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ELECTRONICS

VOLUME 16 NUMBER 8
A DATA PUBLICATION
PRICE TWO SHILLINGS

March 1963

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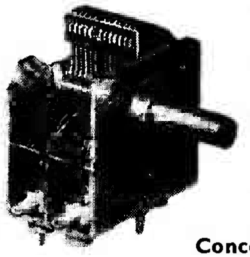

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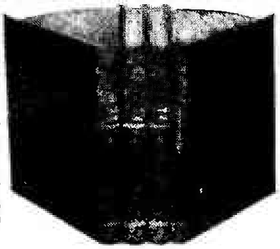

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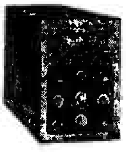
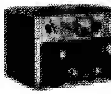
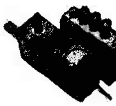


SB-10U



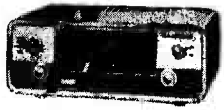
DX-40U



GD-1U

"GLOUCESTER"

GL-58



AM/FM TUNER

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

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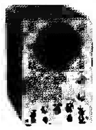
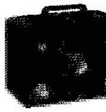


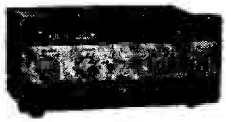
O-12U

S-3U

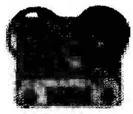


C-3U

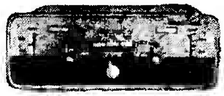
AG-9U



S-33



COLLARO



TA-1S

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

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MA-12

RSW-1

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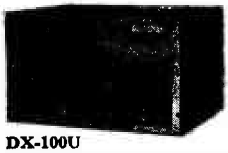
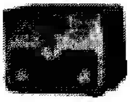
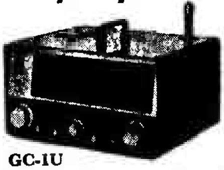

DX-100U


VF-1U


GC-1U

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

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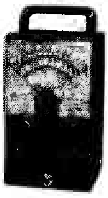
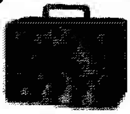

V-7A


MM-1U


RF-1U

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

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USC-1


Truvox D83


FM TUNER


SSU-1

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UJR-1


S-99


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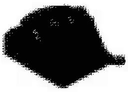
UXR-1


TTA-1

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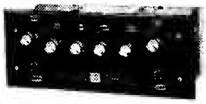
Designed mainly for Mullard Range of Amplifiers, also suitable for any Amplifier requiring input up to 250 mV. Incorporates 5 input channels, including for Tape and Magnetic Pick-ups. Separate Bass and Treble controls. High pass filter 20 to 160 c/s. low pass filter 5–9 Kc/s. Totally enclosed in case, size 11¼" x 4¾" x 4".



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

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

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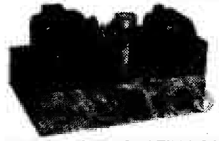
MULLARD "5-10" MAIN AMPLIFIER



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

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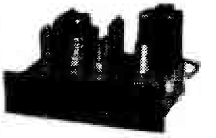
The popular complete "5-10" incorporating Control Unit providing up to 10 watts. Specified components and new MULLARD VALVES. Includes PARMEKO MAINS TRANSFORMERS and choice of the latest PARMEKO or PARTRIDGE output Transformers.



Price : COMPLETE KIT **£12.0.0**

ASSEMBLED AND TESTED **£16.0.0**

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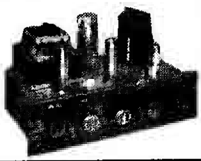

HIGH QUALITY AMPLIFIER DEVELOPED FROM THE VERY POPULAR 3-WATT MULLARD "3-3" DESIGN. KIT OF PARTS **£8.8.0**

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

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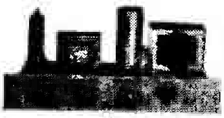


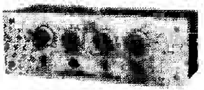
A small Amplifier of genuine high quality performance. Incorporates new MULLARD ECL86 Valve, separate BASS and TREBLE controls and produces up to 3 watts undistorted output.

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

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

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

MULLARD FOUR CHANNEL MIXING UNIT



Self powered Cathode follower output. Incorporates two inputs for CRYSTAL MICROPHONES, one for CRYSTAL PICK-UPS and a fourth for Radio or Tape.

KIT OF PARTS **£8.8.0** ASSEMBLED AND TESTED **£11.10.0** Alternative Model I/L provides for one input matched for moving coil or ribbon mike **£1.17.ex.**

! ! ! SENSATIONAL BARGAINS ! ! !

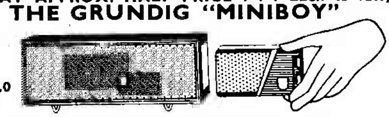
A BULK PURCHASE ENABLES US TO OFFER THESE TWO GRUNDIG MODELS AT APPROX. HALF PRICE . . . Each is fully GUARANTEED.

THE GRUNDIG "MINIBOY"

The "LITTLE" SET with "BIG" PERFORMANCE

Original Price is £26.5.0

OUR PRICE ONLY £10.10.0



INCLUDING SPEAKER ENCLOSURE

A six Transistor (plus two Diodes) Portable covering the Medium Waveband. Small enough to slip into Handbag or Pocket (4 x 2¼ x 1 in.) but when at home "big set" performance is obtained simply by slipping the set into the companion Speaker Enclosure (size 9¾ x 3¾ x 1½ in.).

GRUNDIG T.M.60 TAPE UNIT

FOR STEREOPHONIC or MONOPHONIC OPERATION, BEAUTIFULLY STYLED WITH FINGER TIP CONTROLS. CONSISTING OF TAPE DECK INCORPORATING HIGH QUALITY PREAMPLIFIER. LIST PRICE IS £94.10.0.

OUR PRICE ONLY... £49.10.0

A completely self-contained self-powered Unit designed to add full TAPE RECORDING facilities to existing sound reproducing equipment. Will operate with the majority of high quality audio installations and ideally suited for our MULLARD AMPLIFIERS. When ordering please state the make and type of Amplifier or Radiogram to be used with the Unit.

LOUDSPEAKERS

WE STOCK THE COMPLETE RANGE OF HIGH FIDELITY UNITS by . . . GOODMANS, WHARFDALE and W. B. STENTORIAN

A few recommended examples :

8 INCH TYPES	
GOODMANS "AXIETTE"	£5. 5.6
W.B. HF.816	£6. 0.0
WHARFDALE "SUPER 8/RS/DD"	£6.14.0
10 INCH TYPES	
GOODMANS "AXIOM 10"	£5.16.8
W.B. Model HF.1016	£7. 0.0
WHARDFALE "GOLDEN 10/RS/DD"	£7.17.6
12 INCH TYPES	
GOODMANS "AXIOM 201" 15 watts	£9.15.0
GOODMANS "AXIOM 301" 20 watts	£14. 0.0
W.B. Model HF.1214 15 watts	£10. 5.6
WHARFDALE "W12/RS"	£10.10.0
WHARFDALE "Super 12/RS/DD"	£17.10.0

LEAK AND QUAD AMPLIFIERS

LEAK. "TL/12 PLUS" POWER AMPLIFIER with the "POINT ONE PLUS" PRE-AMPLIFIER . . . 14 watts rated output	**£31.10.0**
LEAK. "TL/25 PLUS" with the "POINT ONE PLUS" PRE-AMPLIFIER . . . 28 watts rated output	**£37.16.0**
LEAK. "STEREO 20" POWER AMPLIFIER with the "VARI-SLOPE STEREO" PRE-AMPLIFIER . . . 22 watts (11 watts per channel)	**£55.9.0**
QUAD II. POWER AMPLIFIER with QUAD II CONTROL UNIT 15 watts output	**£42.0.0**

RECORD PLAYERS

THE COLLARO "JUNIOR" 4-speed single player with separate crystal pick-up	**£3.10.0**
GARRARD Model SRP10. Single Record Player fitted with high output crystal pick-up	**£5. 0.0**
THE NEW GARRARD "AUTOSLIM" 4-speed Autochanger with crystal pick-up	**£7.10.0**
GARRARD "AUTOSLIM DE LUXE" 4-speed Autochanger, incorporates transcription Pick-up Arm	**£11. 8.0**
THE COLLARO "C60" 4-speed autochanger unit with Studio "C" pick-up	**£6.19.6**
B.S.R. Model UA14, a 4-speed Mixer Autochanger with crystal pick-up	**£6.10.0**
The new **GARRARD Model 4HF** High Quality Single Record Player fitted with the latest T.P.A. 12 pick-up arm and G.C.S. crystal Cartridge	**£16.17.6**
PHILIPS Model AG1016. A 4-speed Player which can be operated both manually and automatically. Suitable for Mono or Stereo operation	**£12.12.0**

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

HOME CONSTRUCTORS

A Range of "EASY TO ASSEMBLE" PREFABRICATED CABINETS Designed by the W.B. "STENTORIAN" COMPANY for "Hi-Fi" Loudspeaker systems or to accommodate high quality equipment. **FULL RANGE IN STOCK, please enclose S.A.E. for descriptive leaflets.**

IF YOU ARE PLANNING TO INSTALL HI-FI

AND UNCERTAIN OF THE TYPE OF EQUIPMENT TO USE—OUR WIDELY EXPERIENCED TECHNICAL STAFF WILL WITH PLEASURE PUT FORWARD RECOMMENDATIONS—STATE TYPE OF INSTALLATION CONTEMPLATED and APPROX. PRICE LEVEL.

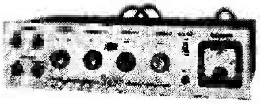
CREDIT SALE TERMS are available on all Equipment over **£10.**

FULLY DESCRIPTIVE LEAFLETS are readily available . . . please enclose S.A.E

SPECIALISTS IN SOUND EQUIPMENT FOR OVER 50 YEARS

TAPE RECORDING EQUIPMENT

STEREO TAPE PRE-AMPLIFIER



Model STP-1. For use with current TRUVOX, BRENELL or COLLARO "STUDIO" ½ and ¼ track Stereo Decks. Incorporates Ferroxcube Oscillator, 4-speed Equalisation Signal Level Meter and separate Gain Controls. Includes separate Power Unit.

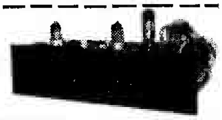
KIT OF PARTS **£22.0.0** ASSEMBLED AND TESTED **£28.0.0**

MULLARD'S TYPE "C" TAPE PRE-AMPLIFIER

Suitable for most ¼-track Mono Tape Decks. Incorporates Ferroxcube Push Pull Oscillator and 3-Speed Treble Inductor. Includes separate Power Unit.

KIT OF PARTS **£14.0.0** ASSEMBLED AND TESTED **£19.10.0**

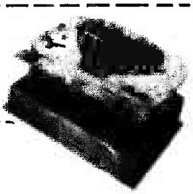
MULLARD'S TAPE AMPLIFIER (Model HF/TR3)



Based on Mullard's Type "A" design and suitable for most ¼ track Mono Tape Decks. Incorporates Ferroxcube 3-speed Treble Inductor and Gilsen Output Transformer. Includes separate Power Unit.

KIT OF PARTS .... **£13.13.0** ASSEMBLED AND TESTED **£19.0.0**

STERN'S "ADD-A-DECK"



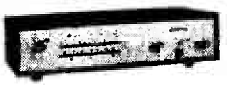
A self-contained Unit consisting of Garrard Deck and matched Pre-amplifier on one chassis. Provides full tape recording facilities and replays through Pick-up Sockets of standard Radio receiver or Amplifier.

PRICE: Includes Spool of Tape ... **£18.18.0**

TAPE DECKS AND COMPLETE RECORDERS

By Collaro, Brenell, Truvox, Wearite, Grundig, Ferrograph, Philips and others . . . Descriptive leaflets readily available.

THE "TUDOR" AM/FM TUNING UNIT



A SELF-POWERED HIGH FIDELITY TUNER OF OUTSTANDING DESIGN. PROVIDES FULL COVERAGE of the VHF/FM TRANSMISSIONS and also the LONG and MEDIUM WAVEBANDS.

PRICE ONLY **£19.19.0**

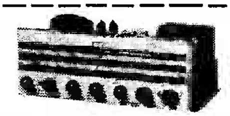
Operates perfectly with the STERN-MULLARD AMPLIFIERS and contains matching FRONT PANEL in Black/Gold or White/Black. Also operates equally well with any Amplifier requiring input of 100 to 350 m/Volts.

Mk. II "Fidelity" FM TUNING UNIT

An attractively presented Unit incorporating MULLARD PERMEABILITY TUNING HEART and corresponding Mullard valve line-up. Very suitable to operate with our Mullard Amplifiers.

KIT OF PARTS ... **£10.10.0**
ASSEMBLED ... AND TESTED **£14.5.0**

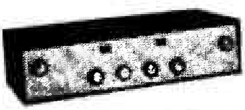
ARMSTRONG RADIOGRAM CHASSIS



We have the full range in stock. Prices Range from **£20.10.0**

Full details are readily available.

THE "TUDOR" STEREO AMPLIFIER



PRICE ONLY **£18.18.0**

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

!! COMBINED PRICE OFFERS !!

Includes small charge for special testing and PRECISE MATCHING of the ASSEMBLED PRE-AMPLIFIER (or Amplifier) to TAPE DECK

STP-1 (Kit) and "STUDIO" Deck	**£39.0.0**
STP-1 (Assembled) "STUDIO" Deck	**£46.0.0**
STP-1 (Kit) and Brenell Deck	**£66.0.0**
STP-1 (Assembled) Brenell Deck	**£75.0.0**
STP-1 (Kit) and Truvox Deck	**£51.0.0**
STP-1 (Assembled) Truvox Deck	**£59.0.0**

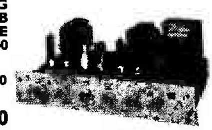
TYPE "C" (Kit) and "STUDIO" Deck	**£26.10.0**	Assembled	**£33. 0.0**
TYPE "C" (Kit) and BRENELL Deck ..	**£43. 0.0**	Assembled	**£50. 0.0**
TYPE "C" (Assembled) and WEARITE Deck	**£70. 0.0**	Includes Head Lift Transf.	
HF/TR3 (Kit) and "STUDIO" Deck	**£26. 0.0**	Assembled	**£33. 0.0**
HF/TR3 (Kit) and BRENELL Deck	**£42. 0.0**	Assembled	**£50. 0.0**
HF/TR3 (Assembled) and WEARITE Deck	**£70. 0.0**	Includes Head Lift Transf.	

To build a complete TAPE RECORDER . . . We offer HF/TR3 AMPLIFIER. STUDIO DECK PORTABLE CASE . . . ROLA 10 x 6 SPEAKER . . . MICROPHONE and 1200 ft. TAPE . . . ALL FOR **£35.0.0** ALTERNATIVELY WE OFFER . . . THE COMPLETELY ASSEMBLED and GUARANTEED PORTABLE RECORDER . . . (Model CR3/S) . . . FOR . . . **£43.0.0**

Full Range of Lustraphone Microphones, Stands, and Accessories are in Stock.

Stereo Amplifiers

MULLARD'S "10+10" STEREO AMPLIFIER



A HIGH FIDELITY DESIGN PROVIDING UP TO 10 WATTS (per channel). SUPERB REPRODUCTION FREQUENCY RESPONSE FLAT TO WITHIN 3dB from 3 c/s to 60 kc/s at 50mW.

TOTAL HARMONIC DISTORTION AT 10 WATTS, 0.1%.

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

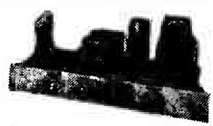
(b) KIT of PARTS **£20.0.0** Built to the highest technical standards and presented strictly to MULLARD'S specification. Two specially designed GILSON OUTPUT TRANSFORMERS with 20% taps are used.

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

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

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

THE "TWIN THREE" STEREO AMPLIFIER



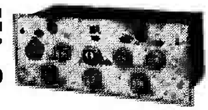
ASSEMBLED AND TESTED for (Carr. & Ins. 7/6 extra) **£9.0.0**

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

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

To construct a STEREO PORTABLE RECORD PLAYER we offer :— Assembled AMPLIFIER with two ROLA 8 in. x 5 in. LOUDSPEAKERS and PORTABLE CASE for £16.10.0 (Carr. and Ins. 10/– extra).

MULLARD DUAL CHANNEL PRE-AMPLIFIER



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

KIT OF PARTS **£12.10.0**

ASSEMBLED AND TESTED **£15.0.0**

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STERN RADIO LTD.
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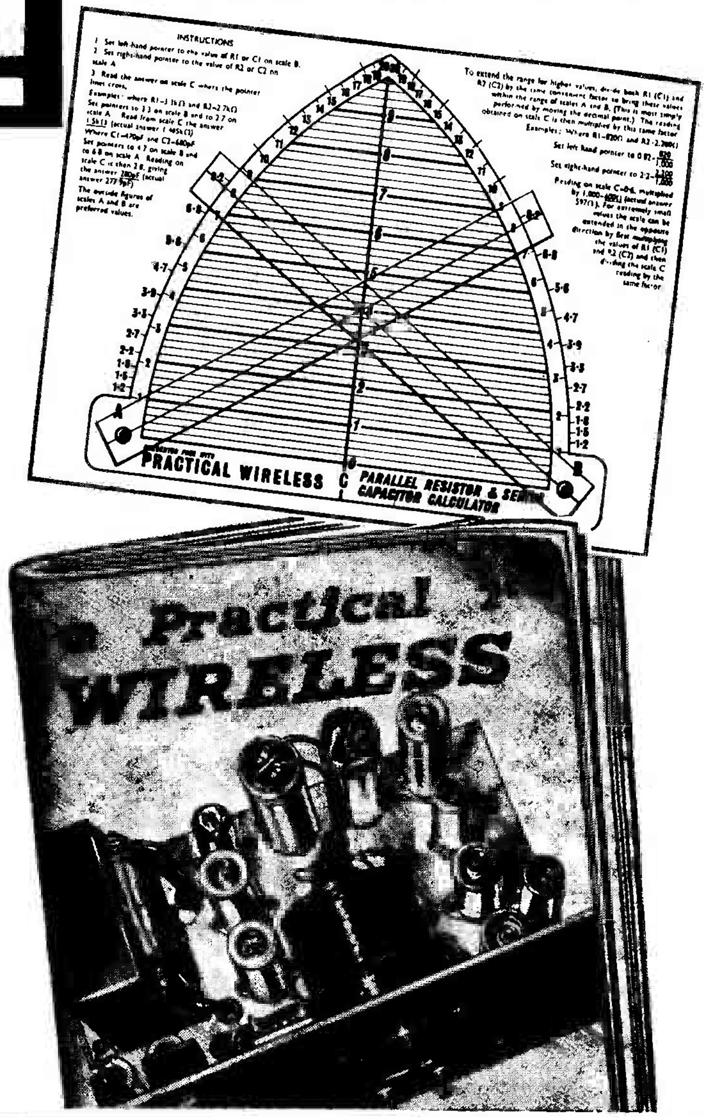

COMPLETE RESISTOR AND CAPACITOR CALCULATOR WITH *COLOUR CODE GUIDE*

Here's a unique time and money-saver! This specially designed Calculator shows you *at-a-glance* how to couple up resistors and capacitors to give any fixed value for any job in hand. It's a *must*—and it's presented FREE in the April PRACTICAL WIRELESS!

APRIL **Practical WIRELESS** 2/-

APRIL ISSUE ON SALE MAR. 7th

MAKE SURE OF YOUR COPY!

COLLARO STUDIO TAPE RECORDER KIT

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

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

COLLARO TAPE DECK £12.10.0 Carr. 7/6

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

New Boxed VALVES All Guaranteed

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

Electrolytics All Types New Stk.

TUBULAR		CAN TYPES	
25/25V	1/9	8+8/450V	4/6
50/12V	1/9	16+16/450V	5/6
50/50V	2/–	32+32/275V	4/6
100/25V	2/–	50+50/350V	6/6
8/450V	2/3	60+250/275V	12/6
4/350V	2/3		
16+16/450V	5/6	100+200/275V	12/6
32+32/450V	6/6		

Ersin Multicore Solder 60/40 3d. per yard. ¼lb. **2/6**, etc.

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

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

Post and Packing, per reel, 1/–, plus 6d. each for additional reels.

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

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

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

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

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

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

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

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1¼" diam. Guar. 1 year. LOG or LIN ratios less Sw. **3/–**. DP. Sw. **4/6**. Twin Stereo less Sw. **6/6**. D.P. Sw. **8/–**.

COAX 80 OHM CABLE
High grade low loss Cellular air spaced Polythene—¼" diameter. Stranded cond. Famous mfrs. **Now only 6d. per yard. Bargain Prices—Special lengths** 20 yds. **9/–**. P. & P. **1/6**. 40 yds. **17/6**. P. & P. **2/–**. 60 yds. **25/–**. P. & P. **3/–**.
Coax Plugs **1/–**. Sockets **1/–**. Couplers **1/3**. Outlet Boxes **4/6**.

Close Tol. S/Micas—10% 5pF–500pF **8d**. 600–5,000pF **1/–**. 1% 2pF–100pF **9d**. 100pF–500pF **11d**. 575pF–5,000pF **1/6**. **Resistors—Full Range** 10 ohms–10 megohms 20% ¼ and ½W **3d.**, ⅛W **5d.** (Midget type modern rating) 1W **6d**, 2W **9d**. **Hi-Stab** 10% ½W **5d.**, ¼W **7d.** 5% ¼W **9d.**, 1% ½W **1/6**. **W/W Resistors** 25 ohms to 10K 5W **1/3**, 10W **1/6**, 15W **2/–**. **Pre-set T/V Pots. W/W** 25 ohms.–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" x ⅛" diamond mesh, **4/6** sq. ft., multiples of 6" cut. Max. width 4 ft.
TYGAN FRET (contemp. pat.) 12" x 12" **2/–**, 12" x 18" **3/–**, 12" x 24" **4/–**, 18" x 18" **4/6**

BARGAINS 4-SPEED PLAYER UNITS

Single Players	carr. 3/6
Garrard TA Mk. 2	**£6.19.6**
B.S.R. Latest Model TU12	**70/–**
E.M.I. Junior "985"	**79/6**
Auto-Changers	carr. 5/–
Garrard RC209	**8½ gns.**
Garrard "Auto-Slim"	**£7.10.0**
Collaro C60	**£7.7.0**
B.S.R. (UA14)	**£6.19.6**

ENAMELLED COPPER WIRE—¼lb reels, 14g-20g, **2/6**; 22g-28g, **3/–**; 30g-40g, **3/9**. Other gauges quoted for.

