the bias resistor.

Why "Cathode Follower"?

If an input signal is applied to the circuit shown in Fig. 1 so that the grid becomes more positive, the anode current will increase. This will cause the voltage across the cathode resistor to increase and the cathode will therefore become more positive. The cathode potential is said to "follow" the grid potential because, if the grid voltage changes, the cathode voltage will also change in the same direction. The change in cathode voltage is almost as great as the change in grid voltage; the voltage between the grid and cathode is therefore comparatively constant.

Gain

The circuit of Fig. 1 may, for a.c. calculation purposes, be replaced by the constant current equivalent generator circuit shown in Fig. 2, providing that the shunting effect of the load is negligible. If the load is not negligible, the effective value of R_k and the load in parallel must be calculated and used in place of R_k in the equations below; this value may not be a pure resistance. In the circuit of Fig. 2, the valve itself is represented by the components within the dotted lines where r_a is an imaginary resistor of value equal to the anode resistance of the valve and the other component is an imaginary device which generates a constant a.c. current of $g_m V_{gc}$ amps where g_m is the mutual conductance of the valve in amps per volt and V_{gc} is the a.c. voltage between the grid and cathode of the valve.

The a.c. current from the imaginary generator divides itself between r_a and R_k, but, as r_a is very much greater than R_k, it is reasonable to assume that all of the current passes through R_k. This current is g_mV_{gc} amps and the voltage across R_k is therefore $g_mV_{gc}R_k$ volts a.c.

From Fig. 1, taking polarity into account, it can be seen that:

$$V_{in} = V_{gc} + V_{out}$$

Therefore $V_{in} = V_{gc} + g_mV_{gc}R_k = V_{gc}(1 + g_mR_k)$

$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{g_mV_{gc}R_k}{V_{gc}(1+g_mR_k)} = \frac{g_mR_k}{1+g_mR_k}$$

From this equation it can be seen that the gain is always less than unity; that is, the cathode follower cannot give any amplification whatsoever. The gain of a practical cathode follower is usually between about 0.7 and 0.95. The input and output a.c. voltages are therefore practically identical. If it had not been assumed that R_k is much less than r_a, the following equation would have been obtained:

$$\text{Gain} = \frac{g_mR_k}{1+g_mR_k+\dfrac{R_k}{r_a}}$$

The fact that cathode followers cannot be used to amplify is the only reason why they are not more widely used. An extra valve which

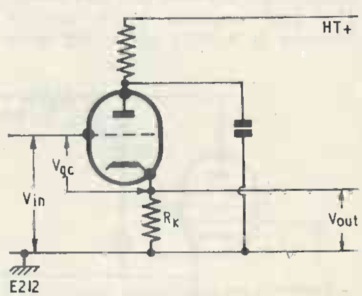
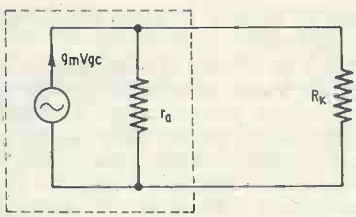


Fig. 1. Basic circuit of a cathode follower. The d.c. grid return is via the signal source. If the signal source has an extremely large d.c. resistance, a large value resistor should be connected between grid and chassis



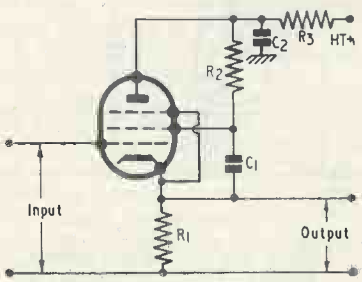
E213

Fig. 2. The constant current equivalent generator of a cathode follower. The valve is represented by the components within the dotted lines

gives no amplification is not economical if a suitable alternative can be found. In order to ascertain some of the uses to which a cathode follower can be put, it is first necessary to consider the input and output impedances of the circuit.

Input Impedance

One of the great advantages of the cathode follower is that its input impedance is very high. This means that it imposes practically no load on the previous tuned circuit; a cathode follower can be used to take a signal from almost any circuit with very little effect on that circuit. There are two main reasons for the high input impedance of the cathode follower circuit. The grid-cathode impedance is high due to the feedback, and the circuit shows no Miller effect between the grid and anode because the anode is at a constant potential. The apparent grid-cathode impedance is very much higher when the valve is working than when it is cold because the cathode follower action leads to an effect between grid and cathode which is exactly opposite to the usual Miller effect between grid and anode. The load imposed by a cathode follower is usually quite negligible up to frequencies of 1Mc or over.



E214

Fig. 3. Circuit of a cathode follower which gives true pentode operation

It should be noted, however, that if a large input voltage is applied to a cathode follower, the anode current may be cut off or the valve may start to take grid current. In the latter case the input impedance will be much less than under normal conditions of operation.

Output Impedance

The output impedance of a cathode follower circuit is much lower than that of almost any other valve circuit. This means that a comparatively large current (i.e. a few milliamps) can be taken from the output of the circuit without the output voltage dropping appreciably. The cathode follower behaves as a source of a.c. voltage of low internal resistance.

The actual output impedance of a cathode follower is

$$\frac{\mu}{g_m\ (\mu+1)} \text{ or, approximately, } \frac{1}{g_m}$$

μ is the amplification factor of the valve. If the valve used has a g_m of 8mA per volt, the output impedance will be 125Ω. Load impedances as low as about 2kΩ can therefore be connected across the output with little change in the output voltage. The output can even be matched very approximately into coaxial cable.

Other Features

The cathode follower operates with 100% negative feedback and the distortion from the circuit is therefore very low. If the input voltage is very high, however, plate current cut-off or grid current may lead to distortion. The maximum input voltage which can be fed to a cathode follower without distortion can best be calculated graphically.