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

TRANSISTOR COMPONENTS

Midget I.F.'s—465 Kc/s 5/16" diam.	**5/6**
Osc. Coil—5/16" diam. M/W.	**5/3**
Osc. coil M. & L.W.	**5/9**
Midget Driver Trans. 3.5:1	**6/9**
Ditto O/Put Push-pull 3 ohms	**6/9**

Elect. Condensers—Midget Type 12V 1mfd-50mfd, ea. **1/9**. 100mfd, **2/–**.
Ferrite Aerial—M. & L. W. with car aerial coupling coil, **9/3**.
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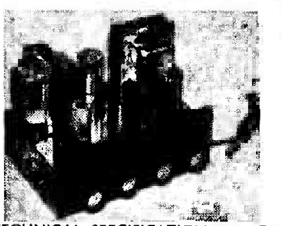

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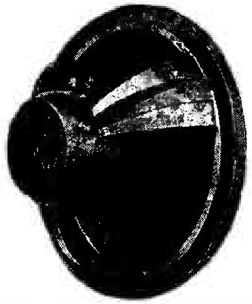

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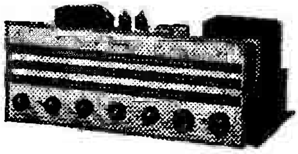

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CONTRIBUTIONS on constructional matters are invited, especially when they describe the construction of particular items of equipment. Articles should be written on one side of the sheet only and should preferably be typewritten, diagrams being on separate 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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TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

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

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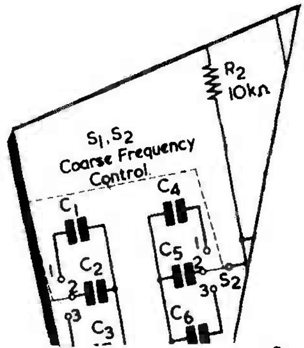

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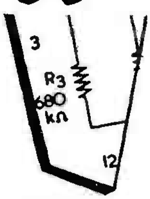


No. 148 Push-Pull Record Player Amplifier With Isolated Chassis

In "Suggested Circuit" No. 141,[1] the writer described an inexpensive record player amplifier employing a UL84 pentode amplifier and a UY85 rectifier. To reduce costs a "live" chassis was employed, the heaters of the two valves being connected in series and fed either via a dropper resistor or from an "80 volt tap" in the gram motor winding. This amplifier circuit is typical of those employed in inexpensive record players of current commercial manufacture, and is capable of giving quite acceptable results for a relatively very low expenditure on component parts. Because of the live chassis technique, the pick-up and gram motor deck had to be isolated by 0.002μF capacitors of adequate rating.

An Isolated Chassis

Circuits for record player amplifiers appear to be popular with readers, and the writer has since given his attention to the design of a more ambitious unit which could still be built at low cost. It was felt that such an amplifier should be capable of offering greater gain with lower distortion than the previous circuit; whereupon a number of problems became evident.

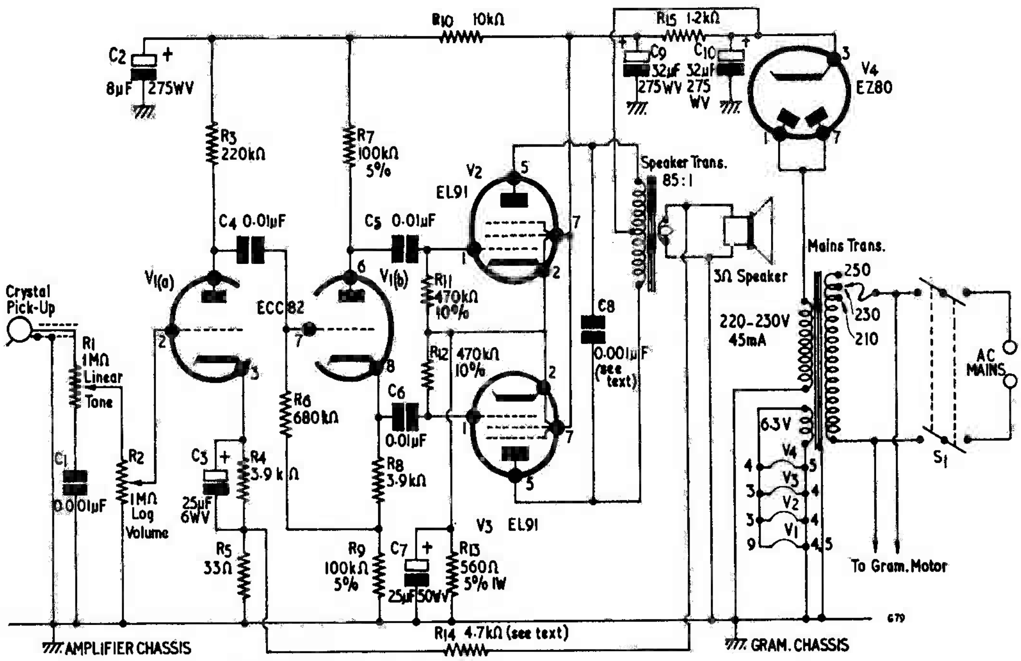
The most important of these problems is concerned with the advisability of retaining the live chassis, or of reverting to an isolated amplifier chassis with a double-wound mains transformer. Apart from the all-important question of safety, the use of a live chassis inevitably results in unavoidable hum because of the necessity of inserting isolating capacitors between the gram motor deck and the amplifier chassis, and of fitting similar capacitors in series with the output of the pick-up. The single pentode arrangement previously described suffers from a low but perceptible hum because of these isolating capacitors, and such hum would obviously become more serious if the proposed amplifier were to offer a higher degree of gain. Another factor is that, whereas the earlier circuit was intended to be a low-cost design in which a small hum level could be tolerated, the proposed amplifier would fall into the high-quality category wherein a hum level as high as that previously given would be quite out of the question. It should be pointed out that a number of commercially manufactured record players and radiograms employing more than a single amplifier valve with a live chassis partly overcome the hum problem by using isolating capacitors which are much higher in capacitance than the 0.002μF specified by the writer. It would appear, however, that these capacitance values do not satisfy the requirements of British Standard 415,[2] and the home-constructor is advised against using them.

After all these points had been considered, it was felt that the only manner in which the hum (and safety) question could be adequately met was to employ an isolated chassis. The use of a double-wound mains transformer would then enable the amplifier chassis, the gram motor deck, and the pick-up screening and return lead to be bonded together, whereupon the risk of hum due to a.c. voltages appearing across isolating capacitors becomes completely obviated.

Having concluded that a mains transformer was inevitable if the aims of the design were to be met, the next design step consisted of finding a compromise between the cost of the transformer and the h.t. consumption in the amplifier. The most inexpensive type of isolating mains transformer generally available to the home-constructor is of the type having a half-wave (i.e. not centre-tapped) h.t. secondary, and the maximum current rating available here is 45mA. After studying the capabilities of different output stage combinations, it was decided that an amplifier having quite an acceptable performance could be operated at this h.t. current. In consequence, the design described this month employs an isolating mains transformer with a 45mA half-wave secondary. To give a practical idea of the component required, a suitable transformer, available from Radio Component Specialists, 337 Whitehorse Road, West Croydon, has an h.t. secondary

[1] "Suggested Circuits" No. 141: "Low-Cost Record Player Amplifier", August 1962 issue.

[2] BS415: 1957, "Safety Requirements for Radio or other Electronic Apparatus".



All fixed Resistors 1/4W. 20% unless otherwise indicated
S1 Ganged with R2

rating of 220 volts at 45mA, together with a heater secondary rating of 6.3 volts at 2 amps. Another suitable transformer is available under Cat. No. TM26A from Home Radio (Mitcham) Ltd., 187 London Road, Mitcham, Surrey, and has an h.t. secondary of 230 volts at 45mA, and a heater secondary of 6.3 volts at 1.5 amps. Either of these transformers could be employed in the present design and they are listed, at the time of writing, at prices between fifteen and sixteen shillings. When the cost of isolating capacitors (not required with the transformer) plus a heater dropper (assuming that the gram motor employed has no "80 volt tap") is subtracted from that of the transformer, it may be seen that the extra expenditure involved in the isolated chassis design is not excessively great.

The Amplifier Design

The first requirement of the amplifier associated with the mains transformer just discussed is that it should give greater gain and less distortion than the single pentode circuit previously described. The most obvious and effective method of reducing distortion is to change from the previous single-ended output stage to a push-pull stage, whereupon the major question which has to be settled is the economic choice of valves which meet the 45mA h.t. current limitation.

What, at first sight, appear to be the most economical solutions are to employ two triode-pentodes, or a double-triode followed by the Brimar double-pentode type ELL80. In the first instance, one triode of one triode-pentode would function as a voltage amplifier, the triode of the second triode-pentode would operate as a phase-splitter, and the two remaining pentodes would make up the push-pull output stage. In the second instance, the double-triode would provide the voltage amplifier and phase-splitter, and the ELL80 the output stage. Unfortunately, the triode-pentodes generally available (with one exception), together with the ELL80, all require an h.t. consumption in excess of 45mA. The triode-pentode which *could* meet the 45mA requirement is the ECL80, but this has the disadvantage of having a common cathode for both triode and pentode sections. The common cathode would make the provision of a simple amplifier circuit, as envisaged here, somewhat difficult.

The alternative choice is to employ two separate pentodes having the requisite h.t. current consumption in the push-pull output stage, these being preceded by a double-triode voltage amplifier and phase-splitter. This choice was adopted, and the valves finally chosen by the writer were an ECC82 for the double-triode and two EL91s for the output stage. In the circuit employed here, the latter would offer some 4 watts of audio power, which should be quite adequate for record player requirements. Despite the fact that three valves are now envisaged, instead of two (i.e. two triode-pentodes, or a double-triode and an ELL80), costs are still low. At the time of writing both the ECC82 and EL91 are advertised in this journal at five shillings each. (Incidentally, the EZ80, employed as the h.t. rectifier, is similarly listed at six shillings.)

The Circuit

The complete circuit of the amplifier is illustrated in Fig. 1. In this diagram the output of the crystal pick-up is applied to the tone control circuit given by R_1 and C_1. When the slider of R_1 is at the lower end of its track, C_1 causes attenuation of the higher frequencies whilst, with the slider at the top of the track, C_1 has negligible effect. R_1 functions, in consequence, as a top-cut tone control.

The a.f. from R_1 is applied to the volume control R_2 and, thence, to the grid of the voltage amplifier $V_{1(a)}$.

$V_{1(a)}$ amplifies in conventional manner, its output being applied to the phase-splitter $V_{1(b)}$. Audio frequency voltages of opposing phase appear at the anode and cathode of $V_{1(b)}$ and are applied, via C_5 and C_6, to the grids of V_2 and V_3. These two valves form the push-pull output stage and their anodes connect to the primary winding of the speaker transformer. A small degree of negative feedback is taken from the secondary of the speaker transformer, and is applied to the cathode of $V_{1(a)}$ by way of R_{14} and R_5.

An EZ80 is used as h.t. rectifier, its anodes being strapped and connected to the half-wave h.t. secondary winding of the transformer. The cathode couples to the reservoir capacitor C_{10}, this being followed by the smoothing components R_{15}, C_9 and R_{10}, C_2. The output valve anodes take their h.t. supply from the reservoir capacitor, whilst their screen-grids are fed from the voltage across C_9. $V_{1(a)}$ and $_{(b)}$ operate from the h.t. voltage across C_2. The method of connection employed in the h.t. circuit allows resistance-capacitance smoothing to be used without the necessity for high wattage ratings in the resistors.

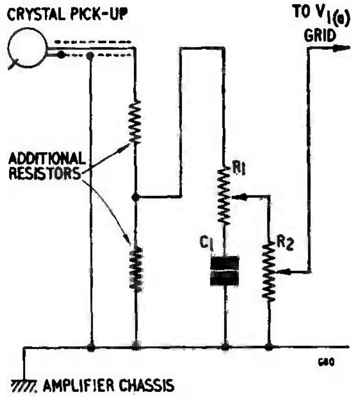
The 6.3 volt secondary winding of the mains transformer has one side connected to chassis and feeds all heaters, including that of the rectifier. The 1.3 amp figure indicated in Fig. 1 represents the minimum current rating required in this winding.

Points of Design

The circuit of Fig. 1 is extremely simple and straightforward and should offer little trouble in practice. Nevertheless, there are some points of design which require a little further comment.

It will, for instance, be noted that no limiter resistor is connected in series with the rectifier and the reservoir circuit. In practice, the required limiting resistance will almost certainly be given by losses in the mains transformer. The EZ80 requires a limiting resistance of 125Ω per anode when employed as a full-wave rectifier with a 250–0–250 volt input. If, in the present instance, the resistance of the h.t. secondary, plus that of the primary, exceeds 125Ω (as it very probably will), the rectifier can be assumed to be working under safe conditions. Should it happen that the sum of primary and secondary resistances falls below 125Ω, a physical resistor to make up the value could be inserted between the secondary winding and the anodes. The constructor should check the resistances of the h.t. secondary and primary windings of the particular mains transformer employed to ensure that the limiting resistance requirement is met before constructing the amplifier.

Capacitor C_8, connected across the primary of the speaker transformer, offers a degree of top-cut. This capacitor appears inside the feedback loop, a fact which would not occur in a more expensive, true high fidelity, design. However, capacitors of this nature appear in the same circuit position in a number of push-pull commercial record player and radiogram designs and, for low feedback levels, help in achieving the desired frequency response. High a.f. voltages are liable to appear across C_8, and it might be advisable to employ a capacitor with a working voltage of 500 because of this. It is possible, according to the speaker and speaker transformer employed, that better results will be given if the value shown in Fig. 1 for C_8 is increased or decreased, and this point may be determined by experiment. Smoother top-cut would be given if an additional 10kΩ resistor were connected in series with C_8.



The speaker transformer should have a ratio (between the whole primary winding and secondary) of 85:1. This corresponds to an anode-to-anode load of 22kΩ. The anode current in each half of the primary is of the order of 20mA and so (from the point of view of cost) a small transformer may be employed.

The cathode bias resistor, R_{13}, is given a value of 560Ω at 5%. This close tolerance is desirable because R_{13} controls the h.t. current drawn by the output pentodes. With the resistor value specified, this current can closely approach the 45mA available from the transformer.

Construction

Few problems should be incurred during construction as, due to its inherent simplicity, the amplifier should prove to be quite stable. Obviously, a logical layout should be used, with the input circuit well removed from the output valves and power circuits. The gain offered is of the same order as a conventional triode-pentode a.f. amplifier, and there will probably be little point in using busbar earth returns in the amplifier chassis. Earth returns to the nearest chassis point should be quite adequate. On the other hand, it would be advisable to use a common earth point on the amplifier chassis for the connections to the pick-up screening and the bonding lead to the gram motor deck. The pick-up screening should be insulated from the metalwork at the deck itself.

Initial construction should be carried out with R_{14} disconnected. When completed, the amplifier should work adequately without this resistor, although gain may be a little excessive. The resistor may then be connected into circuit, whereupon gain should be reduced and output quality perceptibily improved. If R_{14} causes the amplifier to break into violent oscillation, the connections at the speaker transformer secondary should be reversed. The value specified for R_{14} in Fig. 1 should prove adequate for most amplifiers and speaker transformers encountered, and should not result in oscillation due to excessive phase shifts in the latter. If desired, a lower value could be employed, provided it does not cause instability. The lower value will then result in increased feedback.

It is possible that the output from some pick-ups will be higher than is required for the amplifier. If this occurs, a simple fixed potentiometer may be added before R_1, as shown in Fig. 2. The sum of the two resistors employed in the potentiometer should be between 1 and 1.5MΩ, and the amount of attenuation which is given depends upon the ratio between the lower resistor and the total resistance.

If trouble is experienced with mains modulation, this should usually be cleared by reversing the connections at the mains plug. It may also prove helpful, in this respect, to reverse the connections to the gram motor. Because of the use of an isolating transformer, the amplifier and gram chassis can, of course, be earthed.

It should be possible to build the

amplifier on a small chassis capable of being installed in most record player cabinets. Careful attention should be paid to cooling, and adequate ventilation apertures should be provided. This point applies especially to the mains transformer, which will be operating at or near its full rated h.t. output.

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.

R206.—J. G. Taylor, 42 Station Road, Heacham, Kings Lynn, Norfolk, wishes to purchase or borrow the manual/circuit diagram of this receiver. Would also like to hear from any reader having spare parts available.

* * *

Ambassador 545 Receiver.—W. Luke, 50 Cameron Street, Glasgow, N.W., would like to obtain the circuit diagram and also information on adding a bandspread to this receiver.

* * *

"Short Wave Manual".—D. Travers, 53 Berkeley Gardens, Leigh-on-Sea, Essex, wishes to buy or borrow a copy of this manual (published by George Newnes and now out of print).

* * *

Master Oscillator No. 2, Mk. 1/1.—R. H. Band, 49 Plant Hill Road, Higher Blackley, Manchester, 9, requires the circuit or manual or any other available information on this unit.

* * *

Modulator Unit Type 20.—M. McLean, 115 Peterborough Road, London, E.10, wishes to purchase the manual.

* * *

Wavemeter W1191A.—R. L. Natyke, P.O. Box 87, Tetwanwtu, New Zealand, would appreciate any details, circuit, or manual for this unit.

* * *

Recording.—D. J. Rundell, 227 Deeds Grove, High Wycombe, Bucks, would like to hear from any reader who has any ideas on recording TV sound and vision signals on tape. Single track preferred.

* * *

Test Oscillator No. 1.—R. S. English, 182 Lewisham Road, River, Dover, Kent, wishes to obtain the circuit and servicing details of this unit (marked CT212, ZD ref. No. 00783).

Wire Recorders.—V. Axford, 386 Strone Road, Manor Park, London, E.12, is extremely anxious to obtain information of every kind on the G.E.C. wire recorders (U.S. surplus) models 20, 20A, 20B and 20N.

* * *

Hallicrafters SX24.—L. T. Page, Sebring, Belgrave Crescent, Donnington, Chichester, would like to borrow or purchase the circuit or instruction manual for this receiver and also any information regarding modifications.

* * *

BC348R.—4067536 Cpl/T. Swift, C. W., 7 Bulldog Crescent, R.A.F., Manby, near Louth, Lincs, has obtained a cannibalised version of this receiver and urgently requires the manual/circuit diagram, or any other information in order to commence a rebuild.

* * *

Space Probes.—G. A. Woods, 456 Longmoor Lane, Fazakerley, Liverpool, 9, would like to hear from any reader who can provide him with information on the reception of signals from the Tiros satellite or Ranger moon probe. Information also required on the following equipments: Jonell NYO2204, Wartime Civilian Receiver (a.c. mains version) and Ferranti 146.

* * *

Ferguson Tape Recorder, Model 445TR.—A. Lee, 77 Yew Tree Lane, Manchester, 23, requires the circuit or any other available information on this equipment.

* * *

Vibrator Power Pack (P.C.R.) ZA26705 and Rotary Converter 24 Type 320.—N. Pretty, 75 High Street, Great Missenden, Bucks, wishes to borrow or purchase circuit diagram for these units.

* * *

R107 Receiver.—J. Hadley, 71 Holly Road, Quinton, Birmingham, 23, requires information on connecting the tuner unit, the i.f. and output stages; the i.f. frequency; civilian equivalents of the valves used and modification for fitting 6.3V valves.

* * *

R107 Receiver.—D. Campbell, Schoolhouse, Kilchrenan, Taynuilt, Argyll, Scotland, would like to obtain all possible information on this receiver.

Choosing a Rectifier

by M. J. DARBY

APART FROM THE CHASSIS SPACE REQUIRED, quite a number of points must be considered when either a valve or a metal rectifier is being chosen for any particular purpose. A suitable heater supply must be available for valve rectifiers. Indirectly heated valve rectifiers have an advantage over both metal and directly heated valve rectifiers as in general, they do not supply the rectified voltage to the h.t. line until the cathodes of the other valves in the equipment have warmed up. This helps to prolong valve life and reduces any surge voltages appearing across the electrolytic reservoir and smoothing capacitors after switching on.

Output Current

If a large output current is required, full wave rectification is normally employed so that reasonably small values of smoothing components can be used.

The rectifier must also be chosen so that its maximum rated output current is not less than the current required. Metal rectifiers are not usually damaged by large currents for very short periods of time, but the cathodes of valve rectifiers may be damaged under similar conditions of overload. Rectifier valve manufacturers may therefore stipulate a minimum value of resistance which must be present in the anode circuit of the rectifier to limit the maximum current which will pass in normal operation. The minimum value of the limiting resistor specified may vary with the value of the reservoir capacitor (as in the case of the GZ32, for example). Two equal resistors, one in each anode circuit, may be required for full wave valve rectifiers. (Part, or all, of the series resistance may be provided by the mains transformer, if one is used.)

Voltages

A maximum r.m.s. input voltage is normally quoted in rectifier manufacturers' data and care should be taken that this is not exceeded.

A separate value for the maximum peak inverse voltage (p.i.v.) may be quoted. This is the maximum permissible anode-cathode peak voltage in the reverse or non-conducting direction. With capacitor input circuits this peak voltage is equal to 2.8 times the r.m.s. input voltage applied to the anode (or to a single anode in the case of a full wave rectifier). It is also double the output voltage at no load.

In the case of a normal h.t. rectifier circuit, the maximum p.i.v. will not be exceeded if the input voltage does not exceed the maximum permissable value. A value may not therefore be quoted in the data sheets for the maximum p.i.v. of a normal h.t. rectifier valve. This value is, however, almost always quoted for the maximum p.i.v. of e.h.t. rectifiers, as the p.i.v. is not always related to the input voltage in such a simple way in e.h.t. circuits.

Capacitor Input

If a reservoir capacitor is connected directly across the output of a valve rectifier, its value must not be too large or high values of peak cathode current will occur during part of each cycle. A maximum permissible value for this reservoir capacitor is normally quoted in the rectifier data sheets. No such restrictions apply to metal rectifiers. The working voltage of a reservoir capacitor (if one is used) should be at least 1.4 times the r.m.s. input voltage to the anode.

Choke Input

Similarly if choke input is used (no reservoir capacitor) with a valve rectifier, the choke must have a large enough inductance to limit the current peaks to an acceptable value. The rectifier data sheets normally quote the minimum value of inductance which is satisfactory.

E.H.T. Circuits

Rectifiers intended mainly for operation at high frequencies (e.h.t. rectifiers, for example) may have a lower permissible output current at high frequencies (or if a pulsed input voltage is used) than is permissible at 50 c/s using the same valve. The maximum permissible values of p.i.v. and of the reservoir capacitor may also be different for pulsed input or high frequency operation and the manufacturer's data should always be consulted before any such circuit is designed.

Heater-Cathode Voltages

One side of the heater is joined to the cathode in some indirectly heated rectifier valves, but if a separate external cathode connection is present, care should be taken that the maximum permissible heater-cathode voltage is not exceeded. When a separate transformer winding is used for the rectifier heater, it is advisable to connect the rectifier cathode to one side of the heater.

BRIDGE-CONTROLLED THERMOSTAT

by J. BURGESS

This article describes a temperature-sensitive switch which employs a simple single-transistor circuit. An interesting feature of the device is the unusual manner in which commonly encountered components are employed as heat sensing elements

BASICALLY THE CIRCUIT OF THE BRIDGE-controlled thermostat, shown herewith, may be regarded as a Wheatstone bridge network with a transistor as detector instead of the more usual galvanometer. The potential divider R_2 supplies a reference voltage to the emitter of the transistor, whilst R_1 and the sensing element provide a biasing voltage for the base which varies with the temperature of the sensing element. In consequence, the transistor collector current also varies with sensing element temperature and can be made to operate a relay. The latter controls the external circuit which, for the thermostat application, is the heating power supply. The system is quite sensitive and the temperature control given by the prototype was within $\pm 1°$ C.

The Components

The only critical component in the unit is the sensing element. This consists of a coil having a resistance of 1kΩ. A convenient source for the sensing element is given by relay coils or by coils from old high resistance headphones. Both of these have been used in the prototype with complete success, but the headphone coil has been found preferable since it is very small and easy to mount in confined spaces or on the outside of a tank. The change in resistance with temperature in the sensing element is given by the temperature coefficient of the copper wire with which it is wound.