The fact that the input and output are in the same phase is sometimes useful, especially in pulse amplifiers Cathode followers can be used over an extremely wide frequency range, partly because of the negative feedback.

Any suitable small triode or triode-connected pentode can be used as a cathode follower. The results obtained with all valves are almost identical because of the negative feedback. If the valve characteristics change during life, it is unlikely that it will be possible to measure any appreciable change in performance of the circuit as a whole.

Pentode Cathode Followers

If a pentode is connected with the screen-grid bypassed to chassis (as is usual in pentode amplifiers), the pentode will automatically become triode-connected if it is used as a cathode follower. If, however, the circuit shown in Fig. 3 is used, true pentode operation is obtained. The screen-grid is bypassed to the cathode in this circuit and therefore operates at constant voltage with respect to the cathode. The screen-grid dropping resistor, R_2, cannot be omitted or the output which is developed across the cathode resistor would be short circuited by C_1 and C_2 in series. R_2 is effectively in parallel with R_1 with respect to a.c. voltages and allowance should be made for this in any calculations involving the cathode resistor. If R_2 is large, however, it may be neglected.

If a cathode follower is pentode-connected as in Fig. 3, the input capacity between grid and anode is small enough to be neglected. The total input capacity is very much smaller than if the same valve were to be operated as a triode cathode follower. The input impedance at high frequencies is therefore greater in the case of the pentode cathode follower.

Noise

A cathode follower has the same equivalent noise resistance as when the valve is used with the conventional anode loading but, when a cathode follower is used as an r.f. valve, the high input impedance tends to improve the signal to noise ratio. A pentode cathode follower generates more noise than the same valve connected as a triode.

Output

The maximum undistorted output voltage from a cathode follower with a certain value of cathode resistor is usually slightly greater than that which could be obtained from the amplifier with an anode load resistor of the same value. The cathode follower will, of course, require a much greater input voltage.

The value of load resistor chosen for a cathode follower is by no means critical, but there is a rough optimum value. The primary of a transformer can also be placed in the cathode circuit as a load.

Cathode followers find a wide range of uses as impedance transforming devices with a high input and a low output impedance. Next month the uses of the cathode follower will be discussed with practical circuits. Particular reference will be made to the wide variety of uses which cathode followers have in radio receivers.

(To be continued)

SMALL POWER SUPPLY UNIT

By A. S. CARPENTER

In this article, our contributor describes a simple power unit which will be of particular value to the beginner

WHILST A CONSTANT VOLTAGE POWER PACK is, under certain circumstances, very desirable, it is often possible to make do with less ambitious power supplies. Sometimes, simple one or two valve receivers and other items of equipment requiring driving power are made up experimentally. When the time comes to test them it is a good plan to have handy a simple power unit fitted with a socket into which external apparatus may be plugged; such a unit does not cost a great deal either in time or money and will rapidly earn its keep A simple unit of this type is described in this article.

The Circuit

The circuit of the power unit is shown in Fig. 1. A mains isolating transformer, T_1, connects to the a.c. supply via a 2-pole switch and two fuses. Only two secondary windings are fitted to the specified transformer, one being rated at 250-0-250V at 60mA and the other 6.3V at 2A. The latter supply is intended to supply valve heaters in the usual way, and the high voltage winding is connected to the anodes of a valve rectifier V_1, via R_2 and R_3. R_2 and R_3 are limiting resistors and reduce current flow when the reservoir capacitor C_1 charges during the a.c. cycle. The minimum limiting resistance for V_1, under the conditions in which it is used here is 125Ω per anode and this is, in practice, largely contributed by the main transformer itself. The additional resistance inserted by R_2 and R_3 further limits charging currents and ensures cool running of the transformer and rectifier.

V_1 functions as a full-wave rectifier and the rectified d.c. voltage appears at its cathode several seconds after the on/off switch, S_1, is closed. This delay is a desirable improvement over the almost instantaneous potential that appears when a metal rectifier is used, since the valves of externally

Components List

Capacitors
$C_{1a, b}$ 32+32μF dual electrolytic
C_2 0.01μF tubular, 250V a.c. wkg.

Resistors
R_1 100kΩ 1W
R_2 100Ω 1W
R_3 100Ω 1W

Mains Transformer
T_1 Mains a.c. input. Secondaries: 250–0–250V 60mA., 6.3V 2A. Messrs R.S.C. (Manchester) Ltd.

Fuse Holder
Radiospares type FH2 (with home-made cover) or Belling-Lee type L.1033/C3. (See text)

Meter Sockets
Insulated, chassis mounting—Radiospares

Valveholders
I.O. (1). Noval (1).

Warning lamp
6.3V, 0.15A

Warning Lens
Bulgin D196, Red

Switch
d.p.s.t. toggle

Chassis
8 × 4 × 2in

Tagstrip
See text.

Miscellaneous
Spire clips, 6BA nuts and bolts, solder, wire, etc.