Resistor R_1 should have approximately the same resistance as the sensing element. Under this condition the device is most sensitive.

Several relays were tried in the prototype, that giving the best being a polarised type, reference No. 5C9, made by the Telephone Manufacturing Co. Relays of this type are, however, expensive, and a carefully adjusted Post Office type, reference No. LP 104011/Tec (1,200 ohms) was found to give almost as good results. Whatever relay is used, it must be capable of detecting current changes of the order of 150–200μA. Both those mentioned are capable of better than this.

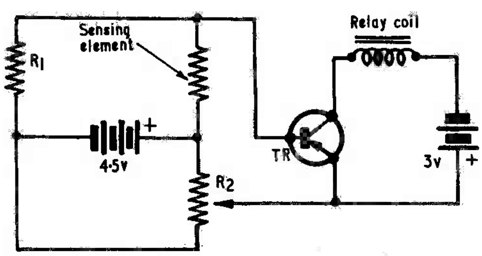
Components List

Resistors
R_1 1kΩ ¼W
R_2 10kΩ wirewound pot.

Sensing Element
1kΩ coil (see text)

Transistor
OC72

Relay
See text



E246

Calibration

Calibration may be carried out by immersing the element in cold water. The element should be housed in a suitable container (a cigar tube is ideal) for this operation. The element should then be left for several minutes to enable it to attain the temperature of the water. R_2 is next turned slowly until the relay closes, and the potentiometer setting marked on its scale. This setting corresponds to the temperature of the water, as read by a thermometer.

The temperature of the water may then be increased slowly, and further temperature calibration points obtained. The transistor should be kept away from the source of heat.

TRANSISTOR TAPE RECORDING Amplifiers

by S. Vipharatana

THE USE OF TRANSISTORS IN A recording amplifier has not been very popular in the past, although articles have appeared featuring various designs for a replay amplifier. There has also, of course, been a large number of portable all-transistor tape recorders on the market for some time. The main object behind the present design was to ascertain whether it was possible to construct a transistorised recording amplifier with a performance comparable in every respect to some of the better quality valve equipment.

The requirements were that the unit was to be compact, reliable, not too expensive and, above all, to have a high standard of performance. The unit to be described has been found to meet such standards. It is, however, only recommended to those who have some previous experience with transistors. This recording amplifier is particularly suitable for those who possess a tape deck and wish to build the associated equipment in a limited space. It draws its power supply (of 300V) from the main amplifier, it employs an EM84 recording level indicator, and has a separate (valve) bias oscillator. It was felt at the time that a twin-triode can be used far more effectively, as a bias oscillator in push-pull, than transistors. The design for the bias oscillator was not included since this can be obtained from various sources. The same applies also to the replay amplifier.

The Circuit

The complete circuit of the recording amplifier is given in the accompanying diagram.

The input is applied to VR_1 which is the recording level gain control. Following this is the selective high frequency boost filter formed by L_1 and C_2, C_3. The purpose of this boost is to make up for the losses occurring in the head and the self-capacitances of the head connecting lead. The output from the boost network is fed to a grounded collector stage whose output impedance matches fairly well into the input impedance of the output stage. The output stage itself consists of three n-p-n silicon medium voltage high frequency transistors type 2S102 or 2S103.

The method of connection employed allows a relatively high supply voltage to be used and offers, therefore, a correspondingly large output voltage. The base of TR_2 is held at a fixed potential by means of the zener reference diode D_1, and this automatically defines the operating current of TR_2, TR_3 and TR_4 since the voltage drop across R_{13} must always be just slightly below TR_2 base. R_{14}, R_{15} and R_{16} form a potential divider across the three resistors and ensure that the voltages across these are equal at all times. It is easy to appreciate this point, since the bases of TR_3 and TR_4 are connected to taps having potentials which are $\frac{1}{3}$ and $\frac{2}{3}$ respectively of the total voltage. R_{12} is the load resistor and the voltage at this point must be equal to the sum of the individual voltages across the transistors.

The maximum V_{ce} rating of the 2S102 and 2S103 is 45V and the stage is biased so as to pass approximately 3mA under quiescent conditions. The voltage across each transistor should then be just over 20V or 62V across the whole configuration. This means that a maximum output swing of some 100V peak-to-peak or 35V r.m.s. is available, which is more than adequate to drive the head far enough to overload the tape, as well as to close the EM84 (some 18V only is required to fully load the tape). The output is connected to the recording head in a Twin-T bias rejector circuit, the function of which is to impose a very high impedance at the bias frequency and thus ensure that a very small proportion of the bias voltage reaches the EM84. If the EM84 is required to monitor the signal prior to connecting the recording head into circuit, then R_{21} will be required to ensure proper rectification in the diode D_2. Otherwise R_{21} may be omitted.

Transistors of the n-p-n type were used merely for convenience, but p-n-p types having similar characteristics could no doubt be employed instead. In this case all connections at the output stage are reversed as far as polarity is concerned.

Layout

Layout can best be decided by considering the rest of the equipment and what facilities are required. The unit can be made as a pair for stereo, and still be many times smaller than a valve unit. The layout itself is no problem, the output is out of phase with the input and the question of instability does not exist. However, since the input is of high impedance it is liable to pick up stray signals. It is therefore essential to place the bias rejector well away from the amplifier; this ensures that no bias is coupled capacitively to the amplifier input to give a false reading on the EM84. The gain of the amplifier at 50 kc/s is still considerable and this trouble was experienced in the unit constructed.

Testing the Constructed Amplifier

Voltage readings with the prototype, with reference to chassis, were as follows:

TR_1 Emitter	2.55V
C_6, D_1	7.4V
TR_2 Emitter	1.95V
TR_3 Base	20.0V
TR_4 Base	41V
TR_4 Collector	64V
H.T. Supply	300V
$C_{14(b)}$	200V
$C_{14(a)}$	243V

All these readings were taken under no-signal conditions, using a Heathkit valve voltmeter type VA-7. When initially connecting to the h.t.

Components List

Resistors

R_1 220kΩ ¼ watt 20%
R_2 20kΩ potentiometer pre-set (see text)
R_3 680kΩ ¼ watt 20%
R_4 220kΩ ¼ watt 20%
R_5 68kΩ ¼ watt 10% H.S.
R_6 68kΩ ¼ watt 10% H.S.
R_7 56kΩ ¼ watt 10% H.S.
R_8 4.7kΩ ¼watt 10% H.S.
R_9 47kΩ 2 watt 10%
R_{10} 33kΩ ¼ watt 10% H.S.
R_{11} 15kΩ ¼ watt 10% H.S.
R_{12} 47kΩ 1 watt 10% H.S.
R_{13} 680Ω ¼ watt 10%
R_{14} 33kΩ ¼ watt 10% H.S.
R_{15} 33kΩ ¼ watt 10% H.S.
R_{16} 33kΩ ¼ watt 10% H.S.
R_{17} 56kΩ ¼ watt 10%
R_{18} 56kΩ ¼ watt 10%
R_{19} 27kΩ ¼ watt 10%
R_{20} 470kΩ ¼ watt 20%
R_{21} 2.2MΩ ¼ watt 20% (see text)
R_{22} 3.3MΩ ¼ watt 20%
R_{23} 6.8kΩ ½ watt 20%
R_{24} 10kΩ ½ watt 20%
R_{25} 680kΩ ½ watt 20%
R_{26} 56kΩ ½ watt 20%
VR_1 250kΩ potentiometer log.

Capacitors

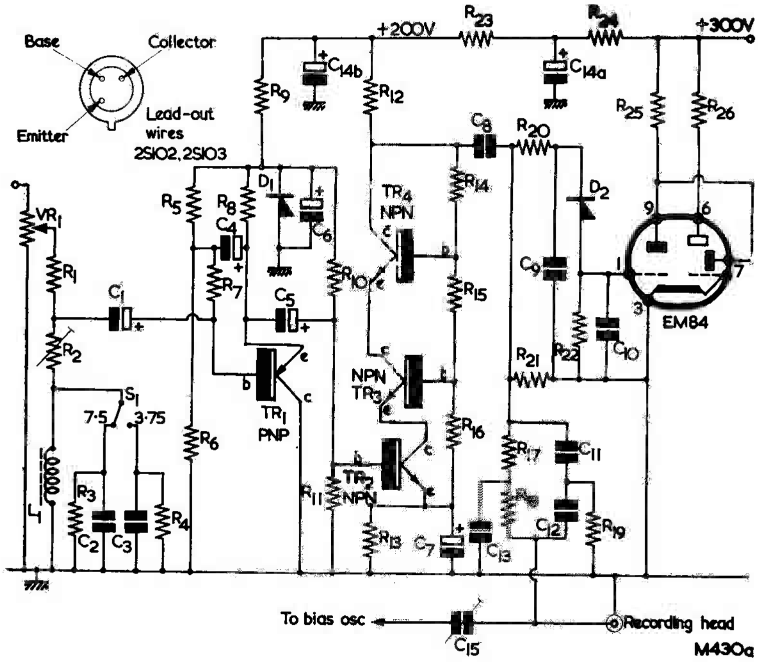
C_1 20μF 6V electrolytic
C_2 150pF 2% silver mica
C_3 330pF 2% silver mica
C_4 20μF 6V electrolytic
C_5 20μF 6V electrolytic
C_6 25μF 12V electrolytic
C_7 100μF 6V electrolytic
C_8 0.1μF 250V paper
C_9 15pF 2% silver mica
C_{10} 0.02μF 20% paper
C_{11} 47pF 1% silver mica
C_{12} 47pF 1% silver mica
C_{13} 100pF 1% silver mica
C_{14} 50+50μF 300V electrolytic
C_{15} 250pF pre-set

Semiconductors

TR_1 OC44 Mullard
$TR_{2, 3, 4}$ 2S102, 2S103 (Texas Instruments, Ltd.) (or any n-p-n transistors with V_{ce} max. rating of 40–45V)
D_1 OAZ205 Mullard
D_2 OA81 Mullard

Valve

EM84 Mullard



supply it might be advisable to use a lower voltage first and see that all is in order before applying the full 300V.

The collector potential of TR_4 must never be allowed to exceed 120 volts above chassis. Small deviations from the figure given above are, of course, quite permissable. In the event of excessive voltage the potential on $C_{14(b)}$ should be checked, and this should be 200 volts. If this potential is in order, next check the emitter voltage of TR_2. Either the bias voltage for this transistor (R_{10}, R_{11}) could be incorrect, or R_{13} could be faulty. In both cases, the output transistors would not then pass the correct current.

If a faulty transistor is employed in the TR_2, TR_3 or TR_4 positions, it will lead to incorrect voltage readings and may well damage one or more of the other transistors. Especial care should be taken to ensure that the circuit is properly followed and that soldered joints are well made.

Operating Notes

The overall performance from recording to playback depends largely on the frequency equalisation, and obviously it is worthwhile making adjustments carefully. It is assumed here that the playback equipment has been adjusted to some fixed standard and it is only necessary therefore to adjust the recording amplifier accordingly.

The purpose of the treble peaking coil, L_1, is to partially compensate for the losses occurring in the head, demagnetising effect of the bias, and lead capacitance, etc. The choice of resonant frequency depends on recording head characteristics as well as on the tape speed. It is normally chosen to be just beyond the turnover point of the response curve or around the highest usable frequency the head is capable of handling. For a modern fine-gap head it is about 12 kc/s and 16 kc/s at tape speeds of 3.75 and 7.5 i.p.s. respectively, and somewhat lower for medium grade heads. The resonant frequency of the peaking coil is selected by capacitors C_2 and C_3 which are individually brought into circuit by the switch S_1 for each tape speed. With the values given, the centre frequency is approximately 12 kc/s for 3.75 i.p.s. and 16 kc/s for 7.5 i.p.s. Other values for C_2 and C_3 can, of course, be used if required. The amount of boost to be applied depends on the losses and whether or not there is some form of treble lift in the playback amplifier. The 20kΩ pre-set potentiometer R_2 controls the amount of treble boost and should be set by trial and error, the lower value setting giving more boost. It was found that some 7dB of boost was available at 3.75 i.p.s. with R_2=6.8kΩ. Once a suitable value has been found a fixed resistor could then be substituted.

H.F. Bias

The bias oscillator may take various forms but as long as it can provide a low distortion waveform any type will suffice. It may be necessary to adjust the bias frequency to be the same as the null frequency of the bias rejector.[1] If this is not done a relatively high bias voltage will find its way to the Magic Eye and produce a deflection.

The bias current is rather critical. If it is too low distortion results, and if it is too high there will be a demagnetising effect and high frequencies will be limited. The correct value depends on the head, and for an average high impedance head will be about 1mA or slightly less. It is checked by inserting in series with the head a small resistance (50–100Ω) and measuring the voltage drop across it with a valve voltmeter. If a valve voltmeter is not available, the adjustment will have to be by trial and error. Bias current is varied by the 250pF trimmer C_{15}, this being connected between the bias oscillator and the recording head. If a valve voltmeter is not available, it is advisable to start with C_{15} set to a low capacitance, and to increase this step by step until playback distortion just clears up.

[1] Around 60 kc/s.—*Editor*.

Performance

The performance of the prototype was as follows:

Frequency Response: 30–22,000 c/s ±2dB (L_1, C_2, C_3 omitted).
Noise: approx. 66dB below 15V (depending on TR_1).
Sensitivity: Gain control at max.
$R_2 = 6.8k\Omega$
$f = 1{,}000$ c/s
$V_{out} = 15V$ (r.m.s.)
$V_{in} = 420mV$
Maximum Output: 34V r.m.s.

Conclusion

In conclusion it is not claimed that this recording amplifier is cheaper to construct than a similar valve version. Nevertheless, it should prove more reliable and certainly more compact. The performance when used with other high quality equipments is most satisfactory, particularly at the faster tape speed.

TUNNEL DIODE BIOLOGICAL TRANSMITTERS

Tunnel diode oscillators can operate with a total power consumption of the order of one microwatt, whilst corresponding transistor devices require about a milliwatt. This has led to the use of tunnel diodes in experimental radio transmitters operating with extremely small power consumptions. Such miniature transmitters are expected to find many applications in biology when a transmitter is required which can be implanted into a living animal or person.

In the past such biological transmitters using transistors have been powered by batteries and their useful life has therefore been comparatively limited. It has been suggested at the International Convention of the I.R.E. that the motion of the diaphragm of an animal with respect to the ribs could be used to drive an ordinary gramophone pick-up which would thus produce enough power to operate a transmitter employing a tunnel diode oscillator. Information about pulse rate, temperature, rate of breathing, etc., could thus be transmitted to observers some distance away. The basic circuits required for this type of transmitter are extremely simple.

Modern Radiotelephone System for Essex Fire Brigade

One of the world's most modern Fire Service Radiotelephone schemes is to be installed for the Essex Fire Brigade by Pye Telecommunications Limited of Cambridge, England.

The new system, which covers the whole of Essex from five divisional headquarters, will employ the new Pye "Cambridge" radiotelephone equipment with fully transistorised receiver.

Each divisional headquarters operates independently but when very large fires occur the Headquarters at Brentwood takes over control of the entire area.

The installation is valued at over £20,000.

NEWS AND COMMENT . .

TV Camera Tubes for Amateur Use

Amateur television enthusiasts can now more readily afford to build their own television cameras since EMI Electronics Ltd is making available 1in vidicon tubes at the greatly reduced price of £12 each. These tubes—type 10667M—although substandard because of minor blemishes, are quite suitable for amateur experimental purposes.

Other uses include setting up and maintenance work on vidicon television cameras which might damage or cause excessive use of a similar expensive high-grade tube.

The tubes are of standard EMI 10667 type, employing a high sensitivity photoconductive target. Typical signal current at an illumination of 2 foot candles on the target and a dark current of 0.01μA is 0.16μA for peak white illumination. The heater is the standard 600mA type.

Storing Electricity in Magnetic Coils

Methods have been developed to store electric power indefinitely by placing it in special magnetic coils at temperatures low enough to liquify air. A device is used which is composed of wire coils which have virtually no resistance to electricity, according to a U.S. Navy physicist, William F. Hassel, who described the methods in a paper read at a recent conference on Space Power Systems.

The coil is bathed in liquid helium at minus 269° Centigrade in order to improve its superconducting qualities. The storage unit is enclosed in an insulated stainless steel case.

Its superiority over the battery lies in its ability to deliver power to a load at a level several orders of magnitude higher than is possible for the battery. The power output of a small superconducting coil can range from megawatts for a period of a second to kilowatts for many minutes.

Ultrasonics

Our reference to this subject in our December issue has aroused considerable interest and we have received many requests for the address of Gulton Industries (Gt. Britain) Ltd.; it is: 132 Sloane Street, London, S.W.1.

We, of course, were dealing with the subject from the model control angle, but another use of which we have recently learned is as an aid to blind persons when they are moving about or travelling.

A device has been produced by Ultra Electronics Ltd. on the basis of a design by Dr. Leslie Kay of the Electrical Engineering Department of Birmingham University, which has now undergone a series of tests.

The aid consists of a transistorised transmitter-receiver which operates with a hand-held "torch", emitting an ultasonic beam of energy, whose frequency varies with time. Any energy received back by the torch differs in frequency from that leaving it, at that instant, by an amount proportional to the time taken for the energy to travel out and be reflected back. Thus, by receiving the differing signals in an earphone, the blind person is able to judge the distance of an obstacle ahead of him.

One user, Mr. Walter Thornton, of Northfield, Birmingham, a youth club organiser at Cadbury's of Bourneville, has already made considerable progress with the use of the device.

Mr. Thornton has commented: "It is particularly helpful in locating things in one's path as one directs the torch which sends out the ultrasonic signal. One of the things I found difficult to determine previously was people standing immediately in front of me—particularly as they may be standing with their backs to me, and do not see me coming. I have, on occasions, walked into people like that, but with the aid, one has good warning of these people and can avoid them.

"To use it as one would need to do in everyday life, one has to develop the speed of reaction to the impulse—it's rather like learning Braille in that way. One has to learn to react quickly, recognising the signal.

"Pitch indicates distance, and the higher the pitch the further away the obstacle. Some surfaces reflect the sound back better. From a surface like glass, a smooth surface, I would expect a harder type of signal. From a hedge there would be a variety of signals, and if one is pointing the torch at a person wearing a sweater, or a loose type of woollen garment, the reaction comes back in a more muffled and softer shape—although this, of course, has to be related to distance.

"Certainly when walking in a crowded area, one gets around with less strain, and doesn't have to concentrate quite so one hundred per cent as when walking alone without any aid. I think it represents real progress", added Mr. Thornton.

In addition to being used by Mr. Thornton, the sonic aid has undergone field and evaluation trials at the Worcester College for Blind Boys and at St. Dunstan's training centre, at Ovingdean, near Brighton.

Further development to implement the lessons learned in the evaluation trials will almost certainly result in reduction of size and weight of the equipment, even though, at present, the transmitter-receiver weighs only just over two pounds, and the torch 12¼ ounces.

In production quantities, it is anticipated that the device can be produced for less than £100, with a further reduction if the demand were great enough.

Obituary

It was with very great regret that we learned, just as we were going to press, the sad news of the sudden death of Mr. C. H. L. Edwards, G8TL, on Thursday 31st January.

Mr. Edwards was one of the best known radio amateurs in this country. A member of the Council of the Radio Society of Great Britain, as he had been for many years, he was also Chairman of their Exhibition Committee, Chairman of the Radio Amateur Emergency Network Committee, and Essex Controller for R.A.E.N., and also Chairman of the Mobile Committee. His enthusiasm was tremendous and he had the ability to fulfil his ideas. His passing will be a great loss to Amateur Radio, and to the R.S.G.B. in particular, and he will be much missed by all who knew him.

"Eddie" was an electrical engineer, being a member of the Institute of Electrical Engineers and an associate of the British Institute of Radio Engineers.

To his widow and daughters we extend our very sincere sympathy.

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

part 19

understanding radio

By W. G. MORLEY

IN LAST MONTH'S ISSUE WE CAME TO THE END OF our theoretical discussion on resonant, or tuned, circuits. Amongst other things, we have found that the resonant frequency of a series tuned circuit is given by the equation $f_r = \frac{1}{2\pi\sqrt{LC}}$, where f_r is the resonant frequency in cycles per second, L the inductance in henrys, and C the capacitance in farads. We have seen also that the same equation holds true with negligible error for parallel tuned circuits, provided that the Q of the circuit is not very low (as it rarely is in practical instances). We shall now carry on to practical points in the design of resonant circuits intended for use at the frequencies encountered in radio work. Before we do this, however, we must spend a little time in examining the relationship between frequency and wavelength, in order that we may familiarise ourselves with the actual frequencies encountered in radio work.

Frequency and Wavelength

The function of a conventional radio or television receiver is to reproduce a signal which is transmitted from a remote point. We are not, at this stage, in a position to see how a complete radio receiver functions, but we *can* look into that part of the process which has to do with the frequencies at which tuned circuits are resonant. A very large number of radio signals are transmitted at any given instant throughout the world, and it is a requirement of the radio or television receiver that it should select only one. This selection is achieved with the aid of resonant circuits.

The custom has become established, in Britain, of identifying many of the signals reproduced by a receiver in terms of their *wavelength*. Other transmissions, on the other hand, may be identified by their *frequency*. In television, a further complication is introduced by referring to a signal as occupying a particular *channel*. These three terms are interrelated in a very simple manner but, until this has been explained, they tend to confuse the beginner. We shall, in consequence, digress from our main subject for a short while and examine the relationship between the three terms. In doing so we shall, also, achieve the important object of making the reader familiar with the actual frequencies he has to deal with in radio work.

In Fig. 110 (*a*) we have a transmitter which broadcasts a radio signal. We may assume that the signal travels through the "ether" (this being a medium which pervades all space and matter), and that it does so at the same speed as light. The transmitted signal may be represented, in simplified form, as an alternating waveform of the type shown in Fig. 110 (*b*). In this diagram, the waveform looks rather the same as the waves which pass along the surface of a pond when a stone is thrown into the centre. The arrow in Fig. 110 (*b*) indicates the direction in which the wave is travelling.

The signal of Fig. 110 (*b*) may be identified in one of two ways. It may, first of all, be identified by its wavelength, as in Fig. 110 (*c*). As may be seen from this diagram, the wavelength is defined as the distance between the crests of each successive wave. Wavelength may be expressed in metres, in yards, in miles, or in any other units of length, but it is most convenient to use metres. The second way in which the signal may be identified is by its frequency. In Fig. 110 (*d*) we introduce a stationary observer whose task it is to count the number of wave crests which pass him in a given length of time. It is obvious that one cycle of the signal appears between each successive crest, and so our observer is actually counting the number of cycles which pass him during the given length of time.

The speed of light (and the speed of radio waves) is almost exactly 300,000,000 metres per second[1], and this fact enables us to obtain a relationship between wavelength and frequency. If the wavelength of the signal were 1,000 metres, then 300,000 crests would pass our stationary observer in one second. This corresponds to a frequency of 300,000 cycles per second, or 300 kilocycles per second. If the wavelength were 1 metre, then 300,000,000 crests would pass the observer in one second, corresponding to 300,000,000 cycles per second, or 300 megacycles per second. The reason for the change in frequency is obvious enough: since the second wavelength is 1,000 times shorter than the first wavelength, 1,000 times more wave crests must pass the stationary observer during the same period of time.

In each of the two instances just quoted, we have found the frequency of the signal by dividing its speed by the wavelength. In other words:

$$\text{Frequency} = \frac{\text{Speed}}{\text{wavelength}}.$$

Provided, of course, that the correct units are chosen, this equation holds true for all wavelengths which may be transmitted.

It is conventional, in radio work, to use the Greek letter λ (lambda) to express wavelength, whereupon our equation may now be expressed as:

$$f = \frac{300,000,000}{\lambda}$$

where f is frequency in c/s, λ is wavelength in metres, and the 300,000,000 figure is the speed of the wave in metres per second. We may also say:

$$f = \frac{300,000}{\lambda}$$

where f is frequency in kc/s or:

$$f = \frac{300}{\lambda}$$

where f is frequency in Mc/s. In the second equation we divide the right hand side by 1,000 to bring f to kc/s, and in the third equation we divide it by 1,000,000 to bring f to Mc/s.

In practice it is difficult to transmit radio waves having wavelengths longer than 30,000 metres (or frequencies lower than 10 kc/s), and virtually all practical radio transmissions have shorter wavelengths than this figure. When we look at a conventional domestic radio receiver we may find that this has a "long wave band" extending from about 1,000 to 2,000 metres, and a "medium wave band", extending from about 200 to 600 metres. We can now express these figures in terms of frequency. Thus, our "long wave band" of 1,000 to 2,000 metres corresponds to a frequency range of 300 to 150 kc/s, and our 200 to 600 metre "medium wave band" to a frequency range of 1,500 to 500 kc/s. If our receiver has a "short wave band" this may be presented as, say, 20 to 60 metres. The corresponding frequency range is 15 to 5 Mc/s.

Many domestic sound receivers are capable of receiving f.m. (frequency modulated) signals, and the appropriate tuning scale is, this time, calibrated directly in terms of frequency. The f.m. transmissions broadcast by the B.B.C. fall within the range known as "Band II", this covering the frequencies from 87.5 to 100 Mc/s. As may be seen, Band II transmissions have a higher frequency (and, thus, a shorter wavelength) than the signals in the "short wave band". It will be noted that domestic receivers tend to have their f.m. tuning scales calibrated in terms of frequency, and their medium and long wave tuning scales calibrated in terms of wavelength!

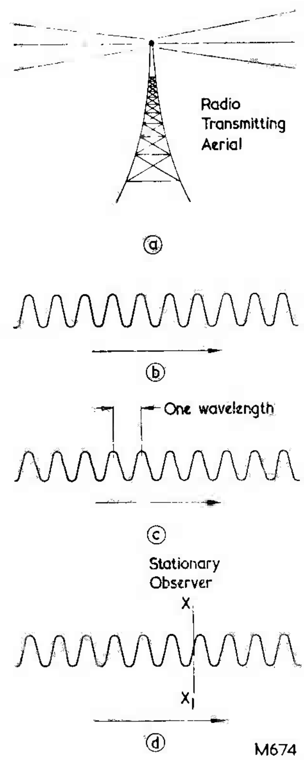


Fig. 110 (a). A radio transmitter broadcasting a signal
(b). The transmitted signal may be presented, in simplified form, as shown here. The arrow indicates the direction in which the signal travels
(c). The distance between successive wave crests is equal to one wavelength
(d). Introducing a stationary observer, whose function is to determine the number of wave crests which pass line XX[1] in a given period of time

Television transmissions are, at the time being, broadcast in "Band I" (41 to 68 Mc/s) and "Band III" (174 to 216 Mc/s). Because of the nature of the television signal and its accompanying sound signal, a single frequency cannot be ascribed to one

[1] Actually, 299,776,000 metres per second (to six significant figures).

television transmission. In consequence, a television transmitter is assigned a numbered channel which defines the range of frequencies, within the appropriate Band, over which it may transmit. Thus, a Channel 3 television transmitter broadcasts a signal in the range 53 to 58 Mc/s, and a Channel 4 transmitter broadcasts a signal in the range 58 to 63 Mc/s.

All these figures are quoted so that the reader may encounter numerical examples of some of the actual frequencies to which tuned circuits in receivers are made resonant. To take a further instance, let us assume that we are receiving the B.B.C. long wave Light Programme transmission on 1,500 metres. This wavelength corresponds to 200 kc/s. In our receiver there will need to be at least one tuned circuit resonant at 200 kc/s if we are to select this frequency in preference to others. If we are listening to Radio Luxembourg on 208 metres (or 1,442 kc/s), our receiver will require at least one tuned circuit resonant at 1,442 kc/s. Should we be receiving a short wave transmission on 30 metres, then our receiver will need at least one tuned circuit resonant at 10 Mc/s. For reception of f.m. signals, we similarly require tuned circuits, and these are, once more, resonant at the frequency of the transmission.

Signals which may be transmitted by way of the "ether" are described generally as *radio frequency* (or *r.f.*) signals. There is another range of frequencies which is commonly encountered in radio work, these consisting of the frequencies which may be heard by the human ear when the air is set into vibration. Such frequencies range from some 30 to 20,000 c/s[2] and are known as *audio frequencies*. In radio work, we occasionally encounter tuned circuits which are resonant at frequencies within the audio frequency range. The abbreviation *a.f.* (for "audio frequency") is commonly used.

Skin Effect

The design of a practical tuned circuit depends to a very large extent on the frequency at which it is resonant. This factor has considerable influence on the design of the inductor and the capacitor.

When we considered self-inductance[3] we saw that, if the magnetic field of a coil changes in intensity, it induces a current which opposes the current causing the change. We encounter rather a similar effect if we cause a radio frequency alternating current to flow in a metal conductor, such as a length of wire. The current produces a magnetic field which is continually changing in strength and polarity and the lines of force of this field extend both outside and inside the conductor. The lines of force inside the conductor induce, in their turn, alternating currents which oppose the flow of the original current. These induced currents are described as *eddy currents*.

The opposition to current flow offered by eddy currents is greatest at the centre of the conductor where there is most metal to support them, and reduces to a minimum at the surface. In consequence, radio frequency currents do not travel through the whole body of a conductor, as do direct currents. Instead, they travel at, and near, the surface only, the effect being described, graphically, as *skin effect*.

Since radio frequency currents travel only through the outer sections of a conductor the latter offers a higher effective resistance than it does to direct current, which utilises all the material of which the conductor is made.

In dealing with parallel and series resonant circuits we stated that much of the inherent resistance and "losses" appear in the inductor. We may now see that one of these "losses" is given by skin effect in the wire with which the inductor is wound. The skin effect causes the actual resistance of the inductor to become effectively increased by quite a considerable amount.

Skin effect occurs at all radio frequencies which are normally encountered, and becomes more pronounced as the frequency increases. This is to be expected, since increasing frequency causes the magnetic field about the conductor to build up and collapse more quickly, with the consequent induction of larger eddy currents. To reduce skin effect losses it is common practice to employ relatively thick wire when winding inductors, this being a common practice in particular at frequencies above 2 Mc/s or so. The use of thick wire ensures that a relatively large amount of conducting material at, and near, the surface becomes available for the flow of radio frequency current. Where very high Q figures are required (higher than would be needed in a normal domestic receiver) the surface of the wire may be plated with a high conductivity material, such as silver.

A factor which tends to partly alleviate the losses given by skin effect is that, as frequency increases, the number of turns required in the inductor of a resonant circuit decreases. In consequence, less winding wire is required, which means that the length of conductor over which skin effect takes place becomes reduced.

It is possible to reduce skin effect in inductors working between about 200 kc/s and 5 Mc/s by employing stranded winding wire in preference to solid wire. The stranded wire, described as *litz* wire, consists of a number of enamelled single strands, each of which is insulated from its neighbours by its enamel covering. The strands are interwoven together in such a manner that each rises to the surface in turn along the overall length. The use of a number of strands in this manner ensures that a larger surface area is available than would be given by a solid conductor of the same overall diameter, and losses due to skin effect are reduced thereby. The strands in the litz wire are connected together at the inductor terminals only; and it is important to ensure that all strands are reliably connected at these points. A variant on litz wire is *bunched* wire. Bunched wire similarly consists of a number of strands of insulated wire,

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2 The upper and lower limits in the audible range vary slightly for different individuals.

3 In "Understanding Radio", part 12, August 1962 issue.

but it may not have the true litz formulation. In general, bunched wires appear to offer the same performance as litz wires, and they are cheaper to manufacture.

Iron Dust Cores

We have noted earlier that the inductance of a coil may be increased by inserting an iron core inside it.[4] It might appear at first sight that, if we were to insert an iron core into a coil operating at a radio frequency, we could similarly bring about an increase in inductance. In practice, however, an iron core is not used in this manner. This is because the radio frequency current in the coil would cause eddy currents to flow in the iron, and energy would become wasted as a result.

The problem of eddy currents may be largely overcome by the use of an *iron dust core*. An iron dust core consists of a plastic binder in which are suspended particles of iron powder or "iron dust". The plastic material is usually of the phenol formaldehyde type, although epoxy resins are also employed.[5] Since the iron in the iron dust core is made up of very small particles insulated from each other by the plastic material in which they are suspended, the eddy currents which flow are considerably lower than would occur in the solid iron core. On the other hand, the effective permeability of the iron dust core (that is, its ability to allow lines of magnetic force to pass through it) is lower than that of a solid iron core of similar size, because it contains less magnetic material.

Over a wide range of operating frequencies, a coil having an iron dust core presents a lower resistance and has a higher Q than does a similar coil without such a core. The very simple reason for this state of affairs is that the coil with the core requires fewer turns to achieve the same inductance, with the result that its effective resistance (including that caused by skin effect) becomes less.

A secondary advantage conferred by the use of an iron dust core is that the latter may have an adjustable mounting which enables it to enter a coil by a pre-determined amount. Because of this it is

[4] See "Understanding Radio", part 12.
[5] Bakelite is a familiar phenol formaldehyde resin, and Araldite a familiar epoxy resin.

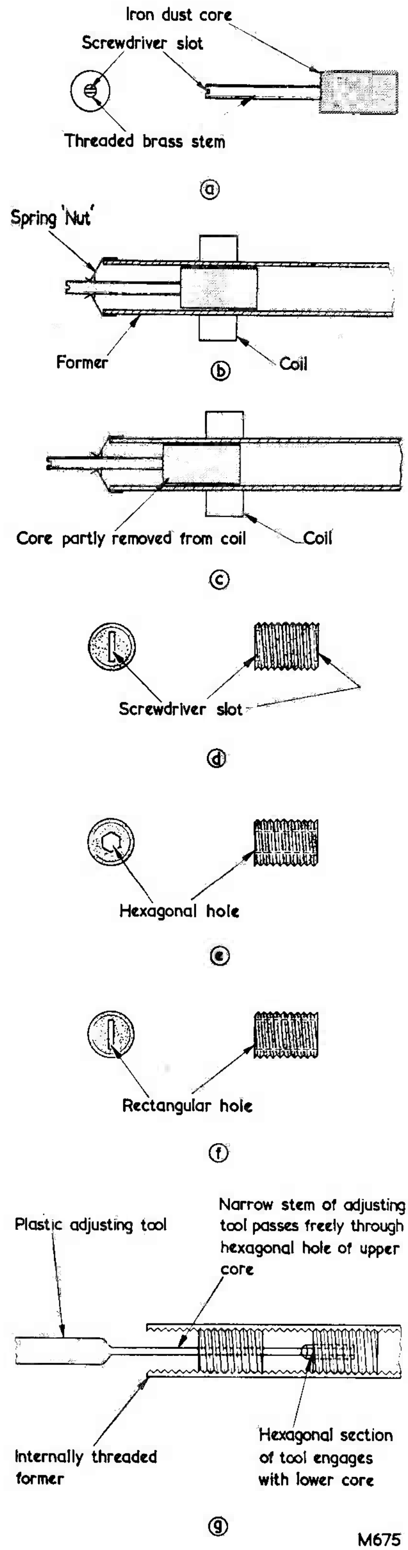


Fig. 111 (a). An iron dust core fitted with a threaded brass stem
(b). The dust core in the position which offers maximum inductance. A wave-wound coil is assumed. The spring "nut" shown consists of a fixture made of spring steel which applies friction to the stem and maintains it in the position to which it has been adjusted
(c). By withdrawing the core from the coil, inductance is reduced
(d). A threaded iron dust core with screwdriver slots
(e). A threaded core with a hexagonal hole passing through its body
(f). A hole having a rectangular cross-section may be employed instead of the hexagonal hole
(g). With the aid of a suitable tool, it is possible to adjust two cores with hexagonal holes from one end of the former

possible to obtain a fine degree of control over coil inductance, a very useful asset in many radio circuits. The range of control is somewhat limited if the core is also to be effective in producing a high Q, since the latter may drop excessively if the core is too far removed from the coil. Another advantage conferred by the iron dust core is that it causes a large proportion of the magnetic field produced by the coil to be concentrated inside it; with the result that less of the field appears around the coil, where it may interfere with other components or circuits. Coils with iron dust cores allow, therefore, a more compact layout of parts about them than do coils without cores.

Despite their construction, iron dust cores are not completely free of eddy currents, and care has to be taken to ensure that the losses these cause do not outweigh the advantage given by reduced winding resistance. Eddy current losses in iron dust cores increase with frequency, and dust cores intended for the higher frequencies have smaller particles of iron spaced further apart in the plastic binder than do cores intended for lower frequencies. A number of grades of iron dust core are available to manufacturers of inductors, that most commonly encountered being suitable for use up to some 20 Mc/s or so. At frequencies above this figure it is preferable to employ grades having finer powder which is more dispersed throughout the binder. As is to be expected, such cores have less effective permeability than the lower frequency types, and do not cause as great an increase in inductance. Because of these limitations, and speaking in very general terms, iron dust cores offer the most pronounced increases in Q at frequencies up to about 1 Mc/s, after which the improvement in Q they provide tends to decrease as frequency increases. Above 40 Mc/s or so, the increase in Q conferred by the use of an iron dust core may be very small. It should be noted that in some circuits, and particularly at frequencies above about 20 Mc/s, the iron dust core may be more attractive as a means of adjusting inductance than as a device which enables high values of Q to be obtained.

Iron dust cores are made in a large number of forms, those most frequently encountered being illustrated in Fig. 111. In Fig. 111 (*a*) we have a cylinder of dust core material fitted to a threaded brass stem. The latter can be passed through a fixed nut, whereupon the core can be moved up or down by turning the brass stem. Fig. 111 (*b*) shows a cross-section through a coil and former, the iron dust core being centrally disposed inside the coil. In this position it provides maximum inductance. Inductance may then be reduced by adjusting the brass stem so that the core partly leaves the coil, as in Fig. 111 (*c*). An alternative type of core is shown in Fig. 111 (*d*). In this instance the cylinder of core material is itself threaded, whereupon it may be caused to move up or down an internally threaded former by being rotated. A screwdriver slot is provided at each end to facilitate adjustment. Threaded cores are cheaper than the type shown in Fig. 111 (*a*), because the brass stem is not required. They are, in consequence, more frequently used. Over the past eight years, threaded cores with screwdriver slots have been largely superseded by the types shown in Figs. 111 (*e*) and (*f*). The core illustrated in Fig. 111 (*e*) has a hexagonal hole passing through its centre, and it is adjusted by a plastic tool having a corresponding hexagonal section. The improved mechanical coupling between adjusting tool and core material then results in less strain on the latter than occurs with screwdriver slots. Iron dust core material is brittle, and is especially liable to break away from a screwdriver slot if the core is carelessly adjusted. Another variant is the core shown in Fig. 111 (*f*), which has a slot of rectangular cross-section passing through its centre. This type of core is adjusted by a tool with a flat brass blade which fits into the rectangular hole.

An incidental advantage offered by the core with the hexagonal hole is illustrated in Fig. 111 (*g*). In this diagram it is assumed that two cores are fitted in a single threaded former. By employing an adjusting tool having a stem which is thinner than the smaller internal diameter of the hexagonal hole, it is possible to adjust both cores from one end of the former.

It is undesirable that a threaded dust core should shift after it has been adjusted to the desired position and, to prevent such an occurrence, a number of different schemes are employed by receiver and coil manufacturers. A common method consists of applying a liquid having a high viscosity to the core before it is inserted into the former. Another alternative consists of laying a thin strand of rubber (or "rubber string") inside the former before the core is fitted. This strand of rubber then keeps the core firmly pressed against the opposite side of the former. Many other similar "locking" devices may be encountered, and they all function by introducing friction between the core and the former which is sufficient to obviate shifting due to vibration, without being so great as to prevent adjustment.

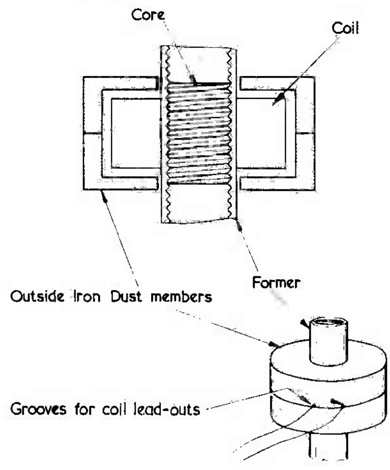


Fig. 112. A pot core assembly M676

In order to further increase Q, or to allow smaller coils of the same Q to be manufactured, the single iron dust core we have considered up to now may be augmented by dust core members mounted outside the former. A typical instance is illustrated in Fig. 112 which shows a *pot core* construction. The coil is enclosed on the outside by the dust core material, with the result that an almost complete magnetic circuit is set up. In consequence, fewer turns are required on the coil than would be needed with the internal dust core on its own. Since the magnetic field about the coil now becomes concentrated almost entirely in the iron dust material, very little appears outside the assembly. The iron dust members over the coil consist of two halves, as shown, grooves being provided at the meeting surfaces to enable the connections to the coil to pass through.

When an inductor has an iron dust core it is represented in circuit diagrams in the manner shown in Fig. 113 (*a*). The presence of the dust core is indicated by the dotted parallel lines alongside the symbol for the inductor. If, as is usually the case, the dust core is capable of adjustment, a T-shaped symbol (indicating "pre-set") is added, as in Fig. 113 (*b*). As a point of terminology, it should be added that cores intended for insertion in radio frequency coils are often referred to as *slugs*.

Ferrite Cores

In recent years, cores made of ferrite materials[6] have been introduced for use in coils operating at radio frequencies. These cores do no consist of particles in a plastic medium, but of a homogeneous material which is produced by sintering or firing. Ferrite cores and assemblies may be made in the same shapes as iron dust piece-parts, but they are more expensive to manufacture. Losses due to eddy currents are largely eradicated because the ferrite materials employed are poor conductors of electricity. It is possible, with ferrite cores, to obtain significantly enhanced Q figures up to frequencies of 50 Mc/s or more.

[6] Ferrites are non-metallic magnetic materials having ceramic-like physical properties.

Fig. 113 (a). The symbol for an inductor having a fixed iron dust or ferrite core

(b). The symbol for an inductor having an adjustable iron dust or ferrite core

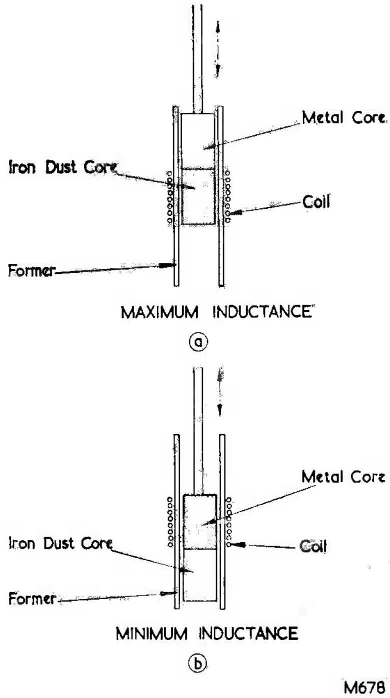


Fig. 114 (a). A composite core, comprising a dust core and a metal core, in the position of maximum inductance. At the frequencies involved, the coil will have a few turns only

(b). The composite core in the position of minimum inductance

Coils having ferrite cores are depicted in circuit diagrams in the same manner as coils having iron dust cores.

Metal Cores

When it is desired to have a means of adjusting coil inductance at frequencies above 50 Mc/s or so, it is common practice to employ threaded metal cores which enter the coil in the same manner as threaded dust cores. These cores reduce the inductance offered by the coil, the lowest inductance being given when the core is centrally disposed inside the winding. The reduction in inductance is brought about by the fact that eddy currents in the metal core cause partial concellation of the magnetic field. The cores are normally made of brass or aluminium.

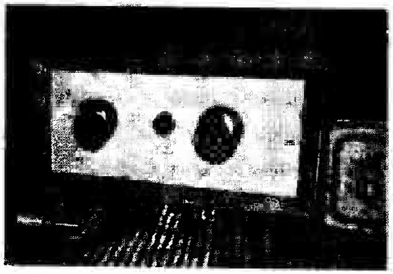
It would be thought that the introduction of metal cores would bring about a large reduction in the Q of the coil, because of the losses which are introduced. In practice, metal cores are normally employed with coils which do not have a very high Q in themselves, and they do not offer a marked reduction in practical circuit efficiency at the frequencies involved.

It is usual to find coils with adjustable metal cores in television tuner units. At Band I frequencies (41 to 68 Mc/s) some tuner unit manufacturers employ adjustable metal cores, whilst others employ adjustable iron dust cores. At Band III frequencies (174 to 216 Mc/s) adjustable metal cores are almost always employed.

An interesting combination of iron dust core and metal core is shown in Fig. 114. The assembly illustrated comprises an iron dust cylinder and a metal cylinder. When the iron dust cylinder is centrally positioned inside the coil the latter offers maximum inductance, this being greater than the natural inductance of the winding. As the assembly proceeds into the coil, the iron dust section leaves the winding and the metal section commences to enter it. In consequence, inductance reduces, falling to a minimum when the brass section is fully inserted into the winding. This minimum inductance is lower than the natural inductance of the winding. A *composite core* of the type shown in Fig. 114 offers a very wide range of inductance change with a single winding. Composite cores are occasionally encountered in tuned circuits operating at frequencies above 50 Mc/s or so.

Next Month

In next month's issue we shall examine typical tuned circuits for operation at various radio frequencies, and shall discuss the effects of dielectric losses in both the capacitor and inductor in the resonant circuit. If space permits, it is hoped also to introduce the transformer.



"208" BOOSTER

An easily made reception aid

By **A. S. CARPENTER**

MANY A.M. RADIO RECEIVERS AND TUNERS IN USE throughout the country are not able to provide good results from the Radio Luxembourg transmissions on 208 metres. Although it might be unreasonable to expect regular reception of this station with a t.r.f. receiver, the more common commercial or home-built superhet should be sufficiently sensitive to perform the task irrespective of whether it contains an r.f. stage prior to the frequency-changer or not.

Where fading of Radio Luxembourg is a problem, it is not always too well appreciated that a receiver a.g.c. circuit cannot function unless adequate signal is applied to operate it. Often the delay is never overcome, and the resultant lack of a.g.c. results in heavy fading.

In all these cases, considerably improved reception of Radio Luxembourg can be achieved by constructing a small and completely self-contained booster unit, and this is the feature of the present article.

The requirements that the unit be small and self-contained are most simply met by utilising transistor circuitry, thus enabling a dry battery to be employed for power. Although it might be possible to construct a booster no bigger physically than a matchbox it is generally more convenient to choose a larger size. Further desirable features of the unit are:

(1) It should be capable of being tuned within narrow limits.

(2) Once set up and placed in position it should, if necessary, be possible to leave it permanently connected to the receiver with which it is used.

(3) When not needed it should be possible to switch if off independently of the main receiver, which should then be able to function normally.