LFC
Choke, 10H, 60mA
V_1 EZ80

Fuses
1A cartridge

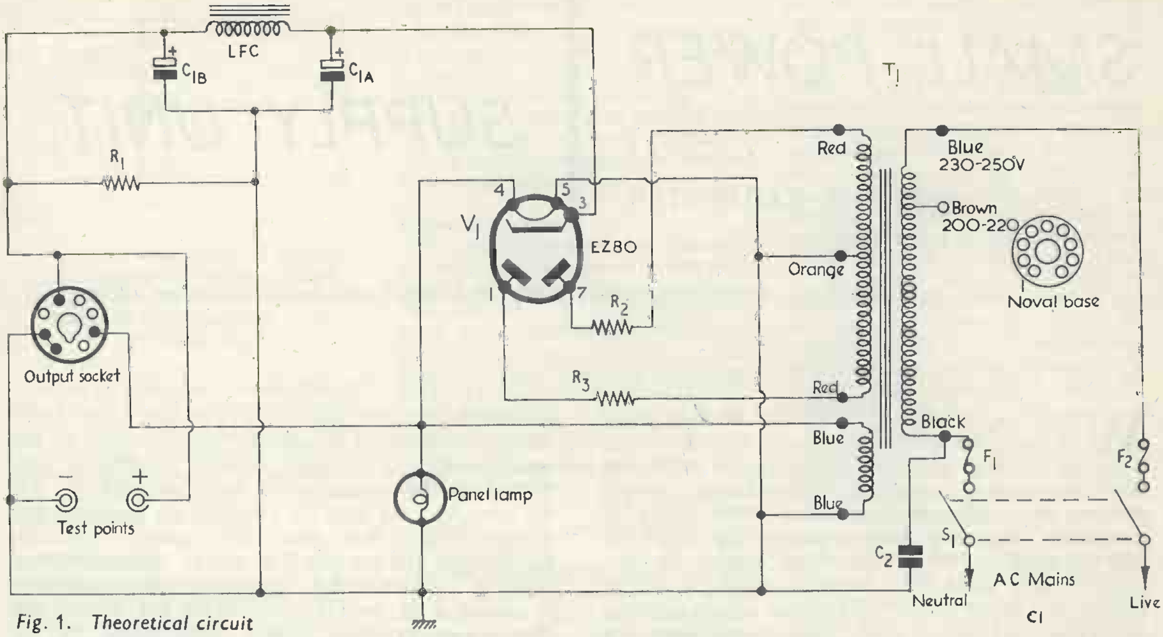


Fig. 1. Theoretical circuit

connected apparatus can receive a period of warming up before the full h.t. is applied.

Connections to T_1 are by means of flying leads and are colour coded as shown in Fig. 1.

The reservoir and smoothing capacitors are C_{1a} and C_{1b} respectively, the choke, LFC, smoothing out ripple in conjunction with these components.

The output is fed to a standard international octal valveholder which is used as the supply point to which external apparatus can be connected.

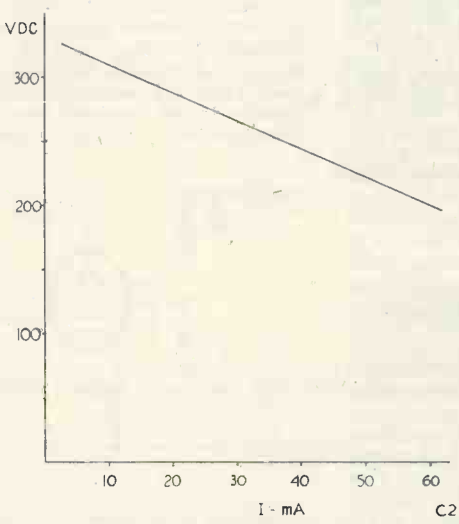


Fig. 2. Graph relating voltage and current

Resistors R_1 is fitted to provide a discharge path for the electrolytic capacitors should a charge be unwittingly left due to disconnecting the external apparatus too soon. The fixed capacitor C_2 effectively earths not only the unit chassis but also, via the h.t. negative line, any equipment connected to it; an adequate rating is essential for this component and only a high grade item should be used. It is also convenient to mount a pair of sockets on the panel into which the leads from a testmeter may be plugged for voltage monitoring purposes. Visual warning of operation is provided by a panel lamp.

Output Services

The unit provides h.t. voltage at currents up to 60mA plus a 6.3V 1.25A heater supply, and this is sufficient for a great many workshop purposes. The available h.t. voltage is dependent upon the load connected externally, the output potential falling as current demand increases and vice versa. The curve of Fig. 2 is representative of what is to be expected.

Layout and Constructional Notes

The design employed completely eliminates uninsulated high potential points above chassis with the exception of the fuses and these are provided a removable home-made cover.[1]

The layouts both above and below chassis are shown clearly in Figs. 3 and 4 together with the wiring. In Fig. 4 the front chassis flange is shown

[1] A suitable fuseholder, alternative to that specified by the author, is the Belling-Lee type L.1033/C3 twin safety type. This is completely enclosed when the fuses are fitted, and has connections at the back.—*Editor*.