(4) If possible a warning lens should be fitted to prevent the unit from being left switched on by accident.

These features are incorporated in the design presented here which, in use, is connected in series with the aerial and the main receiver.

The Circuit

An inspection of Fig. 1 reveals that the booster is built around an OC44 transistor, this type having a cut-off frequency ($f\alpha$) in grounded base of approximately 15 Mc/s. Under static conditions the transistor operates with an emitter current of approximately 1.6mA, the total current drain of the whole unit being less than 2mA.

The Luxembourg signal from the aerial is conveyed via S_1 to the junction of C_2 C_1 (connected in parallel)

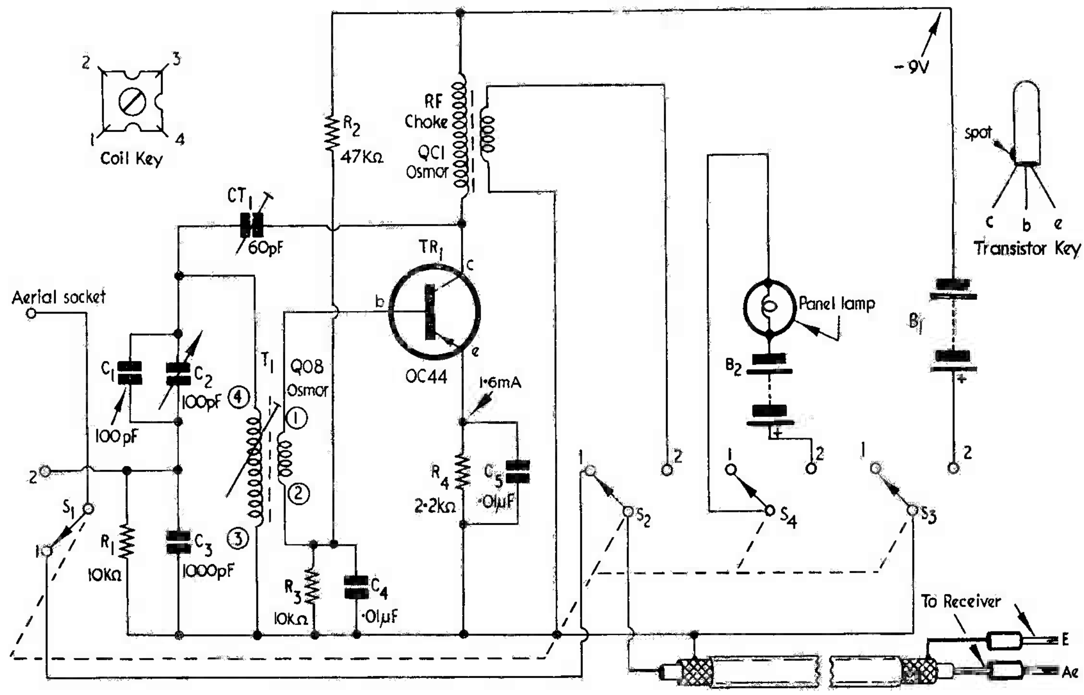


Fig. 1. The circuit of the booster unit

C29

Components List

Capacitors

C_1	100pF. Ceramic or mica.
C_2	100pF max. Variable
C_3	1,000pF. Ceramic or mica
C_4	0.01μF. Ceramic or paper
C_5	0.01μF. Ceramic or paper
CT_1	60pF max. Trimmer

Resistors (All $\frac{1}{4}$W 10%)

R_1	10kΩ
R_2	47kΩ
R_3	10kΩ
R_4	2.2kΩ

Transistor

TR_1 OC44

Inductors

T_1 Osmor type QO8.
R.F. Choke. Osmor type QC1. Modified (see text)

Switch

$S_{1, 2, 3, 4}$ 4-pole, 2-way, miniature

Panel Lamp

M.E.S. lamp with holder (see text)
Coloured lens and bush. Bulgin type D197 (see text)

Batteries

B_1	9 volt. EverReady type PP3
V_2	Voltage to suit panel lamp (see text)

Tagboard

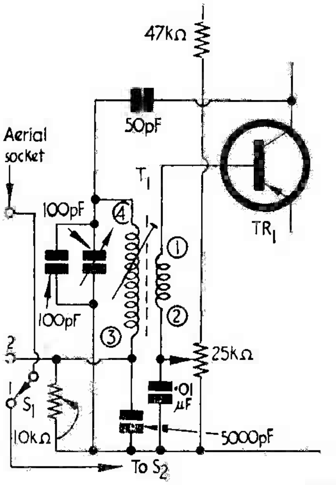
Miniature 8-way, $1\frac{1}{2}$ x $1\frac{1}{2}$in (see Fig. 3)

Miscellaneous

2 stand-off insulators (or spacing pillars) 1in
2 Control knobs
Aerial socket, battery clips, plugs, coaxial cable etc.

and C_3, a capacitive potentiometer being thus formed across the tuned winding of T_1. The ratio of the potentiometer is variable within limits, and is controlled by C_2. When C_2 is suitably adjusted the signal is presented to the base of TR_1 via the low impedance winding of the coil and appears considerably amplified, at the collector. Regenerative feedback is returned, via CT_1, to the base of the transistor in the correct phase, and the amplified signal appears across the r.f. choke in the collector circuit. The fact that T_1 is a type of coil usually associated with a superhet valve oscillator is of little consequence in the present instance, for we are only interested in a small section of the medium waveband.

Although it is theoretically possible to take the



C30

Fig. 2. Revised input circuitry to include a gain control

signal from the collector via a fixed capacitor it is generally more satisfactory to extract it via a low impedance winding. This is accomplished by winding a coil of 30 turns of fine wire between the two sections of the r.f. choke specified, and this is used to apply the signal to the main receiver via S_2 and a length of coaxial cable. This link between booster and receiver *must* be screened to prevent the direct pick up of unwanted signals. Temperature stability for TR_1 is achieved by including resistors R_2, R_3 and R_4.

A small panel-mounted, coloured warning lens and low consumption lamp are also fitted, the lamp becoming extinguished when the 4-way switch S_1 to S_4 is rotated to position "1". This is the "Off" position and it also causes the aerial to be connected directly to the receiver as well as disconnecting the battery B_1. A separate battery (EverReady 1289) and 0.15A lamp may be employed for the lamp circuit but, as this section is entirely independent of the booster proper, alternative items can be selected. For instance, a 6V battery in conjunction with a cycle dynamo rear lamp bulb (0.04A) would provide good service. Again, the facility may be omitted entirely, the appropriate section of the rotary switch (S_4) being left out of circuit.

No variable gain facility is provided, although this might prove beneficial under certain circumstances. Of the various ways in which the facility may be accomplished perhaps the simplest is to make the potential applied to the transistor base variable by inserting a potentiometer in either the emitter/base or collector/base circuits. The first of these methods would cause the transistor to be brought progressively nearer the grounded base configuration as the control is retarded. A suitable arrangement, which also shows an alternative way of connecting the aerial, is illustrated in Fig. 2, in which a 25kΩ potentiometer is connected in place of R_3. By exchanging CT_1 for a 50pF fixed capacitor, variable control of regeneration and, hence, overall gain can be effected.

Constructional Notes

There is no "chassis" as such since all components are built directly on to the inside of the front panel, as may be seen from the wiring diagram, Fig. 3. The layout shown should be followed as closely as possible, because unwanted positive feedback can occur under certain circumstances; e.g. if T_1 is placed too near the choke. The front panel measures $6\frac{7}{8}$ x 3in.

The miniature tagboard shown in Fig. 3, is raised on 1in spacers, and below this is mounted the low

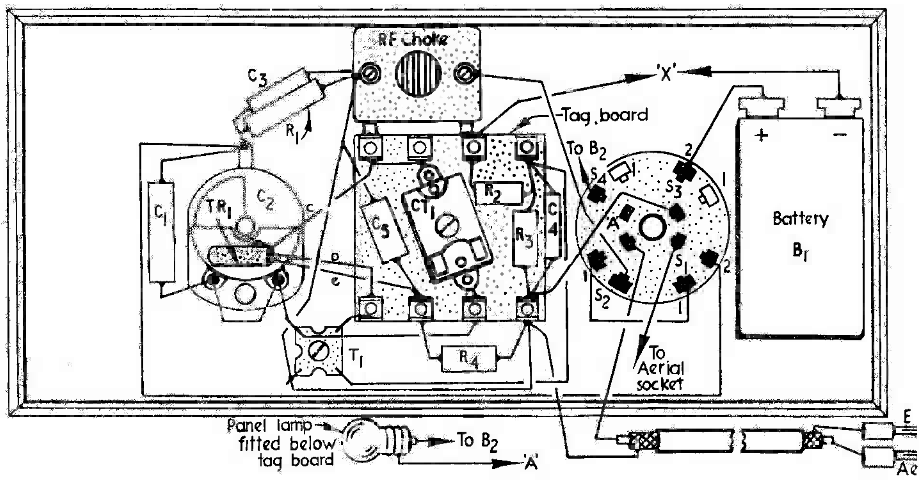


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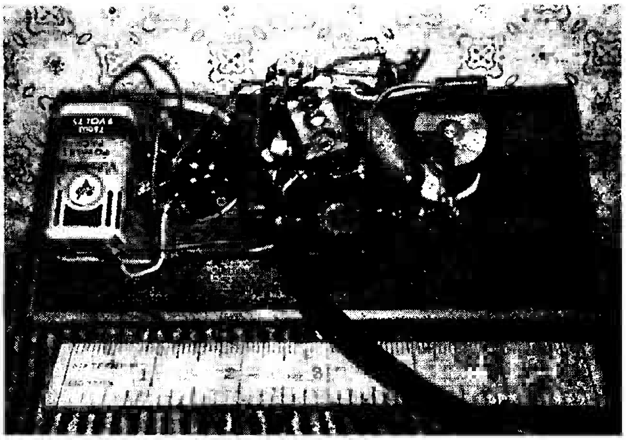
Fig. 3. The layout and complete wiring. The panel size proper corresponds to the inner heavy lines of the surround, the outermost lines being those formed by the quadrant frame (see text and Fig. 6). Battery B_2 is not shown



The completed "208" Booster showing all the main components. Compare with Fig. 3 on opposite page

consumption panel lamp (see Fig. 4). To save defacing the front panel of the prototype unduly, the r.f. choke and the battery were firmly held with No. 1 Bostik adhesive. Alternatively, however, mounting bolts and a clamp for the battery may be employed. The coil was rigidly retained by soldering two of its tags direct to the tagboard and tuning capacitor as shown.

Before it is mounted, the choke requires slight modification, as was mentioned earlier. Approximately 30 turns of 38 s.w.g. d.s.c. or enamelled copper wire (which can be obtained from a discarded coil) are wound on between the two pies, as shown in Fig. 5. Anchor wires of 22 s.w.g. tinned copper wire are then inserted in the free holes at the end of the choke base to act as tags and to receive the ends of the winding. External connections are made to these tags.*

Wiring up is on conventional lines, the transistor and battery lead marked "X" in Fig. 3 being left until last. Sleeving is filled over the transistor lead-out wires, which are not shortened, and connections to it are made using a conventional heat shunt.

The wiring should now be thoroughly checked. When fully satisfied, the lead marked "X" can be connected, after first making sure that the rotary switch is in position "1". Next, the aerial lead is removed from the receiver and plugged instead into the socket on the booster, the plugs at the end of the coaxial linking cable being inserted appropriately in the receiver sockets.

If the receiver is now switched on it will perform normally and should be adjusted to receive the Radio Luxembourg signal. The booster may now be switched on and its tuning control rotated—with CT_1 almost fully unscrewed—in an attempt at boosting the signal being received. Should no improvement result at any setting of C_2 change the core position of T_1 and try again. If some boosting occurs when the vanes of C_2 are fully enmeshed, screw the coil core so that it more fully engages the windings, and readjust C_2. Should the reverse be the case too much inductance is in circuit and the core of T_1 needs to be slightly removed from the windings.

* When fitting the additional winding, care should be taken to ensure that the wire coupling together the two pies of the choke is not damaged.—*Editor*.

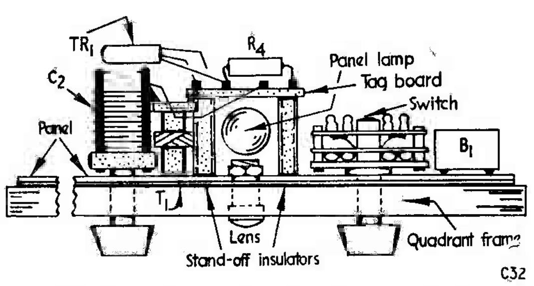


Fig. 4. A side elevation showing panel lamp location

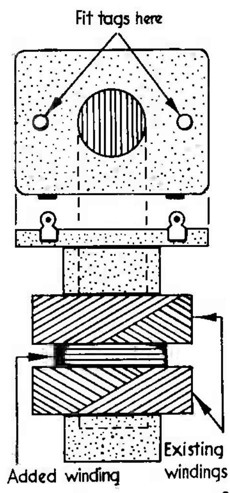


Fig. 5. Details of choke modification

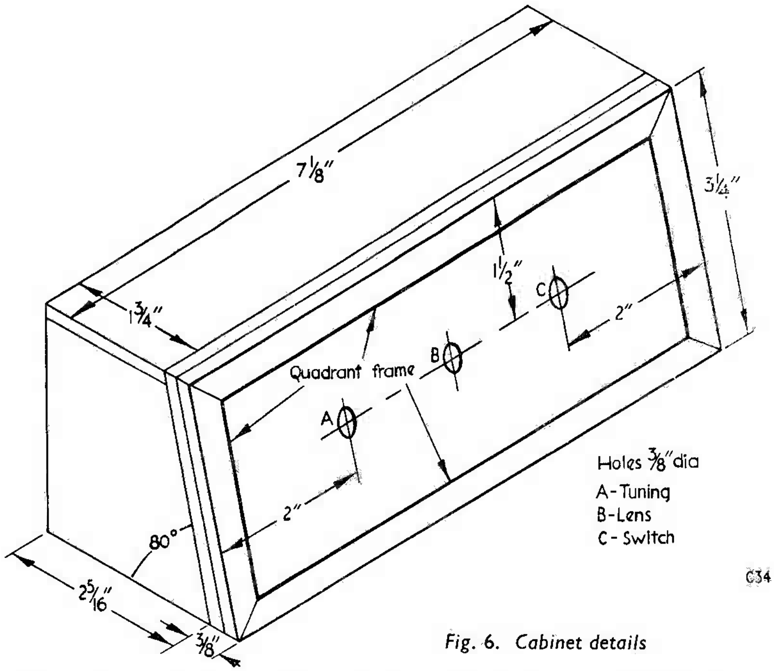


Fig. 6. Cabinet details

When it is possible to get a peaking point with the vanes of C_2 approximately 50% enmeshed, gently tighten CT_1 to increase sensitivity until a "burbling" or oscillatory noise results. Finally, unscrew the trimmer until the noise just ceases.

The booster is now set up and, to prove its efficiency, turn the rotary switch to "Off" and note how the volume level drops!

It might be found that a short burst of oscillation occurs for a few seconds when the booster is again switched on. If this is a nuisance it may be obviated by either reducing the capacitance setting of CT_1 or by switching the unit on, say, half a minute earlier than the main receiver.

The benefits of the booster are graphically shown on a receiver fitted with a Magic Eye tuning indicator. In a practical test the Radio Luxembourg signal was quite unable to change the Eye shadow, but the shadow fully disappeared when the same signal was applied via the booster. This indicated that a good control bias was being set up in the receiver in addition to the enhanced level of volume. Although gains will differ according to the situation, 25dB can be taken as a fairly representative figure.

It will also be found that by carefully manipulating the tuning control on the unit, interference caused by adjacent transmissions can be tuned out.

A Cabinet

A cabinet can easily be made from plywood or even hardboard and, since negligible weight is involved, the sections may be held together quite simply with internally fitted reinforcement strips and Bostik No. 1 adhesive. If four sections of $\frac{3}{8}$in quadrant are mitred to form a frame $\frac{1}{4}$in larger than the panel dimensions, a $\frac{1}{8}$in rebate will be formed if the frame is glued to the panel edges and allowed to overlap by this amount all round. The top, bottom and side sections can then be made to come up to the framing neatly and simply. It is also convenient to allow the panel to slope backwards slightly. Necessary dimensions for a simple cabinet are given in Fig. 6, these agreeing with the prototype. The aerial socket is mounted at the rear of the cabinet.

New EMI Oscilloscope Type WM18

Oscilloscope type WM18 is a new readily transportable measuring instrument intended for use in laboratories engaged in development of computers, radar, television and pulsed equipment.

The Y amplifier has two independent inputs for use separately or differentially. Both inputs have a bandwidth of 25 Mc/s at a maximum sensitivity of 50 mV/cm. An X5 pre-amplifier can be switched into one input channel giving a bandwidth of 20 Mc/s at 10 mV/cm. A built-in signal delay of 190 nanoseconds enables pulse leading edges to be measured.

Sweep speeds are 1.5 sec/cm to 50 nanoseconds/cm unexpanded in a 5–15–5 sequence. Variable sweep expansion up to X5 is provided.

A high degree of trace brightness is obtained by providing 12kV for the cathode ray tube beam accelerating anodes.

Voltage and time measurements are made by graticule or dial; the accuracy of measurement is 5% f.s.d. by graticule and 3% f.s.d. by dial. The instrument is fan cooled and will operate in ambient temperatures of up to 40°C.

This month Smithy the Serviceman, aided by his able assistant, Dick, looks into the question of simple but practical analogue computers which may be built by the home-constructor or experimenter

SERVICING IN PROGRESS
starring
Britain's Premier Fast-Talking Comedy Duo
SERVICEMAN SMITHY
"The King Of The Oscilloscope"
and
CRAFTY DICK
With his latest "Tokyo Wonder" Testmeter

Also available for Social Clubs, Works Outings and Buffalo Lodges

SMITHY THE SERVICEMAN GAZED in horror at the 7 x 5ft placard which Dick leaned reverently against his bench.

"There," said Dick proudly, "now, what do you think of that?"

Smithy spluttered helplessly.

"But what," he asked weakly, "is it *for*?"

"It's to drum up business," replied Dick briskly. "You know as well as I do that things have been very quiet over the last few days."

"They haven't been so quiet," said Smithy, gradually recovering his self-assurance, "that we have to advertise our services by displaying a notice like that!"

Smithy pointed a trembling finger at Dick's garishly coloured creation.

"It's not quite finished yet," replied Dick carelessly. "I've got to add a few decorations to it yet, such as girls high-kicking, and so on. It should look very effective outside the Workshop."

Quiet Times

"That notice," said Smithy, who had now completely returned to his normal self, "will *not* go outside the Workshop."

"Hey?"

"It will not," continued Smithy firmly, "be employed in any manner of advertising whatsoever."

"Well, that's a fine thing, I must say," protested Dick indignantly. "I've spent half the morning on it, and all the thanks I get is that you don't want to use it!"

"Your devotion to the Workshop does not go unmarked," commented Smithy. "But I'm afraid that I cannot allow it to be expressed in the manner you have chosen."

"Dash it all," said Dick disgustedly, "I've got to do *something* with my time! I'm fed up with coming to work and having nothing to do when I get here."

Smithy sighed. The Workshop was going through one of its occasional quiet spells. Plenty of receivers were coming in for repair, but their faults were simple and required little time or work from his assistant and himself. Smithy welcomed these quiet periods, as they gave him a chance to catch up with his paperwork. Dick, on the other hand, detested them. On this particular morning, he had cleared the only receivers which were outstanding in less than an hour. After this he had nothing else to do, and had taken to pacing up and down the Workshop and banging things with a screwdriver until Smithy's nerves had tautened almost beyond endurance. The Serviceman had given a silent prayer of thanks when Dick's wanderings had finally caused him to find the large sheet of board on which he had been mysteriously engaged for the last hour and a half. Now that Smithy had seen the results of Dick's concentrated (and blessedly silent) labours, he realised that something constructive must be done if his assistant's energies were to be diverted into a useful channel.

"Why," asked Smithy tentatively, "don't you build something?"

"What's there to build?" retorted Dick. "I've already knocked up all the odd bits of home-made test gear we use around the place."

Smithy stroked his chin reflectively. Suddenly, he was visited by an inspiration.

"You could always," he remarked, "make up a computer."

"A *computer*?"

"That's right," grinned Smithy, ignoring the incredulous expression on Dick's face. "A computer! It would be quite an instructive exercise for you and it shouldn't use up too many of the Workshop's spare parts."

"But computers," protested Dick, "are things which have a fantastic amount of valves or transistors."

"I appreciate that," replied Smithy. "However, what I'm thinking of at the moment is a very simple little analogue computer using a few potentiometers and a pair of headphones only."

"What," asked Dick suspiciously,

"will this computer do?"

"A few simple tasks," replied Smithy. "It will, for instance, multiply two numbers together. It will also tell you the resistance in a circuit if you know the voltage and current. And it will find the square roots of numbers."

"All this," queried Dick, "with just a few pots and a pair of phones?"

"That's right," confirmed Smithy. "If you were to build up a unit of this type with reasonable care you should be able to get about the same accuracy as you have with a slide rule. Even if you just threw it together you should still get quite useful results."

"It sounds," said Dick enthusiastically, "quite fascinating to me. Tell me more!"

Now that he had a concrete project in mind, Dick had completely forgotten his previous complaints. He perched himself on his stool and waited expectantly.

"Are you sitting comfortably?" asked Smithy.

Dick nodded.

"Good," said Smithy. "Then I'll begin."

"Sure," said Dick. "I'm fully with it!"

"Fine," replied Smithy. "Now, the scale of the pot will tell us exactly what voltage we get between the slider and the bottom of the track. If, for instance, we set the potentiometer to 0.4, we will get 0.4 of the battery voltage between the slider and the bottom of the track. If we set it to 0.7, we will get 0.7 of the battery voltage, and so on."

"I see," said Dick frowning. "I should imagine also that, if you set the pot to 1, you'll get the full battery voltage; and that if you set it to 0 you will get zero battery voltage."

"You've got it," confirmed Smithy. "Whatever the setting of the potentiometer, the scale tells you the proportion of the battery voltage which is tapped off."

He stopped, and proceeded to draw another circuit on the paper.

"We now," he stated, "add another potentiometer. (Fig. 2). This is connected between the slider and the bottom of the track of the first pot, and it is calibrated

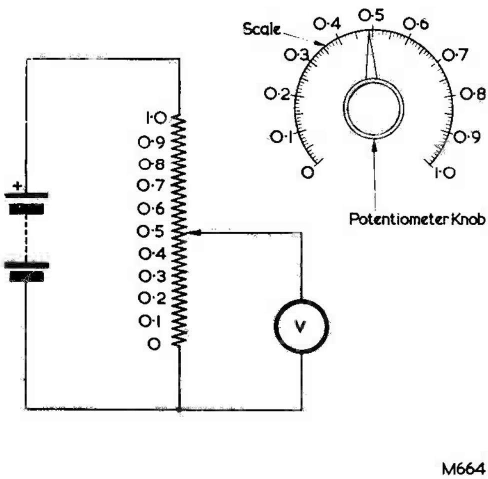


Fig. 1. If a linear potentiometer is calibrated from 0 to 1, the calibration will indicate the fraction of the battery voltage tapped off by its slider

A Simple Computer

The Serviceman drew a notebook towards him and produced a pen.

"To understand how our little computer works," he said, scribbling a circuit diagram on the paper, "we start off by considering a single potentiometer connected across a battery. (Fig. 1). This potentiometer has a linear track and it is fitted with a scale graduated from 0 to 1. O.K.?"

from 0 to 1 in exactly the same way. For the time being we shall assume that the second potentiometer draws no current from the first potentiometer."

Smithy paused for a moment.

"Let us next," he continued, "see what voltages we get from the second potentiometer for different settings of the first. If we put the first potentiometer, which I've labelled R_1, to 0.5, then half the battery voltage is applied to the second potentiometer, R_2. If R_2 is similarly set to 0.5 it causes half the voltage tapped off from R_1 to appear between its slider and the bottom of the track. In other words, the voltage at the voltmeter is now one quarter of the battery voltage."

Dick looked a little puzzled.

"Well, that seems obvious enough," he commented after a moment. "The first pot taps off half the battery voltage and the second pot taps off half the voltage from the first pot. You're *bound* to get a quarter of the battery voltage at the voltmeter. Where does the computer action come in?"

"It has," replied Smithy, "*already* come in! As I shall now proceed to explain to you. We have set up both R_1 and R_2 to 0.5 and are getting an output voltage which is equal to a quarter, or 0.25, of the battery voltage. Now, 0.5 multiplied by 0.5 equals 0.25, and so our two pots have, in effect, multiplied 0.5 by 0.5 and given us 0.25.

"If," Smithy carried on, "we repeat the exercise with other settings of R_1 and R_2 we will find that we get the same effect. If R_1 is set to 0.2, then one-fifth of the battery voltage is passed to R_2. If R_2 is left at 0.5, then half this voltage appears at the output. This is one-tenth, or 0.1, of the battery voltage. And, 0.5 multiplied by 0.2 equals 0.1. Let's try another combination, by putting R_1 to 0.6 and R_2 to 0.8. If you want to work it out in fractions, this means that $\frac{6}{10}$ of the battery voltage is applied to R_2 which then taps off $\frac{8}{10}$. The output voltage is obviously $\frac{6}{10} \times \frac{8}{10}$ of the battery voltage, which is equal to $\frac{48}{100}$, or 0.48. The figure 0.48 is equal to 0.6 multiplied by 0.8, and so R_1 and R_2 have once again done a bit of effective multiplication for us. All right?"

"All right?" echoed Dick enthusiastically. "I'll say it is! Blimey, I'd never have thought that you could get this effect with just two pots."

He paused and frowned.

"I can appreciate," he continued, after a moment, "how the multiplication business is carried out, but I'm not quite clear how you measure the output voltage. Do you use the voltmeter?"

Smithy chuckled and pulled the notebook towards him again.

Adding A Third Potentiometer

"The business of measuring the output voltage," he said, "is quite simple, and merely consists of adding a third potentiometer—

which I shall call R_3—to the circuit (Fig. 3). This third potentiometer is calibrated from 0 to 1 in exactly the same way as R_1 and R_2, and we put a centre-zero milliammeter between its slider and that of R_2."

"In other words," interjected Dick, "you're making up a bridge."

"That's it," agreed Smithy. "The last example we mentioned had R_1 set to 0.6 and R_2 set to 0.8, whereupon the voltage between the slider of R_2 and the bottom of the track became 0.48 of the battery voltage. If we now set R_3 to 0.48 the milliammeter will read zero, because R_3 will similarly tap off 0.48 of the battery voltage."

"Blimey," repeated Dick, supremely impressed. "You've really got something here, Smithy!"

"It *is* rather fascinating," conceded Smithy. "And I should add that this three-potentiometer arrangement forms the basis of our complete computer. If you want to multiply two numbers you simply set R_1 and R_2 to the appropriate calibration points. You next adjust R_3 to give a zero reading in the milliammeter, whereupon you read off the product of the two numbers from its scale.

"This isn't," continued Smithy, "all you can do, by any means. If we call the R_1 scale number A, the R_2 scale number B, and the R_3 scale number C, then the circuit gives us the equation $A \times B = C$. This is the same as saying

$$A = \frac{C}{B} \text{ or } B = \frac{C}{A}."$$

"Which," chimed in Dick excitedly, "is the same sort of thing as

$$R = \frac{E}{I}."$$

"You've got it," said Smithy. "If you wanted to find R when a voltage of 0.4 caused a current of 0.5 amps to flow, you would set R_3 to 0.4, and R_2 or R_1, to 0.5. You would then adjust the remaining potentiometer—which could be either R_2 or R_1—until you had a zero reading in the milliammeter. This third pot would then indicate 0.8, which is your answer in ohms."

"Will the circuit also find square roots?" asked Dick. "You said it would, earlier on."

"Square roots," replied Smithy, "are nearly as simple. To take an easy example, let's assume that we want to find the square root of 0.25. We would first of all set R_3 to this figure, after which we would adjust R_1 and R_2 in step until we had the milliammeter reading zero and both R_1 and R_2 at the same figure. That figure would, of course, be 0.5, which is the square root of 0.25. I need hardly add that, here, we're merely reversing the first example we considered. If R_1 is set to 0.5 it taps off half the battery voltage, and if R_2 is set to 0.5 it taps off half of that from R_1. The result is obviously a quarter of the battery voltage, or 0.25."

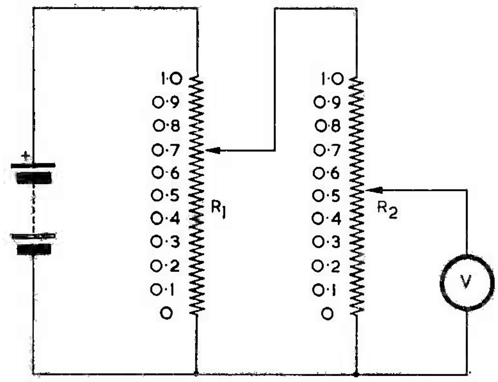


Fig. 2. When a second, similarly calibrated, potentiometer follows the first, the output voltage relative to that from the battery is the product of the two fractions indicated by the potentiometers

Different Calibrations

"The calibration figures," said Dick thoughtfully, "tend to confuse me a little. I find it rather difficult to think in terms of nought point something all the time!"

"They aren't all that helpful," agreed Smithy. "But they're very useful in explaining how the gadget works. One way of making calculations easier would consist of providing each potentiometer with two ranges. The first of these ranges would be given by calibrating R_1 and R_2 from zero to 10 and R_3 from zero to 100. (Fig. 4). We know that the circuit gives us $A \times B = C$, so all we are doing is to multiply A and B by 10. Since C is their product, we must obviously multiply this by 100."

"That seems fair enough," said Dick, frowning. "Let's just try it out for size! If we set R_1 to 7, then we are tapping off $\frac{7}{10}$ of the battery voltage. If we next set R_2 to 3, the final voltage tapped off is $\frac{7}{10} \times \frac{3}{10}$, or $\frac{21}{100}$. Since R_3 is graduated from zero to 100 we will

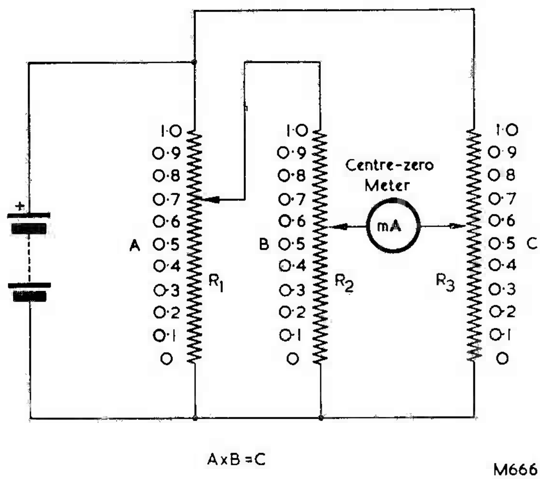


Fig. 3. By adding a third potentiometer and a null-indicating meter, the product of the fractions indicated by R_1 and R_2 may be presented by R_3

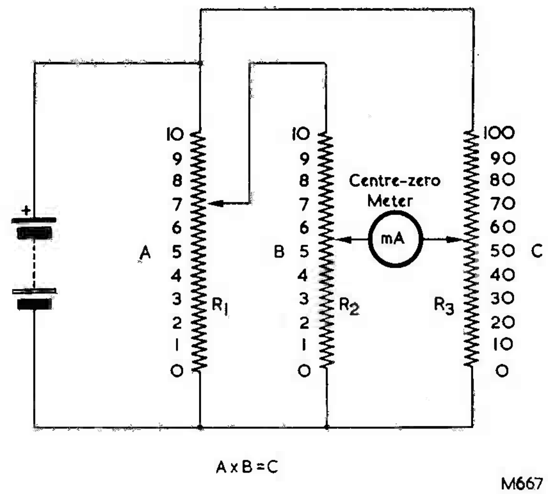


Fig. 4. It is more convenient to multiply the R_1 and R_2 calibration by 10, and the R_3 calibration by 100, as shown here

get a zero meter reading at 21, which is $\frac{21}{100}$ of the battery voltage."

"Satisfied?" asked Smithy.

"Definitely," replied Dick.

"Fine!" said the Serviceman. "Now the second range would best be given by calibrating R_3 from zero to 10. This means that R_1 and R_2 have to be calibrated from zero to $\sqrt{10}$."

"That's awkward!"

"Not really," replied Smithy. "The square root of 10 is 3.16, and this would give us the second range marking for R_1 and R_2 which corresponds to 10 in the first range. However, we want to calibrate the second range in whole numbers, and the easiest method of doing this would consist of working forward from the first range. 3.16 in the second range corresponds to 10 in the first range, so any whole number in the second range corresponds to that number multiplied by 10 and divided by 3.16 in the first range."

"Take it easy," interrupted Dick. "You know I never got past first grade in maths!"

"Don't worry about it," chuckled Smithy, scribbling out his figures on the paper in front of him. "I'll make it painless for you by doing the maths myself! Chuck the log tables over, will you?"

"We've got log tables in the Workshop?" queried Dick, in a tone of utter disbelief.

"Of course we've got log tables," replied Smithy sharply. "They're under the front left-hand leg of my bench."

Dick raised Smithy's bench and extracted the Workshop book of log tables. Blowing away the dust, he handed the tables over to the Serviceman.

"Right," said Smithy, turning the pages energetically. "It won't take long to work out a few figures here, because the log of $\sqrt{10}$ is 0.5."

"I'll take your word for it," commented Dick carelessly. "Log tables are just one more of the riddles of existence, so far as I'm concerned."

"Life," commented Smithy abstractedly, as he started working out his figures, "appears to be full of unexplained mysteries to you."

"It is," confirmed Dick morosely. "I seem to spend all my days encountering things which are completely unexplained."

"Such as?"

"Well, for instance," said Dick, "why do you hardly ever have a Woolworth's and a Marks and Spencer's side by side?"

"You can't," replied Smithy briskly. "They've got to be spaced out."

"Yes, but *why*?"

"It's because of the Woolworth and Marks and Spencer Effect," grunted Smithy, turning over to the antilogarithm page.

"The *what* Effect?"

Smithy frowned as he checked his calculations.

"The Woolworth and Marks and Spencer Effect," he repeated in a preoccupied tone. "If you have a Woolworth's and a Marks and Spencer's closer together than 50 yards, the two buildings approach each other at a rate of an inch every three years."

"You're pulling my leg," gasped Dick incredulously.

"No, I'm not," replied Smithy. "You'll almost always find them spaced out by more than 50 yards. 50 yards is the critical distance."

"It seems very peculiar to me," said Dick doubtfully. "In any case, I'm certain I've seen a Woolworth's and a Marks and Spencer's closer together than 50 yards somewhere."

"You probably have," said Smithy imperturbably. "They would have been built before the Effect was discovered. If you live in a town where they're closer together than 50 yards you can be certain that the buildings in between have to be rebuilt every fifteen years or so."

"Most buildings in shopping areas," protested Dick, "*are* rebuilt every fifteen years or so."

"True enough," said Smithy laconically. "But in this case it's because they're getting all squashed up between the Woolworth's and the Marks and Spencer's."

Before Dick could reply, Smithy put down his pen with an air of finality.

"There we are," he proclaimed with pride. "I've worked out the corresponding figures between the second and first ranges for R_1 and R_2. (Fig. 5). 3 on the second range corresponds to 9.49, 2 to 6.32 and 1 to 3.16. I'll add for good measure, that 2.5 corresponds to 7.90 and 1.5 to 4.80."

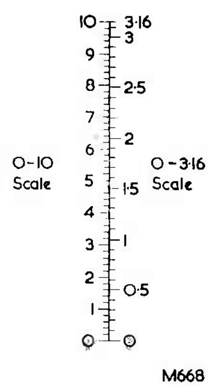


Fig. 5. A second calibration from 0 to 3.16 ($=\sqrt{10}$) may be added to R_1 and R_2. This may be marked off from the 0–10 calibration with the aid of the scale shown here

"That's funny," commented Dick. "The figure which corresponds to 1 is the square root of 10."

"True enough," agreed Smithy cheerfully. "But then the process of multiplying by 10 and dividing by 3.16, or $\sqrt{10}$, is bound to be the same as multiplying by $\sqrt{10}$!"

"I'm sorry I spoke," said Dick hastily. "I'd rather go back to Woolworth's and Marks and Spencer's!"

Practical Points

However, the Serviceman completely ignored his assistant's remark, and returned to the main subject under discussion.

"Having sorted out our two sets of ranges," he pronounced, "there are a number of practical points to consider with respect to our little computer. The first of these has to do with the null-indicating device which, in the case we've considered up to now, is a centre-zero milliammeter."

"What about the battery?" interrupted Dick. "Would this have to provide a particular voltage?"

"When the bridge is balanced, battery voltage doesn't matter," explained Smithy patiently. "After you've arrived at the final adjustment of the computer, R_1 and R_2 provide the same fraction of the battery voltage as does R_3. So the battery voltage doesn't enter into the figures finally obtained."

"Could you use an a.c. supply," persisted Dick, "instead of the battery?"

"You could," replied Smithy a little testily, "and that is just what I'm trying to get at, if you'd only let me get on with it. If you use a centre-zero milliammeter of high sensitivity you'll be passing some pretty hefty currents through it when the pots are a long way off their final setting, and its needle will be hard up against the end-stops. At the same time, the meter needs a high sensitivity if you're going to get really accurate results at the null. These two factors tend to conflict against each other."

"They wouldn't," said Dick, "if you used one of those meters which have a non-linear characteristic. The type I mean has high sensitivity at low currents and low sensitivity at high currents. Or you could have a two-valve or two-transistor null amplifier with the meter between the anodes or collectors."

"All the devices you mention," commented Smithy, "would be perfectly O.K. But they're much too complicated for a simple gubbins such as that we have here. It would be far easier, to my mind, to employ a pair of high-resistance headphones as the null detector, and to replace the battery by an a.f. tone. (Fig. 6). The human ear has a non-linear characteristic which enables it to pick out a null at very low level, and there are few experimenters who don't have an audio oscillator knocking around. The only requirement of the oscillator is that its frequency shouldn't be higher than 1,000 c/s. Otherwise you might get stray capacitances causing unwanted a.f. to be applied to the phones, with the result that the null becomes masked. I would say that an a.f. tone around 400 c/s or so should give excellent results."

"What about the values of the pots?"

"The post values are not critical in themselves," replied Smithy. "And, for R_1 and R_3, could be of the order of 100 to 500Ω or so. However, there is one important point which I haven't cleared up yet. I said at the beginning that we assume that R_2 draws no current from R_1 but, in practice, this obviously isn't true. The result is that the presence of R_2 will cause R_1 to be slightly non-linear. The effect can be reduced by giving R_2 a value some ten times higher than that of R_1 whereupon it could have a resistance between 1kΩ and 5kΩ."

"But," protested Dick, "even if R_2 *has* such a value, won't it still upset the calibration of R_1?"

"Only if you don't take it into account," replied Smithy. "When the computer is balanced, no current is drawn from the sliders of R_2 and R_3. At the same time, current is drawn from R_1, by the track of R_2. Therefore, whatever its setting, the lower half of R_1 is always effectively shunted by a fixed value of resistance, this being that of the track of R_2. So far as calibration is concerned, I would suggest that this be carried out by actual voltage measurements rather than by relying on exact linearity in the potentiometer. A suitable method of calibrating R_2 and R_3 would then consist of connecting them to a battery, and of measuring the voltage between the slider and the bottom end of the track with a voltmeter having a very much higher resistance than the potentiometer. (Fig. 7 (*a*)). You then make out the 0–10 scale for R_2 and the 0–100

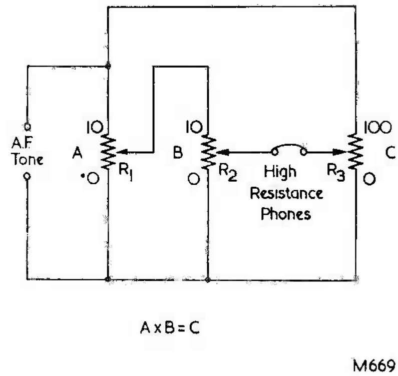


Fig. 6. It may be found more convenient to use a pair of high resistance phones as a null indicator instead of the meter of Figs. 3 and 4

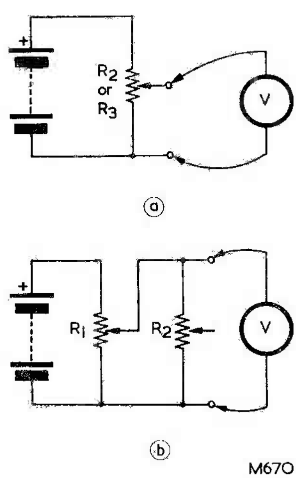


Fig. 7 (a). Calibrating R_2 or R_3 (b). Calibrating R_1. It is necessary in this case to connect the track of R_2 between the slider of R_1 and the lower end of its track

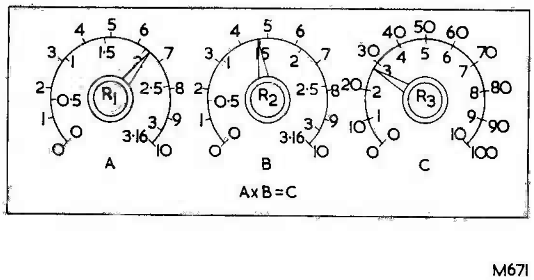


Fig. 8. A suitable panel layout for the completed computer. R_1 and R_2 have two scales, 0 to 3.16 and 0 to 10. These correspond respectively to the 0–10 and 0–100 scales of R_3

scale for R_3 by checking the fraction of the battery voltage which is tapped off. You can add the 0–3.16 scale to R_2 afterwards, picking up the whole numbers from the 0–10 scale in the manner I described earlier.

"R_1 can be calibrated in the same way as R_2," continued Smithy, "but you must first connect R_2 between its slider and the bottom end of its track. (Fig. 7 (*b*)). This then allows for the current drawn by R_2. The scale for R_1 won't be quite as linear as that for R_2, but it should be easy enough to sort out. Incidentally, the battery should, this time, have a low internal resistance."

"All this seems fair enough," commented Dick. "Although I'm still not *quite* certain why you have to go in for all this voltmeter business. Couldn't you just measure the angle over which each pot works and divide it up between zero and 10?"

"The main snag against doing that," said Smithy, "is that the ordinary common-or-garden pot you bump into for radio work isn't all that linear, especially at the ends of its travel. You will find some pots which have minimum ohms for quite a few degrees rotation at either end of the travel, because the slider rests on that part of the track which is in contact with the terminal clamp. Alternatively, you may find pots which never go down to minimum ohms at all, because the mechanical design doesn't allow the slider to get there."

"I see," said Dick contemplatively. "Nevertheless, the calibration process with the voltmeter still sounds rather a long-winded process."

"Not really," stated Smithy. "Although you do need to be rather conscientious near the ends of the pot travel. In between, you have merely to pick out the whole numbers for the 0–10 scale, or the tens for the 0–100 scale. The divisions in between can be added later."

"What sort of pot would you advise?"

"Wirewound pots should be the best," said Smithy, "and the larger they are in physical size the better. The tracks of carbon pots would be too liable to become worn and to change in value. You should be able to get quite a high degree of resolution from a good wirewound component, this probably being good enough to enable you to use a scale diameter of some six to eight inches in the finished unit." (Fig. 8)

Using Four Potentiometers

Dick absorbed this information.

"Well, I never thought," he commented after a moment's thought, "that we would be in the computer business! Are there any other versions of the design?"

"Not with three pots," replied Smithy, scribbling a further circuit on the paper. "But you can go on to four pots if you like. (Fig. 9). In this case R_1 and R_2 are balanced by R_3 and R_4. R_3 carries out the same functions as R_2, and R_4 the same function as R_1. If the scale numbers given by R_1, R_2, R_3 and R_4 are A, B, C and D respectively, than $A \times B = C \times D$. Which gives you quite a few equations including,

$$A = \frac{C \times D}{B}$$

$$\frac{A \times B}{C} = D,$$

$$\text{and} \quad \frac{A}{C} = \frac{D}{B}$$

As you can see, much harmless and instructive fun may be obtained!"

Dick picked up Smithy's pen.

"How about adding a third pot after R_2," he asked, "like this? (Fig. 10). This would give you $A \times B \times C = D$. If you kept R_1, R_2 and R_3 in step, you could also find cube roots for D."

"That's quite a feasible idea," commented Smithy, "provided you remember that the circuit has one short-coming. Previously, R_2 presented a constant resistance to R_3, and we could allow for this in the calibration. Now, however, the resistance presented by R_2 to R_1 will vary according to the position of the R_2 slider. You could partly overcome this snag by giving R_3 a value very much higher than R_2, so that the error introduced is not too great. Alternatively, you could go back to the d.c. power supply and isolate R_3 by an emitter-follower or something like that. But this is, I feel, rather more complicated than the simple nature of the basic device warrants."

"The basic idea certainly *is* simple," said Dick enthusiastically,

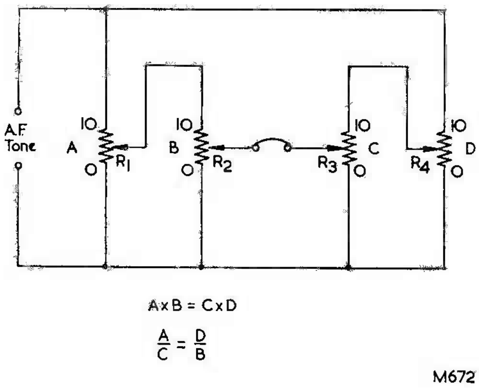


Fig. 9. A fourth potentiometer, R_4, causes the basic computer circuit to solve the equations shown

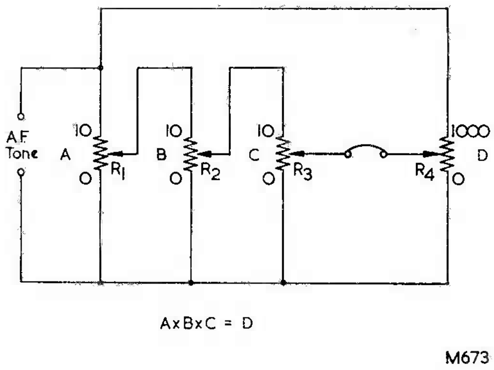


Fig. 10. A third potentiometer following R_3 allows the equation shown to be solved. It will be noted that the R_4 scale has to be calibrated from 0 to 1,000 to correspond with the 0–10 scales of R_1, R_2 and R_3. This circuit has a basic disadvantage which is discussed in the text

"and I think that my next job in order will be to knock up the three-potentiometer job using the headphones."