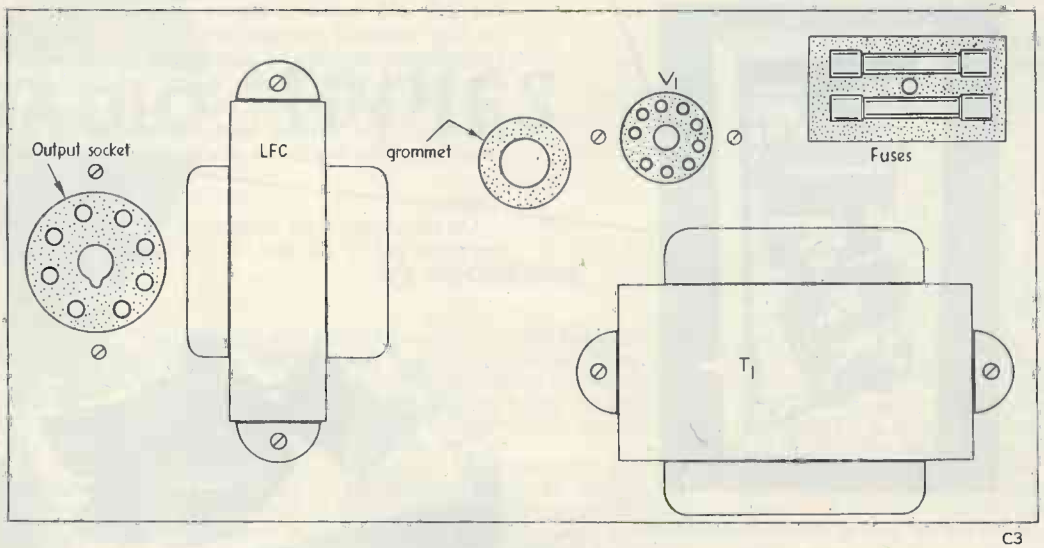


Fig. 3. The above-chassis layout

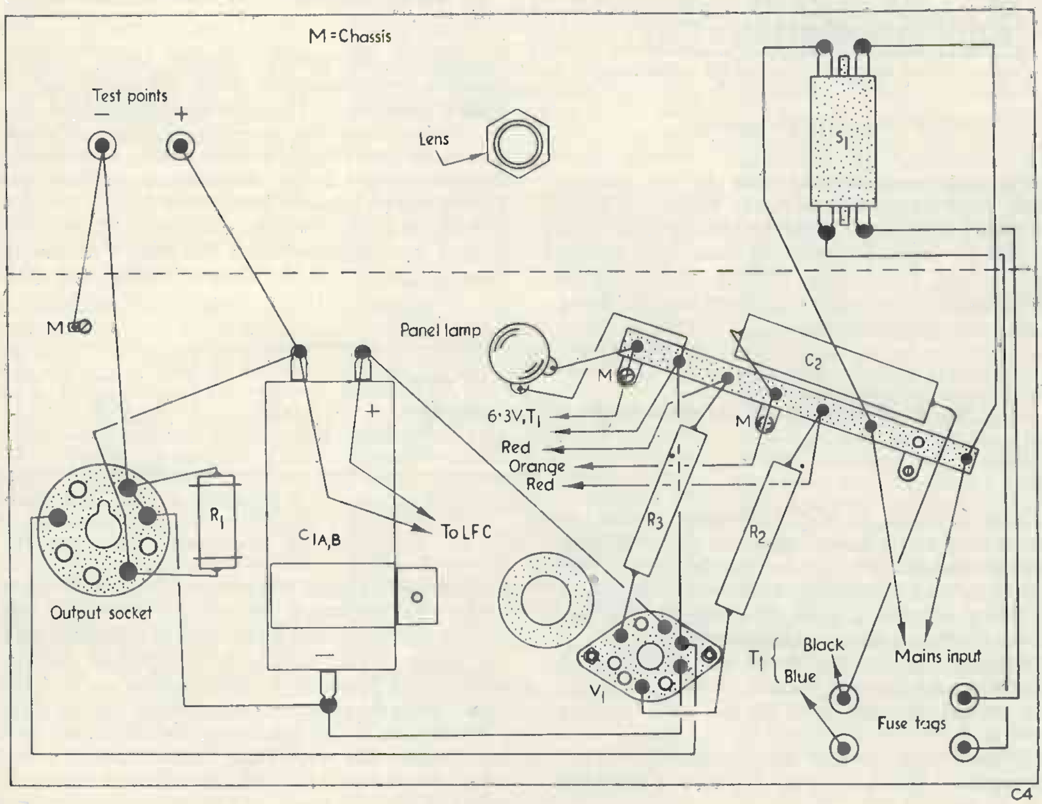
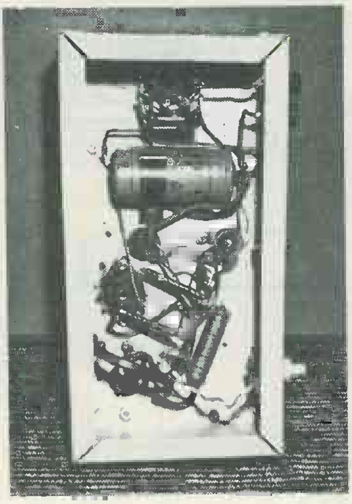


Fig. 4. The below-chassis layout



Under-chassis view of the power supply unit

pressed out flat to reveal the connections more clearly. A sectional chassis consisting of a separate top and four sides was used in the prototype but a conventional type will also be quite satisfactory.

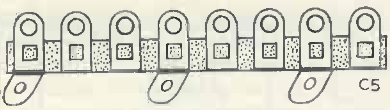


Fig. 5. Details of the tagstrip

Note the large grommetted hole in the chassis top plate used to convey all leads below.

The mains lead is brought in through the rear chassis flange via a grommetted hole (not shown in Fig. 4) and the simple tagstrip illustrated in Fig. 5 provides all necessary anchors for the flying leads, and component wires.

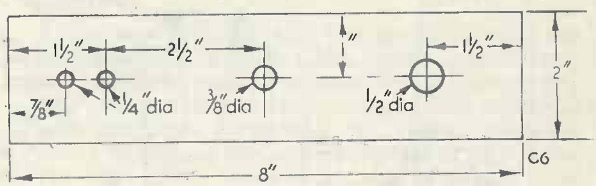


Fig. 6. Dimensions for the front flange

No fuse is fitted to the secondary circuit of T_1 but one may easily be incorporated by connecting the Orange lead (centre tap) to chassis via a 0.15A torch bulb instead of directly as shown; this would ensure safety should a fault develop on the h.t. line of the pack or connected apparatus.

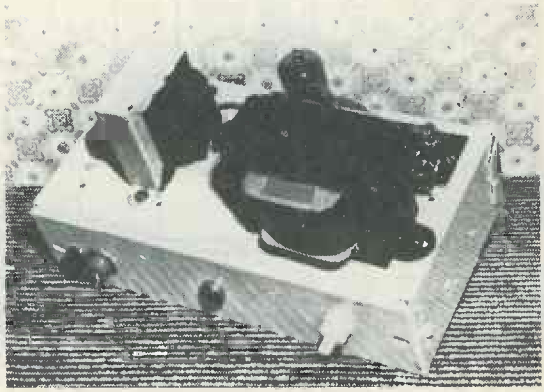
Since the layout is clear from the photographs and diagrams no general chassis drilling diagram is given except for the front flange, and for this refer to Fig. 6.