"As you like," commented Smithy, "and let's hope it keeps you quiet for the rest of the day! Before concluding on these simple computers I should add, by the way, that the subject has been dealt with before, and that I have myself encountered it in an article in a magazine published in Brazil*. According to this article, circuits similar to the three-potentiometer arrangements we've discussed here are used in computers produced commercially in the United States by Edmund Scientific Company, New Jersey, and by General-Electric."

* Julian M. Sienkiewicz, "Introducao Aos Computadores Analogicos", *Electronica Popular*, October 1962.

Back in Production

But Smithy was talking to the empty air. Dick had already started to investigate the spares cupboard in search of suitable potentiometers.

Glancing round, Smithy suddenly caught sight of Dick's multi-coloured placard. He surreptitiously picked this up and took it away, hiding it safely out of sight behind one of the racks. He went back to his bench and restored its equilibrium by re-inserting the log tables under its front left leg. Finally, and with the air of one who, by his cunning, has gained at least two hours respite, he resumed his paperwork.

For a moment, however, his concentration was disturbed by an elusive doubt which hovered around the back of his mind. Just who, out of the two of them, really *was* the guv'nor in the Workshop? Frowning, Smithy dismissed the thought and bent forward over his work. There was no point in wasting time over a question as obvious as that!

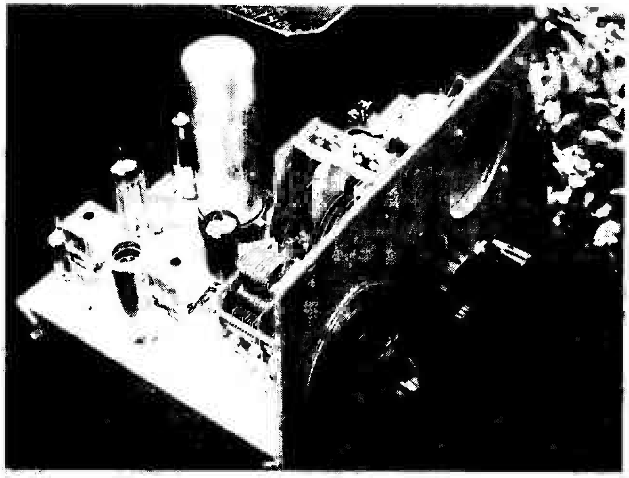
Improvement in the carrier frequency stability of the BBC's 200 kc/s transmission

In 1945 the BBC inaugurated high-precision frequency control of its 200 kc/s transmission of the Light Programme from Droitwich. The long-term frequency stability, which was then within 1 part in 10^7, has now been considerably improved and is maintained within 5 parts in 10^9. The diurnal rate of frequency change of the 200 kc/s frequency is not greater than $+1$ part in 10^{10} and the resultant error will be corrected on the first Sunday in each calendar month starting on 3rd February, 1963.

The availability of this transmission will be increased to 20½ hours each weekday during 1963 with the planned extension of the Light Programme transmission hours. It is hoped that users of the 200 kc/s transmission for frequency standardising and allied purposes will benefit by this extended availability and the enhanced frequency stability now provided.

Details of the frequency deviations may be obtained on a monthly basis on application to the National Physical Laboratory, Teddington, Middlesex, where daily frequency comparisons are made between the BBC's 200 kc/s transmission and the Laboratory's Caesium frequency standard.

The new carrier frequency generators at Droitwich employ Essen type quartz rings operating at a nominal frequency of 100 kc/s. These quartz rings were provided by the British Post Office and operate in equipment supplied by Messrs. Airmec Ltd. of High Wycombe to a British Post Office design. The apparatus is housed in a specially designed screened building at Droitwich to obviate disturbance due to mechanical and electrical interference.



Compact Bandspread Superhet

By **F. G. RAYER**

THIS RECEIVER COVERS APPROXIMATELY 15–50m, 70–230m and 190–550m, thus including most short wave bands as well as medium waves. The 80m and 160m amateur bands are sometimes of particular interest but are often omitted from the tuning range of many receivers. Bandspread tuning is provided, and is very useful on the short wave ranges. Fig. 1 shows the circuit, in which the 500pF 2-gang capacitor C_5 C_{10} is used for band-setting. The full 180 degrees rotation of the 25pF bandspread capacitor covers a narrow band of frequencies, simplifying tuning, and allowing accurate logging.

For simplicity, Fig. 1 shows only one aerial coil and one oscillator coil. Three sets of coils are actually employed. As an aid to maximum efficiency, a panel aerial trimmer, C_3, is fitted, and this is adjusted for best results when receiving weak signals, assuring that there is no loss of performance due to misalignment between aerial and oscillator circuits. It also reduces the number of pre-set trimmers which would otherwise be required. A small capacitor, C_1, is included in the aerial circuit so that this can be tuned sharply, and to help reduce 2nd channel interference which can be troublesome on high frequencies.

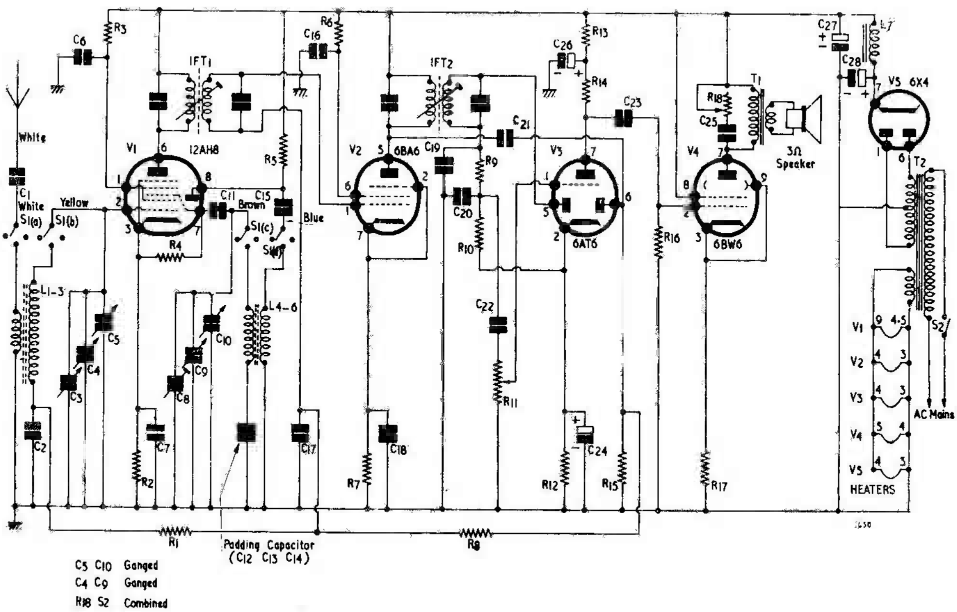


Fig. 1. The circuit of the receiver for one waveband only. Full coil switching is given in Fig. 2

The small speaker provides reception on all bands, and the 6BW6 bias resistor is 330Ω as the full output from this valve is not required. If a larger separate speaker is used, R_{17} can be reduced to 240Ω, and a 25μF 25 w.v. capacitor shunted across it. The small speaker was found to be very satisfactory in practise.

Reception is fully up to 4-valve (plus rectifier) superhet standard on all bands, while the bandspread control and panel trimmer contribute to ease of operation and full efficiency.

Coil Pack

This was made separately, and the circuit is shown in Fig. 2. Coloured leads pass from the switch to identify connections, and the pack is made and wired complete before being fitted to the chassis. The grid coils connect to the a.g.c.

Components List

Resistors

All 20% ¼ watt unless otherwise stated.

- R_1 100kΩ
- R_2 220Ω
- R_3 33kΩ ½W
- R_4 47kΩ
- R_5 27kΩ ½W
- R_6 33kΩ ½W
- R_7 68Ω
- R_8 1.8MΩ
- R_9 33kΩ
- R_{10} 270kΩ
- R_{11} 1MΩ pot, log track
- R_{12} 3kΩ
- R_{13} 33kΩ
- R_{14} 220kΩ
- R_{15} 1.8MΩ
- R_{16} 470kΩ
- R_{17} 330Ω ½W
- R_{18} 50kΩ pot, linear track, with on-off switch

Transformers

- T_1 50:1 mains pentode output transformer
- T_2 Mains transformer. Secondaries: 250-0-250V at 60mA, 6.3V at 2A. Osmor Radio

Switches

- S_1 4-pole, 3-way, miniature
- S_2 On-off, combined with R_{18}

Valveholders

2 B9A valveholders
3 B7G valveholders

Speaker

3½in, 3Ω

Chassis

Universal chassis 9 × 7 × 2 in. Home Radio (Mitcham)

Miscellaneous

Front panel
Epicyclic drive
Knobs, including Bulgin dial type K402/406/412
Aerial terminal or socket
Wire, etc., etc.

Capacitors

- C_1 25pF
- C_2 0.1μF
- C_3 30pF panel trimmer or midget tuning capacitor
- C_4, C_9 25pF two-gang, bandspread (see text)
- C_5, C_{10} 500pF two-gang, bandset
- C_6 0.05μF
- C_7 0.05μF
- C_8 30pF air-spaced trimmer, Philips concentric
- C_{11} 50pF
- C_{12} 4,500pF padder
- C_{13} 2,500pF padder
- C_{14} 470pF padder
- C_{15} 100pF
- C_{16} 0.05μF
- C_{17} 0.1μF
- C_{18} 0.05μF
- C_{19} 100pF
- C_{20} 100pF
- C_{21} 30pF
- C_{22} 0.01μF
- C_{23} 0.01μF
- C_{24} 25μF, 12 w.v., electrolytic
- C_{25} 0.02μF
- C_{26}, C_{27}, C_{28} 8+8+8μF, 275 w.v. electrolytic, (see text)

Coils

All coils and choke are Osmor Radio types

- L_1 QA2
- L_2 QA4
- L_3 QA8
- L_4 QO2
- L_5 QO4
- L_6 QO8
- L_7 60mA smoothing choke
- I.F.T.1, I.F.T.2 } Pair 470 kc/s i.f. transformers Valve type—square section cans

Valves

- V_1 12AH8
- V_2 6BA6
- V_3 6AT6
- V_4 6BW6
- V_5 6X4

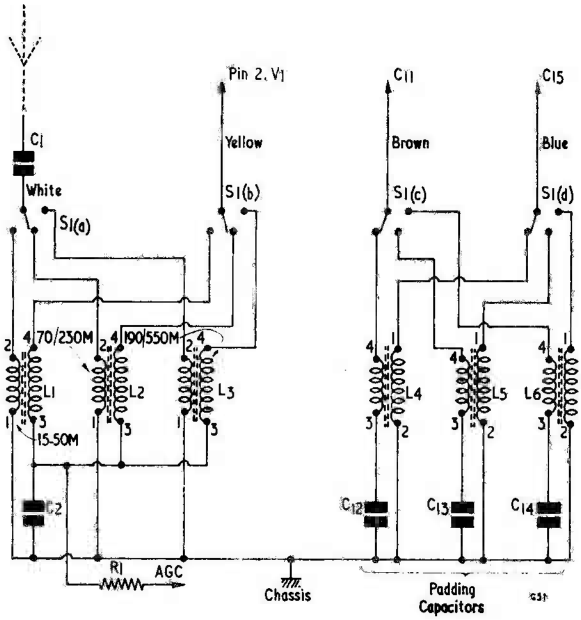


Fig. 2. The coil pack circuit

line via R_1 as it was decided to apply a.g.c. to the 12AH8 on all bands.

Padders should be of the values shown to avoid ganging difficulties. The coils employed, together with their colour coding, and required padder values, are as follows:

Coil pack wiring appears in Fig. 3, the rotary switch being shown removed from the front flange so that tag connections are visible. The coil pack is constructed on a piece of aluminium 3 x $3\frac{3}{4}$in, one edge being bent up to form a $1\frac{1}{4}$in flange. This flange is centrally drilled for the switch.

Band	Aerial Coil	Oscillator Coil	Padder
15–50m	QA2. Blue foot, Yellow body	QO2. Red foot, Yellow body	4,500pF
70–230m	QA4. Blue foot, Black body	QO4. Red foot, Black body	2,500pF
190–550m	QA8. Blue foot, Brown body	QO8. Red foot, Brown body	470pF

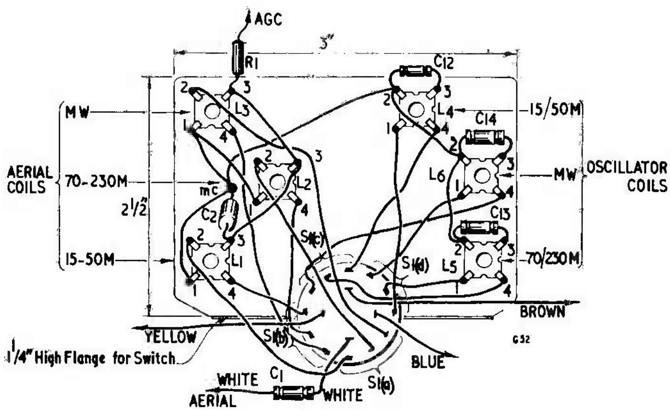


Fig. 3. Coil pack connections. Before commencing wiring, the switch should be set to its full clockwise or anti-clockwise position to ensure that inner and outer tags have the same relationship as that shown here

The coil clips require mounting holes as detailed in the accompanying leaflets, and all drilling is completed before mounting the switch or coils. Fig. 3 shows the positions of the coils, and orientation should be as indicated.

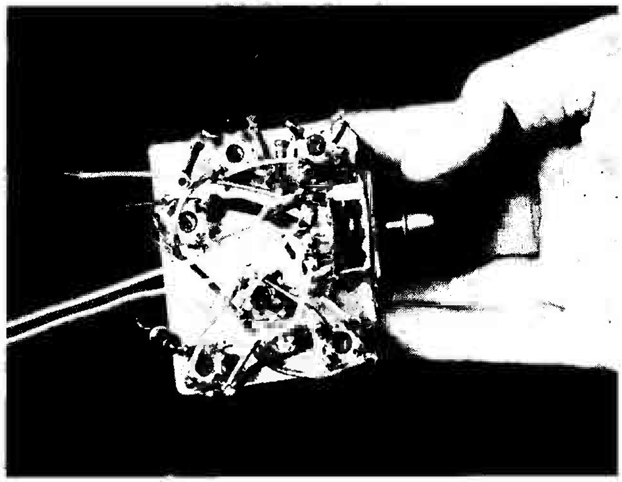
Wiring will be simplified, and the possibility of errors will be reduced if wire of a particular colour is used for each circuit. For example, white may be employed for the aerial capacitor lead and the primary circuits of the aerial coils. In the same way, yellow, brown and blue may be used to identify the other circuits, as shown.

The 15–50m coils are inserted first, the leads to these being short and direct. The 70–230m coils may then be added and, finally, the medium waveband coils. Chassis return leads should be short, especially for the 15–50m coils.

Leads may be soldered to the switch before it is mounted, and these can afterwards be cut to appropriate length and taken to the coil tags.

Receiver Chassis

The receiver chassis is 7 x 9in with 2in runners, and the panel is 9 x 6½in. Fig. 4 shows the layout of components above the chassis. All holes should be made before mounting components, to avoid damage and trouble due to metal fragments.



The completed coil pack

Valveholders are fitted so that their tags take of the positions illustrated in Fig. 5. The 12AH8 and 6BW6 holders are 9-pin, with 7-pin holders for the 6BA6, 6AT6 and 6X4.

Clearance holes are needed for the i.f. transformer tags so that they cannot touch the chassis. Insulated

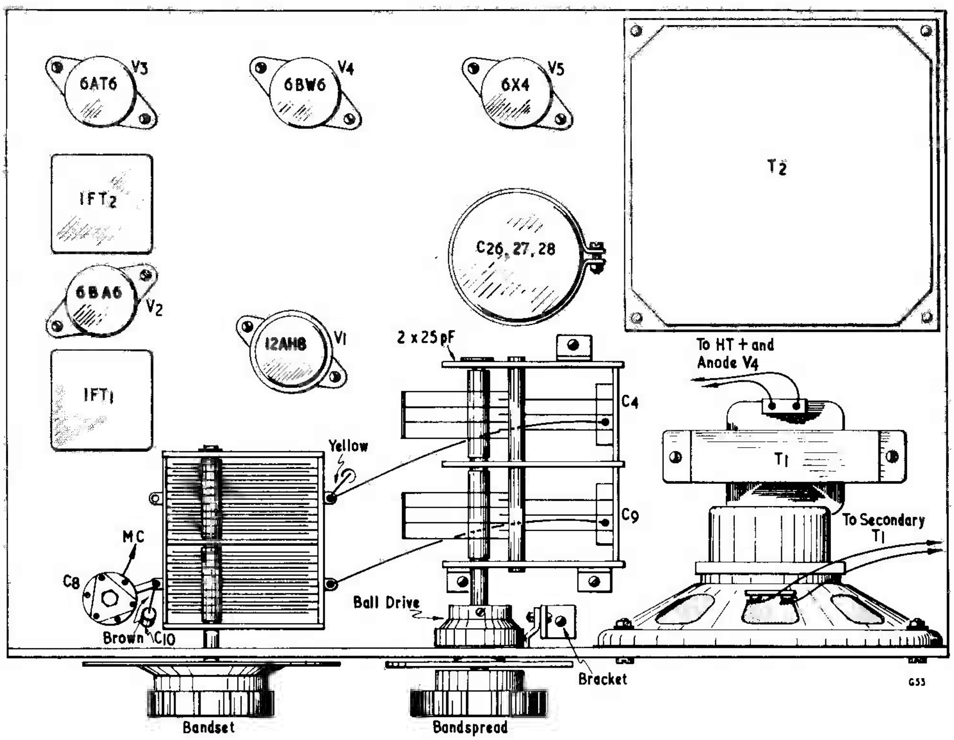


Fig. 4. The components above the chassis

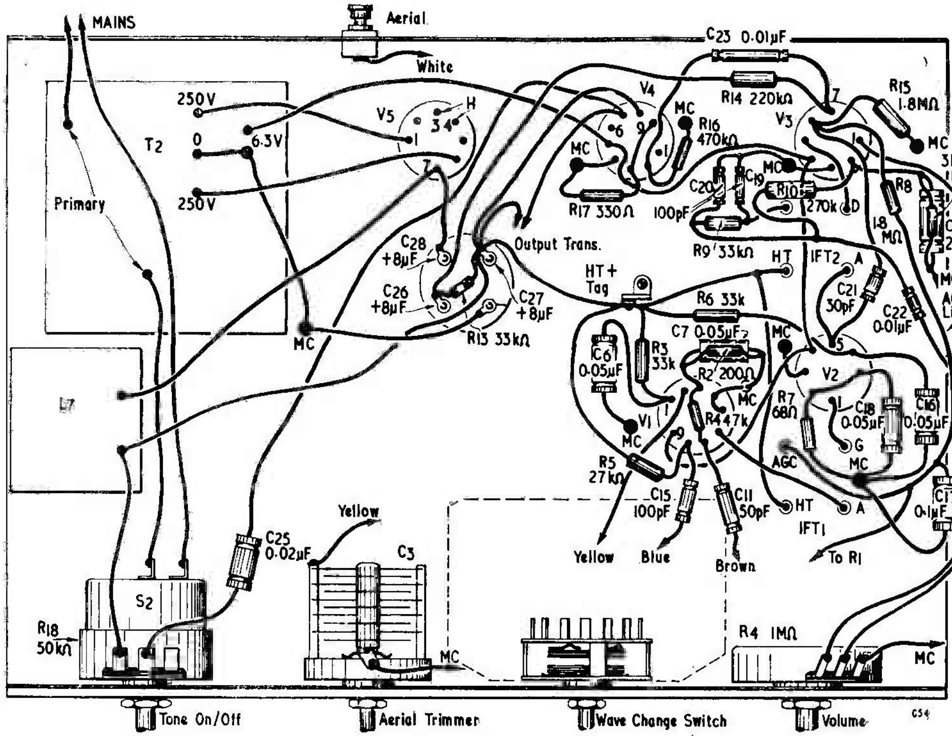


Fig. 5. The underside of the chassis

sleeving is also slipped over these tags. Each i.f. transformer requires two fixing holes for short 6BA bolts, and a central ¼in hole to allow adjustment of the core from below.

The 2-gang 500pF capacitor is mounted near the panel, and has no reduction drive. A Bulgin dial is fitted directly to its spindle, to allow band-setting against a mark on the panel.

The 2-gang bandspreading capacitor used in the prototype is a surplus component, and is fitted in such a position as to allow the epicyclic drive to be accommodated. The lug of this drive is bolted to a bracket fixed to the chassis. A 2-gang capacitor with a maximum capacity of about 15pF to 30pF or so is suitable. Separate miniature short wave tuning capacitors, ganged with a coupler, would also be satisfactory.

The corresponding sections of the variable capacitors are in parallel, leads being short and direct and clear of the chassis. The 30pF trimmer C_8 is soldered to C_{10} as in Fig. 4. C_5 C_{10} is bolted to the chassis, and a tag is secured underneath by one of the fixing bolts. A short lead goes directly from this tag to the chassis return tag of the coil pack, so that the circuit path from the 15m coil to the gang capacitor frame is as short as possible.

The speaker is best left out until the rest of the construction has been completed. The actual type of mains transformer used is of little importance. For smoothing, a capacitor with three 8µF sections was employed, but separate capacitors of 8 or 16µF are quite in order.

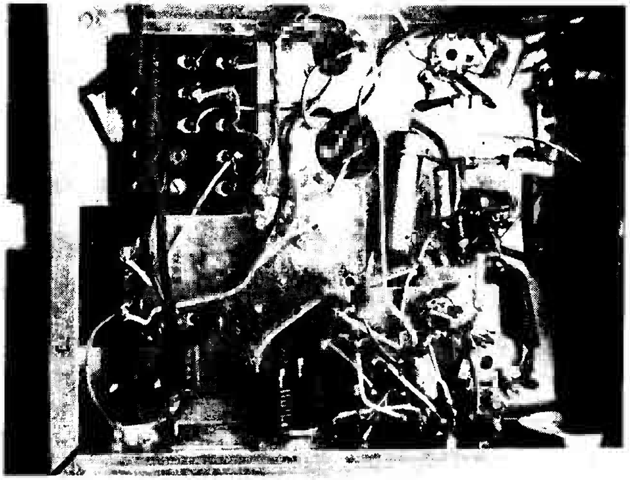
Underneath the Chassis

Most of the wiring is completed before inserting the coil pack. See Fig. 5. Heater leads are kept near the chassis. All leads, and the wire ends of resistors and capacitors, are covered with sleeving. Wiring points are more easily reached if the chassis has removable sides, as with the particular chassis listed. The sides may then be added later.

All heaters are in parallel, including that of the 6X4. Some mains transformers have a separate rectifier heater winding. If such a winding is present, it can be used for the rectifier.

An insulated tag forms a connecting point for several components, in the h.t. positive circuit. Some valveholders may have central metal spigots; if so, these are wired to chassis. Volume control leads run closely against the side chassis member, clear of other wiring and components.

The main lead is of good quality flex, and passes through a rubber grommet in the rear of the chassis. If a 3-pin mains plug can be used this is preferable. A 3-core flexible cord can then be fitted so that the receiver chassis can be earthed to the appropriate pin of the plug via the green conductor. An insulated terminal or socket is used for the aerial.