The mains lead should be connected in the correct sense as shown in Fig. 1, and a 3-pin plug fitted at its far end.

The transformer primary is shown connected for 230–250 volt a.c. inputs in both Figs. 1 and 4. In this instance the unused brown lead from the transformer should be taped and neatly positioned out of the way. If the mains supply voltage is 200–220, the blue lead from the primary should be taped, the brown lead connecting to the appropriate fuse tag in its place.

Testing

On completion, an ohmmeter should be connected between pin 4 of the output socket and chassis,



Above-chassis view of the completed power pack

whereupon its pointer should swing rapidly to indicate low resistance then gradually fall to a higher reading. The initial low reading is due to changing current in C_{1a} and C_{1b}. Should the ohmmeter read zero a fault exists, and should be cleared straight away. Ohmmeter readings should also be taken between pins 1 and 7 of V_1 and chassis in turn, and low readings obtained. A zero reading should be obtained when the meter is connected between pin 7 on the output socket and chassis, and infinity, except for a slight kick as C_2 charges when the resistance to chassis of either side of the mains plug (with S_2 closed) is checked. Finally the meter prods should be connected across the mains plug pins and S_1 checked for correct operation. With S_1 closed a low reading will be given.

If all is in order the meter should be set to read d.c. volts—not less than 500V—and connected with correct polarity to the test terminals. The unit can then be given an operational trial to ensure correct operation.

RADIO topics

By RECORDER

EVERY NOW AND AGAIN IT IS MY pleasant duty to take a stroll down London's Park Lane as I go shopping for Standards. Park Lane nowadays has one-way traffic, with the result that it resembles a Speedway for London Transport; but it is possible to get right away from the roar of the buses by turning off, half-way down the Lane, into Park Street.

British Standards House is at No. 2 Park Street. After entering, I pass the board showing the Committee meetings for the day and go into the room designated "Sales". The young lady behind the counter then passes me the particular British Standard I wish to buy, and in return I hand over my hard-earned cash (later to be reimbursed, I must hasten to add, by Data Publications Ltd.).

British Standards Institution

Altogether nearly all of the manufactured goods we buy are governed, either in whole or in part, by British Standards, many people have only a hazy idea of what the British Standards Institution sets out to do and how it achieves its ends. The Institution is very active in the electronic field, and a number of British Standards cover the performance of electronic components as well as dealing with such things as safety precautions and interference.

It was in 1901 that standardisation work in this country commenced. In that year the Institution of Civil Engineers set up an Engineering Standards Committee which became, later, the British Engineering Standards Association. This Association received a Royal Charter in 1929, and the name was changed to the British Standards Institution in 1931. The purposes of the Institution were laid down in the 1929 Royal Charter and it is worthwhile detailing these in full, as they define very clearly the principles under which British Standards are drafted and issued. The purposes are:

"(*a*) To co-ordinate the efforts of producers and users for the improvement, standardisation and simplification of engineering and industrial materials so as to simplify production and distribution, and to eliminate the national waste of time and material involved in the production of an unnecessary variety of patterns and sizes of articles for one and the same purpose.

"(*b*) To set up standards of quality and dimensions, and prepare and promote the general adoption of British Standard specifications and schedules in connection therewith and from time to time to revise, alter and amend such specifications and schedules as experience and circumstances may require.

"(*c*) To register, in the name of the Association, marks of all descriptions, and to prove and affix or licence the affixing of such marks or other proof, letter, name, description or device.

"(*d*) To take such action as may appear desirable or necessary to protect the objects or interests of the Association."

It will be noted that the primary function of the Institution is to *standardise*, and to thereby reduce the time and money wasted in producing many different varieties of the same object. Standardisation is achieved by the preparation of British Standard specifications (or British Standards), and such specifications are only issued after full and thorough consultation has taken place between producers, distributors, consumers and any other bodies who have an interest in the particular product or field of products.

The word "specification" infers also that a standard of "goodness" has to be met, and this is a very important point. What are, effectively, requirements for "goodness" appear in most British Standards, in addition to such things as purely dimensional requirements. Thus, in the Standards for enamel covered copper winding wires we find not only specifications for the diameter of the wire and the thickness of its insulation, but we also find requirements which define the mechanical and electrical strength of the enamel, and the number of pinholes which are permissible in a given length. Specifications covering wire dimensions are an obvious approach to standardisation. If a transformer manufacturer has been winding his components with 26 s.w.g. wire bought from Messrs. X Ltd., he manifestly wants his windings to come out the same size if he changes over to 26 s.w.g. wire from Messrs. Y. It is in the other specifications, those covering enamel qualities and pinholes, that the question of "goodness" arises. The wire manufacturer is obviously going to keep his wire within standard dimensions, or his product won't get past the first coil-winding girl on his customer's shop floor. But he has also got to keep his wire up to the standard of "goodness" dictated by the subsequent specifications. These specifications won't mean a thing to the girl winding the coil, but if the coil subsequently breaks down they may mean quite a lot to the owner of the equipment in which it is fitted.

Although British Standards generally incorporate this effective requirement of "goodness" in the product covered, we will see shortly that this does not mean that they necessarily lay down exceptionally high standards which are difficult to meet. Also, there is no obligation on the part of any manufacturer to satisfy any British Standard at all (provided, of course, that he does not falsely claim to meet such a Standard). Indeed, it seems in some fields (not electronic products) that a proportion of manufacturers do not claim that their products meet a British Standard even though those products may be *better* than its specifications require. Further, newly introduced products may be unable to meet a British Standard because such a Standard has not yet been published.

Preparing a Standard

A British Standard has, initially, to be proposed. Proposals may come from manufacturers, users, or any other persons interested in the field to be covered. No work is started on the Standard unless there is support for it from the responsible bodies concerned.

After a successful proposal, a Technical Committee is formed, this including representatives from all interested bodies, and the process of working out a draft specification commences. This can take quite a number of Committee meetings to finalise, in which the most time-consuming topics may include the means of test of specific qualities and the reconciling of any conflicting views which may arise between, say, manufacturers and users. Eventually, a specimen draft is worked out and this is sent to all bodies concerned so that people other than committee representatives may make any further comments. If all goes well, the draft then becomes approved and published. It should be noted that specifications are only published if they have the general support of manufacturers as well as users.

From time to time British Standards are brought up to date, either by the addition of amendment slips or by the issue of a revised Standard. The date of issue of a Standard is indicated by the second group of figures in its title. Thus, B.S.1568: 1960 (Magnetic Tape Sound Recording and Reproduction) was issued in 1960.

The number of bodies participating in the preparation of a particular Standard may be very large, especially if, as occurs occasionally, the Standard covers a wide field and is not applicable to a single set of products. One typical example is B.S.905:1959 (Interference Characteristics and Performance of Radio Receiving Equipment for Aural and Visual Reproduction) in the preparation of which no less than 44 bodies took part, 23 sending Committee representatives. These bodies included the War Office, the British Radio Equipment Manufacturers Association, British Railways and the Radio Society of Great Britain.

At a Committee Meeting

Technical Committees are served by Sub-Committees for some of the detailed work, and I sat in at several of these sub-committee meetings myself some years ago. The meetings commenced at 10.30 a.m., a Technical Officer on the Institution staff acting as secretary. Our time was devoted to getting an early draft specification into shape, much of this being spent on discussing means of measurement. As I recall it, we devoted a considerable period to the best method of determining corrosion factor in electrical self-adhesive tape, this being a process which cannot be determined without extremely specialised laboratory equipment. Refreshment was brought round half-way through the morning session (coffee and bikkies) and half-way through the afternoon session (tea and bikkies). An interesting and enlightening experience; and I regret that, due to the hurly-burly of life these days, I have not been able to follow the subsequent history of the embryo Standard we discussed at those meetings.

I should add that, on my initial nomination, I received a very helpful leaflet entitled *Notes for B.S.I. Committee Members*. The information concerning the history of the Institution and its Charter reproduced here is taken from this leaflet.

The Kitemark

As many readers will be aware, manufacturers of some products append the B.S.I. Kitemark to their goods. These Kitemarks imply that the product meets the appropriate British Standard, and they are used under licence from the B.S.I., which carries out periodic inspection and testing of the product.

The Council of Industrial Design

Another body which examines manufactured goods operates along completely different lines to the British Standards Institution. This is the Council of Industrial Design, whose function is to examine the appearance of a particular product and judge it thereby, efficiency and performance being of secondary importance. If a product is considered satisfactory for appearance it is entered in the Design Index, which may be consulted at the Design Centre in the Haymarket, London. Also shown at the Design Centre is a display of approved products.

The fact that the efficiency of a product is of secondary importance makes the Design Index of rather doubtful value. Thus, the March and June issues of the Consumer Association publication *Which?* refer to a mains-driven photographic slide projector in which a live point could be touched. (The manufacturer has now added a protective covering). However, this potentially dangerous device was listed in the Design Index of the Council of Industrial Design.

You Can't Win—1

Changing to an entirely different topic, the wife of a friend of mine recently talked me into volunteering to repair their a.m. steam radio, which had become very insensitive indeed.

When I got the set home I found that I had been preceded by Smithy's Phantom Fiddler, who had cured a case of instability by the delightfully simple process of detuning the i.f. cores. A little digging around revealed that a 0.02μF decoupling capacitor was not working as it should, and a replacement cleared out the whistles altogether. I was then able to bring up the i.f. transformers to correct alignment, whereupon the set assumed that gratifying liveliness which demonstrates that all tuned circuits are peaked to perfection and that the repair job has been well and truly done. A swing of the dial down to 208 metres brought in Luxembourg at good strength, and the receiver could then be described as offering an adequate performance for the average British listener.

I took the set back next day and demonstrated its capabilities. I was just about to prove the sterling worth of my friendship by saying that I was not going to make a charge for the repair when the wife turned round and spoke to me.

"You're not", she said, "going to make a charge for the repair, are you?"

Sometimes you just can't win.

You Can't Win—2

Which reminds me of the only printable story I have heard over the last year or so.

Jones and Robinson were co-directors of a large company, but Robinson was always one up on Jones. Robinson bought his Bentley just before Jones did, he got his country home just before Jones, and he similarly beat him to the installation of his swimming pool.

One morning Jones got out of his car at business just as Robinson arrived in his. What was more, Robinson was very busily talking over a brand-new radio-telephone installed in his car. Furiously, Jones stalked up to his office and immediately contacted the G.P.O., who said they were very sorry but they could allow no further car telephone installations in the district as the very last available frequency had been bagged by "a Mr. Robinson."

Jones was not to be beaten, however, and after several months of wire-pulling he eventually acquired a fully licenced car telephone of his own.

The next morning, as he was driving to business, he decided to ring Robinson who would be similarly travelling up in *his* car. A delighted grin came over Jones's face when, after a few moments, he heard Robinson's voice in his receiver.

"Just a minute, Jones," said Robinson. "I'm busy on the other line."

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8/450V	2/3	60+250/275V	12/6
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16+16/450V	5/6		
32+32/450V	6/6		

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5¾"	900ft, 16/-	1,200ft, 19/6	1,800ft, 37/6
7"	1,200ft, 21/-	1,800ft, 28/6	2,400ft, 47/6

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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.

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

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

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

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

Mains Neon Tester—Vest Pocket Screwdriver with Neon Indicator. For 200/250V Mains, Bargain, 2/9.

Condensers—Silver Mica. All values, 2pF to 1,000pF, 6d. each. Ditto, Ceramics 9d. Tub. 450V T.C.C., etc., .001 mfd. to .01 and .1/350V, 9d. .02–.1/500V 1/-. .25 Hunts 1/6. .5 T.C.C. 1/9. etc., etc.

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

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Close Tol. S/Micas—10% 5pF–500pF 8d. 600–5,000pF 1/-. 1% 2pF–100pF 9d. 100pF–500pF 11d. 575pF–5,000pF 1/6. **Resistors—Full Range** 10 ohms–10 megohms 20% ⅛ and ¼W 3d., ¾W 5d. (Midget type modern rating) 1W 6d, 2W 9d. **Hi-Stab** 10% ½W 5d., ¼W 7d. 5% ¼W 9d., 1% ¼W 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.–50 K 3/-. 50 K–2 Meg. (Carbon) 3/-.

JASON FM TUNER UNITS

Designer-approved kits of parts:
FMT1, 5 gns. 4 valves, 20/-.
FMT2, £7. 5 valves, 37/6.
JTV MERCURY 10 gns.
JTV2 £13.19.6. 4 valves, 32/6.
NEW JASON FM HANDBOOK, 2/6. 48 hr. Alignment Service 7/6. P. & P. 2/6.

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

Speaker Fret—Expanded bronze anodised metal ⅛" & ¼" diamond mesh, 4/6 sq. ft., multiples of 6" cut. Max. width 4 ft.

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

BARGAINS 4-SPEED PLAYER UNITS

Single Players	carr. 3/6
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B.S.R. Latest Model TU12	79/6
E.M.I. Junior "985"	89/6
Auto-Changers	carr. 5/-
Garrard RC209	9½ gns.
Garrard "Auto-Slim"	£8.12.6
Collaro C60	£7.15.0
B.S.R. (UA14) De-Luxe Model	£7.10.0

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Osc. coil M. & L.W.	5/9
Midget Driver Trans. 3.5:1	6/9
Ditto O/Put Push-pull 3 ohms	6/9

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OC45	9/6	OC71	6/-
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SIEMENS TYPES—Contact cooled, 250V, 50mA, 7/6; 250V, 85mA, 10/-; 250V, 125mA, 15/-; 250V, 300mA; 26/6.

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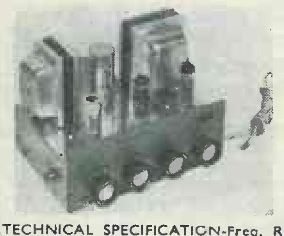

3 VALVES 3 WATT

3 ohm and 15 ohm Output
3 ohm and 15 ohm Output

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

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

COMPLETE KIT (incl. valves, all components, wiring diagram and special quality sectional Output Trans.)

ONLY £6/19/6 carr. 4/6d.

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

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

Recommended Speakers—WBHF 10 12 £5, Goodmans Axiom 10 £5/15/8. Axiette £6/10. or Axiom 112 £8/10.

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continued on page 71

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SMALL ADVERTISEMENTS

continued from page 69

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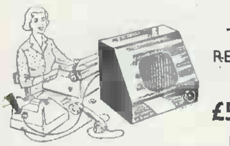

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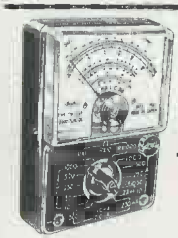

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Fully Guaranteed
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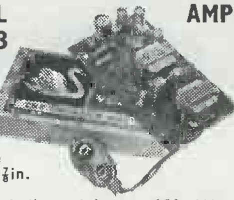

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OC76	7/–	OC45	8/6	OCP71	29/–
OC81	7/–	OC170	9/6	OC41	9/–
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MC 24. Stick Microphone with muting switch and cable, **25/–.** P.P. 1/6.
LAPEL. Miniature Mic. With clip. Ideal for recording, **15/–.** P.P. 1/–.

BATTERY ELIMINATOR AND CHARGER

Replaces PP3 or T6003 9 volt batteries to run transistor radios from mains. Also charges to give 5 times normal battery life. Fitted neon indicator and supplied with full details, **29/6.** P.P. 1/6. 'Petit' type **18/6,** P.P. 1/6.

BATTERY RECORD PLAYER

★ 6–$7\frac{1}{2}$ volt Garrard turntable with crystal pick-up. Plays 45 r.p.m. Ideal for above amplifier.
65/– P.P. 1/6.
★ **PORTABLE RECORD PLAYER CABINET** for above player and amp., **22/6** for 7" x 4" speaker. P.P. 1/6.

Henry's Radio Ltd

PADdington 1008/9
5 HARROW ROAD LONDON W2
Open Mon. to Sat. 9–6, Thurs. 1 o'clock
Send 1/– stamp for Illustrated Price List

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Redesigned 'Contessa' Mk. III

★ combined portable and car radio ★

- **NOW** WITH 600mW **MELLOWTONE** OUTPUT ON MEDIUM AND LONG WAVES
- **NOW** FITTED HORIZONTAL TUNING SCALE WITH ALL STATIONS CLEARLY MARKED
- **NOW** SUPPLIED WITH SIX MULLARD TRANSISTORS AND TWO DIODES
- **NOW** FITTED RECORDING SOCKET AND CAR AERIAL SOCKET
- **NOW** SUPPLIED WITH TWO-TONE BEIGE OR TWO-TONE BLUE CABINET WITH GOLD FITTINGS

GUARANTEED THE VERY BEST OBTAINABLE

● **All parts sold separately** ●

TOTAL COST
£10.19.6 P.P. 3/6

OVERALL SIZE
$10\frac{3}{4}'' \times 7\frac{3}{4}'' \times 3\frac{5}{8}''$

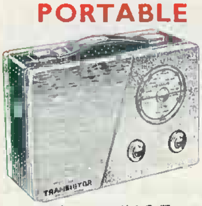
● **Detailed Leaflet on Request** ●

The New "CONTESSA" 6-Transistor Portable Superhet Radio. Features simple printed circuit construction and fully illustrated building instructions, with all parts clearly marked and identified. Fitted with 8" Ferrite aerial. Double IFTs and the latest in components and design. Full tuning of both Medium and Long Wave bands with unbeatable selectivity and sensitivity. Clearly marked station dial and room-filling "MELLOWTONE" push-pull output are standard features. FULL AFTER-SALES SERVICE AND GUARANTEE

★ ALL THESE EXTRA FEATURES AT NO EXTRA COST ★

— THE IDEAL PORTABLE WHEREVER YOU MAY BE —

"TRANSFIVE" PORTABLE RADIO



Medium and Long Wave Portable

$8\frac{1}{2} \times 6\frac{1}{4} \times 3\frac{1}{2}$in.

£6.19.6
P.P. 2/6

A simple to build 5-Transistor and Diode, Printed Circuit, Medium and Long Wave Portable. Features 5" speaker, Car aerial socket, Mullard transistors and carded components. Building plans free on request. THE IDEAL PORTABLE.

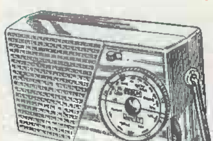
Full after-sales service and guarantee.

"QUINTET" MEDIUM AND LONG WAVE POCKET RADIO

PUSH-PULL SPEAKER OUTPUT

Size
$5\frac{1}{4}'' \times 3'' \times 1\frac{3}{4}''$

Red or Blue with Gold trim



Total Cost
£5.10.0 P.P. 2/-

A 5-Transistor and Diode medium and Long Wave Printed Circuit loudspeaker Radio. Features Mullard transistors and plainly marked printed circuit with carded components. Excellent results with full station separation guaranteed. Including Radio Luxembourg. Push-pull output up to 200mW. Fitted phone/record socket and car aerial socket.

Full after-sales service and guarantee.

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"CAPRI" POCKET SIX. 6-TRANSISTOR MEDIUM AND LONG WAVE POCKET SUPERHET RADIO

● SIZE $4\frac{1}{2}'' \times 2\frac{3}{4}'' \times 1\frac{1}{4}''$ REALLY POCKET SIZE ●

The most compact 6-transistor and diode radio with speaker available to the home constructor. Features the latest in miniature components and circuitry. Supplied with Mullard transistors and two-tone moulded cabinets in red/white or blue/white with gold fittings. All components are supplied in packets and clearly identified. A printed circuit is used with fully illustrated building instructions. Push-pull output coupled with a sensitive and selective circuit make the "CAPRI" hard to beat. Fitted Earphone/Record socket.

● FULL AFTER-SALES SERVICE AND GUARANTEE

● ALL PARTS SOLD SEPARATELY—DETAILED LEAFLET ON REQUEST

★ **DESIGNED BY EXPERTS FOR THE HOME CONSTRUCTOR** ★

TOTAL COST **£6.19.6** P.P. 2/- (Battery 2/6)

"CARVERTER"

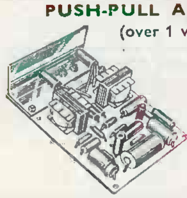
Mobile Transistor Short Wave Converter

As featured in the May edition of *The Radio Constructor*. Just plugs into the aerial socket of your car radio. Crystal controlled—covers amateur and Short Wave broadcast bands from 5 to 16 Mc/s. Supplied complete with long life battery and 39/40 metre band crystal. Send 1/- stamp for full Booklet. **No modifications to car radio at all.**

Total cost with sprayed cabinet, etc.
69/6 P.P. 2/-

750mW 4-TRANSISTOR PUSH-PULL AMPLIFIER

(over 1 watt peak output)



- ★ Uses OC71/OC81D, 2—OC81
- ★ ±3dB 70 c/s to 12 kc/s
- ★ Overall size $4'' \times 2\frac{3}{4}'' \times \frac{3}{4}''$
- ★ Built on printed circuit

BUILT & TESTED **69/6** P.P. 1/6 OR COMPLETE KIT **59/6** P.P. 1/6

Ideal for Record Player, Intercom., Baby Alarm for Tuners, etc.

3 ohm output, fully guaranteed, 9 volt operated. Descriptive leaflet with uses FREE on request

"PW-6" SUPERHET RADIO

Medium and Long Wave Radio

Size
$5\frac{3}{4} \times 3\frac{3}{8} \times 2$in.

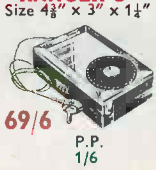
£7.19.6 P.P. 2/-

Modified version of previously advertised "PW" Superhet. Now with new style Two Tone Cabinet. First grade components and transistors. Printed circuit. Features matched set of 6 Transistors. New $2\frac{1}{2}''$ quality speaker and new illustrated building instructions.

NOW AVAILABLE A 7-TRANSISTOR VERSION OF ABOVE £8. 10. 0. P.P. 2/-.

"RANGER 3"

Size $4\frac{3}{8}'' \times 3'' \times 1\frac{1}{4}''$



69/6 P.P. 1/6

A Three-Transistor Two Diode Personal Radio for Medium Waves and Amateur top band and shipping. Quality output on personal phone. Fitted air spaced tuner, vol. control. No aerial or earth. **Luxembourg guaranteed.**