Below-chassis view of the completed receiver

When other wiring is finished, the coil pack is inserted, and held by the switch nut. The leads from the pack can then be connected—yellow to pin 2 of the 12AH8 and fixed plates of the variable capacitors; white via C_1 to the aerial socket; brown to C_{11} and C_{10} as in Figs. 4 and 5; and blue to C_{15} as in Fig. 5.

Circuit Alignment

This is simplified to some extent by the presence of the panel trimmer. If a signal generator is available, the i.f. transformers can be adjusted to 470 kc/s. If no generator is to hand, tune in a medium wave station, and adjust the i.f. cores for best results. If adjustments are made by ear, keep the volume control near maximum but reduce volume by choosing weak stations or using a very short aerial. The i.f. cores should then be found to peak up sharply.

All adjustments should be with an insulated tool, such as a plastic knitting needle shaped to engage with the cores. The receiver can be placed on its side so that the cores can be adjusted from both below and above, as two are present in each i.f. transformer. No core should be at the limit of its travel in either direction. When the four cores have been positioned for maximum possible sensitivity, do not touch them again.

To align the coils, deal with each band separately. C_8 is at first set at about half capacity. A station is then found with C_5 C_{10} nearly closed, and the aerial coil core for the band selected is adjusted for best results. A station is then tuned in with the gang capacitor nearly open, and it should be found that the panel trimmer C_3 can be peaked sharply for best results. If not, readjust C_8.

It should be noted that best results will always be obtained, even if alignment is slightly in error, *if maximum sensitivity is within the range of the panel trimmer.* When alignment is at its best, frequent adjustment of the panel trimmer should not be required. The positions of the coil cores have most influence at the high wavelength (low frequency) ends of the bands—that is, with the bandset gang capacitor nearly closed. This allows some adjustment of coverage.

It should be quite easy to reach settings which will enable the panel trimmer to be adjusted for best results throughout all bands. For general reception, little adjustment of the panel trimmer will be required. With weak signals, and to allow maximum performance with any aerial, it is adjusted for best results.

As a guide, the following bandset dial readings were obtained. These will naturally differ somewhat with other receivers and were given with the bandspread capacitor adjusted to approximately half capacity. The bandset capacitor had a 0-100 dial.

Band 1. 19m—0. 20m—7. 25m—28. 30m—40. 35m—52. 40m—64. 45m—75.

Band 2. 80m—15. 100m—33. 120m—48. 140m—62. 160m—70. 180m—80. 200m—85.

Band 3. 200m—0. 250m—20. 300m—36. 350m—50. 400m—62. 450m—73. 500m—84. 550m—95.

When the bandset reading for a particular short waveband has been found, tuning is carried out with the bandspread capacitor. In effect, each waveband is thus broken up into a number of much smaller bands.

New TV and VHF sound station to serve Pembrokeshire

The BBC recently placed contracts with Phelps & Owens Ltd. of Milford Haven for the construction of the building and with British Insulated Callender's Construction Co. Ltd. for the design, supply and erection of a 500ft aerial mast for the new television and VHF sound broadcasting station which is to be built at Woodstock Slop, some seven miles north-east of Haverfordwest, Pembrokeshire.

This new station, which it is expected will be completed in the autumn of this year, is one of several the BBC is building to extend and improve the coverage of its television and VHF sound services. It will serve some 40,000 additional people and provide improved reception for a further 40,000 people in Pembrokeshire.

Simple
Echo Chamber

By PETER F. BRETHERICK

ONE OF THE MODERN EFFECTS USED BY RECORDING organisations is the addition of echo, and it plays a major part in the recording of "pop" records today. The echo effect is introduced by the use of what is called an "echo chamber" and, although its name implies that it is a large hollow container, it can in practice be a small electric device which is sometimes no bigger than a shoe-box.

It may be thought by the reader that the echo effect would require either a colossal concrete funnel or a complex tape mechanism which would be too complicated and too expensive for the average constructor. The unit about to be described has none of these disadvantages. It can be employed with almost any type of microphone or electric guitar and quite amusing results can be obtained when it is used with a radio tuner.

Basically, the unit consists of a high gain amplifier with a power output of some 3 to 4 watts (which is in excess of that necessary), together with an echo coil and a pick-up. The amplifier drives a small loudspeaker to which the echo coil is coupled. The audio signal from the loudspeaker travels down the coil and, after a delay in time, reaches the other end where it is detected by the pick-up and fed, together with the normal signal from the output of the echo amplifier, to the main amplifier. Thus, the main amplifier which, in the case of a guitar, would be the guitar amplifier, receives the normal signal and the echo signal via one lead. See Fig. 1.

The Echo Amplifier

The echo amplifier, the circuit of which is shown in Fig. 2, consists of a directly coupled triode-pentode valve, ECL82, fed from an EF86 high gain voltage amplifying pentode. Any other suitable amplifier could, of course, be used, provided that it has a high gain and adequate power output. It should be noted that excessive output power would result in distortion from the small speaker employed, and would also tend to make the echo coil jump about somewhat.

The amplifier is designed primarily for simplicity and low hum level. Consequently, all component values are critical and all input connections must be screened. The h.t. supply must be provided by a double-wound mains transformer as, quite apart from safety reasons, the unit will be used in conjunction with a high power amplifier whose chassis is almost sure to be earthed. The 10-watt resistor, R_9, should be kept reasonably clear of the other components due to its dissipated heat which, although not excessive, is quite considerable. The layout is not critical, except that all leads should be as short as possible and heater leads tightly twisted and kept close to the chassis. An 18 s.w.g. aluminium chassis approximately 8 x 6 x 2½in will be found suitable.

The circuit should need little explanation, the only unusual thing being the relatively low values of the coupling capacitor C_3, and the bass cut capacitor, C_1, in the guitar input channel. The aim of both these components is to cut the bass frequencies as much as possible, in order to compensate for the loss of treble in the echo coil.[1]

The Echo Coil

Initially, the reader may have visions of this coil consisting of yards of wire draped all around the room. However, if it is wound carefully and suspended properly, it should stretch out to no more than 24 inches.

[1] C_6, in conjunction with VR_3, forms a bass boost control. Whilst it may seem rather surprising to boost the bass after it has been cut, the circuit is, in practice, more straightforward than other forms of tone control.

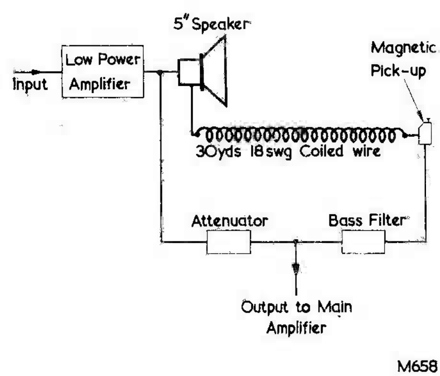


Fig. 1. The basic principles of the echo unit

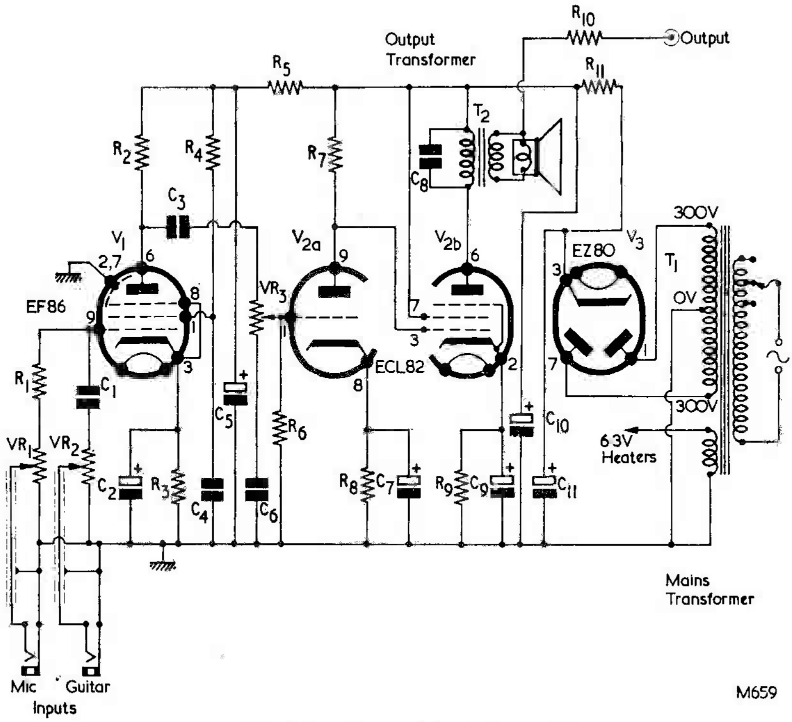


Fig. 2. The circuit of the echo amplifier

Components List
(Fig. 2)

Resistors

R_1 100kΩ ¼ watt 20%
R_2 100kΩ ¼ watt, Hi-Stab
R_3 2.2kΩ ¼ watt, Hi-Stab
R_4 390kΩ ¼ watt, Hi-Stab
R_5 100kΩ ¼ watt, 20%
R_6 1MΩ ¼ watt, 20%
R_7 470kΩ ¼ watt, 20%
R_8 2.2kΩ ¼ watt, 5%
R_9 2.7kΩ 10 watt, 5%
R_{10} 1MΩ ¼ watt, 20%
R_{11} 470Ω 1 watt, 20%
VR_1 1MΩ log
VR_2 1MΩ log
VR_3 1MΩ log

Capacitors

C_1 0.005μF, 350 w.v.
C_2 50μF, electrolytic, 12 w.v.
C_3 0.01μF, 350 w.v.
C_4 0.25μF, 350 w.v.
C_5 16μF, electrolytic, 350 w.v.
C_6 400pF, 350 w.v.
C_7 50μF, electrolytic, 12 w.v.
C_8 0.01μF, 350 w.v.
C_9 16μF, electrolytic, 150 w.v.
C_{10} 32μF, electrolytic, 350 w.v.
C_{11} 32μF, electrolytic, 350 w.v.

Valves

V_1 EF86
V_2 ECL82
V_3 EZ80 or EZ81

Miscellaneous

T_1 Primary to suit mains voltage.
Sec: 300–0–300V 60mA, 6.3V 2A.
T_2 55:1 for 3Ω speaker
B9A valveholders (3), chassis
8 x 6 x 2½in, 5in speaker (see text)

18 s.w.g. galvanised iron wire was found to be the best and the cheapest material for the coil, and this is obtainable from most hardware merchants in 50-yard coils for a few pence. Copper wire, which would need only two-thirds the length to produce the same time-lag of echo, was found to be very flimsy and needed more support; it was also considerably more expensive.

The coil should be wound on a 1in diameter former, e.g. a broom-stick, using about 30 yards of the wire. It must be carefully wound, each turn touching its predecessor. When the finished coil, which should take about 30 minutes to wind, is carefully pulled off the former, it should stretch

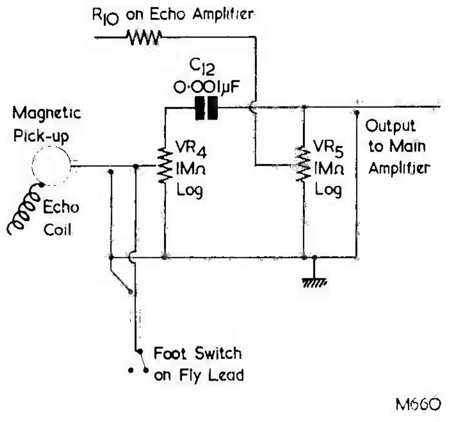


Fig. 3. The output mixing controls

Components List

(Fig. 3)

Potentiometers
VR_4 1MΩ Log
VR_5 1MΩ Log

Capacitor
C_{12} 0.001µF, 350 w.v.

Pick-Up
Magnetic (see text)

Switch
Foot-switch. Open when depressed

a maximum of 36 inches when held vertically and no turns should be touching. The 1in diameter former was used as it gave the best result for length and needed little support.

The Pick-Up

The most effective detection device was found to be a magnetic pick-up of the type found in old 78 r.p.m. record players and which are readily obtainable on the surplus market, if not already to hand. The end of the coil should neatly clamp in the needle socket in the pick-up.

A headphone could be used as a magnetic microphone, having its diaphragm drilled and the end of the coil pushed through and bent over. The only drawback to this is that acoustic feedback occurs if the volume is turned too high. There is, of course, no reason why a crystal pick-up should not be used, provided the reader can devise a method of connecting the end of the coil to it. Whichever method is used, the impedance must be fairly high; if a low impedance pick-up is used, a matching transformer must be employed.

The Output Controls

Fig. 3 shows how the echo and the main signal are mixed. Tone compensation for the echo output is again provided by means of the 0.001µF capacitor. A foot switch is provided to turn the echo on or off, as required. Except, of course, for the pick-up, foot-switch and output lead, the components shown in Fig. 3 should be mounted on the same chassis as the amplifier. There should now be five controls on the amplifier, giving a wide variety of effects.[2]

Assembly

The choice of case is left to the constructor, but it was found that a cabinet 24 x 8 x 7in successfully housed everything. The amplifier and speaker should be mounted at one end of the cabinet and the pick-up at the other. The speaker should be chosen with care, for it must have a tough cone. The free end of the coil, i.e. the opposite end to the pick-up, should now be carefully pushed through the cone and bent in a right angle behind it. The coil should be supported where necessary by means of elastic held by drawing pins at the top and bottom of the cabinet. If the coil is too long for the cabinet it may be doubled back. See Fig. 4.

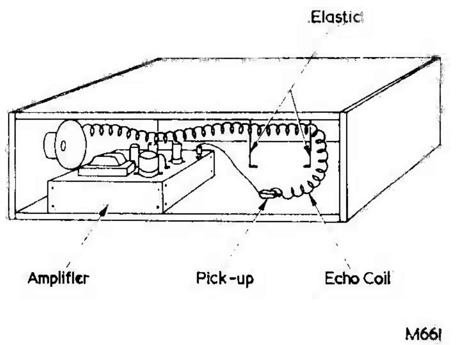
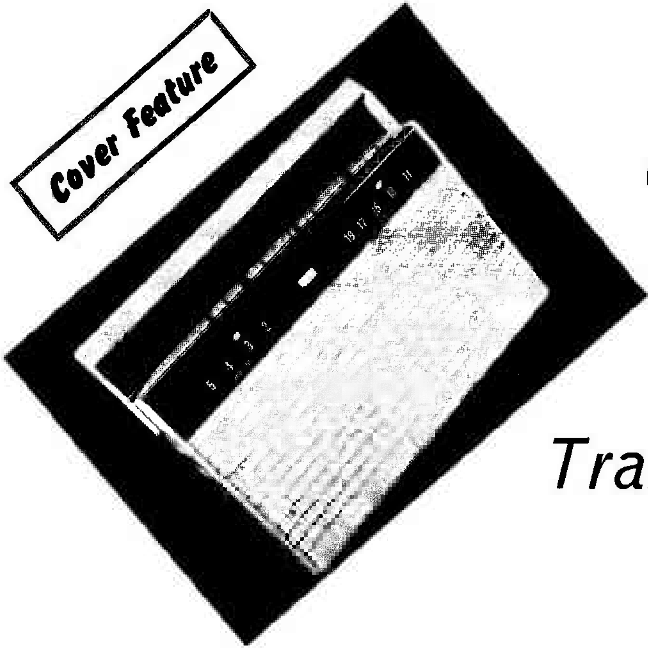


Fig. 4. Internal layout of the "echo chamber"

Finally

Should the echo produced be very distorted, the coil should be checked to see if any turns are touching or whether the coil touches the sides of the cabinet. If it is touched or gently flicked with the main amplifier switched on, a loud clang should result from the main amplifier. If this does not happen, check that the pick-up is working and that the associated connections are correct; also make sure that the foot switch is not in the closed position.

[2] It will be noted that, as with VR_1 and VR_2 of Fig. 2, the inputs to the potentiometers in Fig. 3 are applied to the sliders instead of across the tracks, as is more usual. This method of connection ensures that one level is not unduly affected by adjustments in the other potentiometer.



The "COROVER SIX" Transistor Receiver

Described by **E. GOVIER**

The "Corover Six" receiver represents an ideal constructional project for those readers requiring a portable radio for the coming summer months. Operating over both the medium and long wavebands, provision is made for use as a car radio; additionally a socket for personal earphone listening or tape recording work is fitted

THE "COROVER SIX" TRANSISTOR RECEIVER, ABOUT to be described, is one of the latest designs to be placed on the home constructor market. It is a six transistor battery operated superhet fully covering both the medium and long wavebands. The design incorporates the latest techniques and components, alloy diffused transistors being used to provide greater gain and sensitivity than has hitherto been possible in home constructor designs. The latest type of fixed capacitor (see Fig. 5) has also been incorporated. An internal ferrite rod aerial is employed on both wavebands, and external aerial and earth sockets are provided for use when the receiver is operated in a car.

As may be seen from the cover illustration, the moulded plastic case is complete with a carrying handle, and that shown has a pleasing two-tone colour scheme of light green and dark blue. A combined on/off and waveband selector switch is situated in the centre of the cabinet between the dial scales, whilst the volume and tuning controls are recessed into the right hand side. The carrying handle is removable as, also, is the back of the cabinet, thus allowing easy access to the circuit when required. The cabinet dimensions are 4in high by $6\frac{3}{4}$in wide and $1\frac{1}{2}$in deep, and the weight complete with batteries is some $1\frac{1}{4}$lb. The batteries used are four Ever-Ready Penlight cells type U7 or U12, or equivalents.

The frequency coverage is as follows; medium wave 187 to 570 metres (1,600 to 525 kc/s) and long wave 1,100 to 1,940 metres (270 to 155 kc/s).

Circuit

The circuit is shown in Fig. 1, from which it will be seen that it employs six transistors and two diodes. The whole assembly is built on a printed circuit board. This latter component is supplied ready drilled and cleaned, and is complete with a layer of surface protecting fluid which permits easy soldering. (See under "Construction.")

The first stage is constructed around a Mullard AF117 transistor, TR_1, operating here as the mixer/oscillator. When $S_{1(a), (b)}$ is in the medium wave position, the ferrite rod winding L_1 is tuned by variable capacitor CV_1 and trimmer CT_2, the signal frequency being induced into winding L_4 and applied, via C_3, to the base of TR_1. On long waves, the combination L_2 and C_1, together with trimmer CT_1, are tuned by CV_1 and CT_2, the resultant signal being fed into the base of TR_1 via C_3. TR_1 operates as a self-oscillating mixer, the main oscillator winding being tuned on medium waves by CV_2 (ganged with CV_1) and trimmer CT_4. On long waves the oscillator winding is tuned by the foregoing capacitors plus the added capacitances given by C_6 and trimmer CT_3. The resultant i.f. (470 kc/s) appears across the secondary winding of IFT_1 and

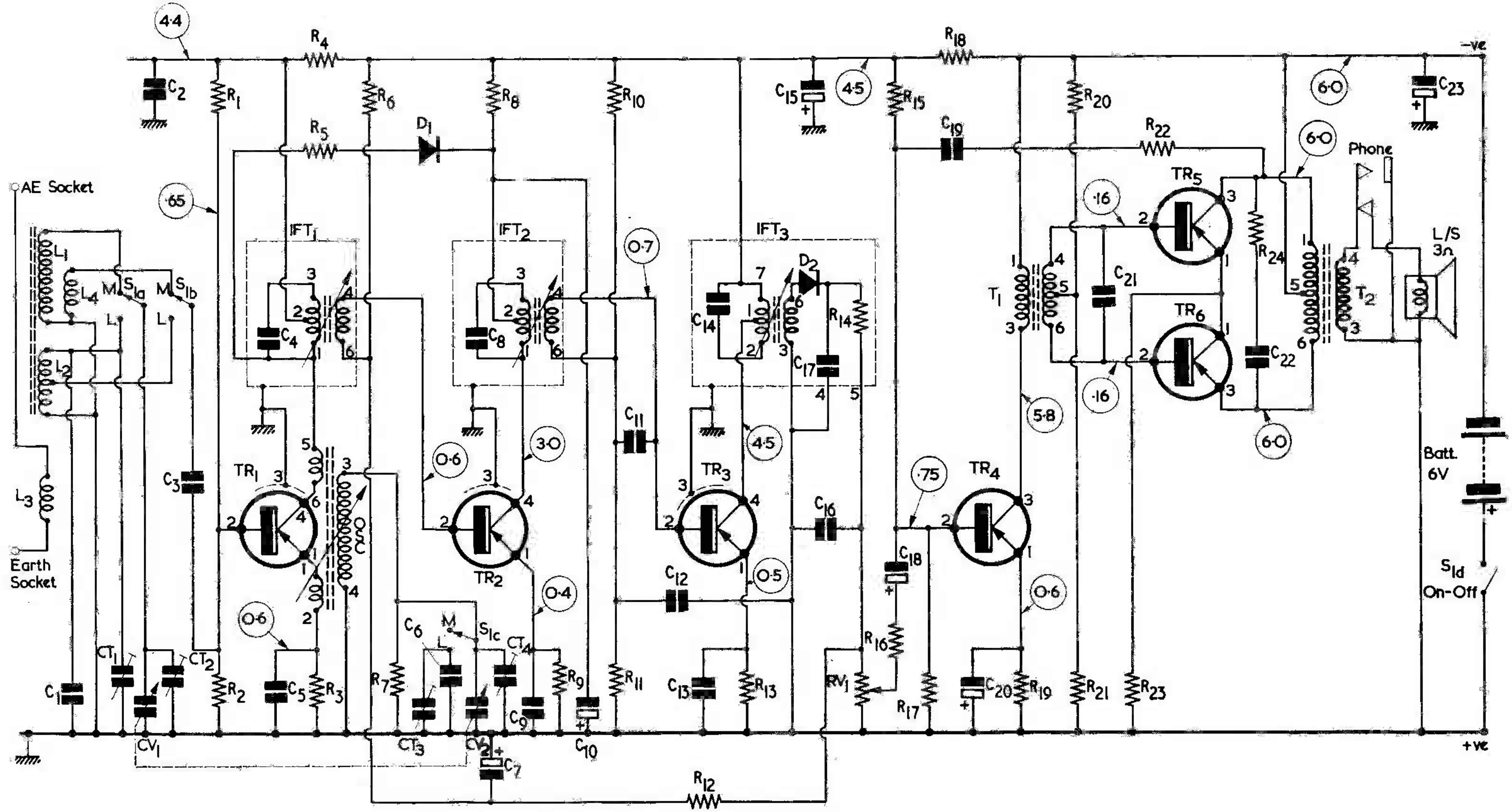


Fig. 1. Circuit of the "Corover Six" transistor receiver

Components List

Resistors (all ±10% ¼ watt)

R_1	33kΩ	R_{11}	3.3kΩ	R_{18}	470Ω
R_2	6.8kΩ	R_{12}	8.2kΩ	R_{19}	680Ω
R_3	560Ω	R_{13}	470Ω	R_{20}	2.7kΩ
R_4	100Ω	*R_{14}	330Ω	R_{21}	68Ω
R_5	1kΩ	R_{15}	15kΩ	R_{22}	330kΩ
R_6	33kΩ	R_{16}	2.7kΩ	R_{23}	4.7Ω
R_7	150kΩ	R_{17}	3.9kΩ	R_{24}	150Ω
R_8	1kΩ				
R_9	470Ω				
R_{10}	18kΩ				

Transistors

TR_1 AF117 (Mullard)
TR_2 AF117 (Mullard)
TR_3 AF117 (Mullard)
TR_4 OC81D (Mullard)
TR_5, TR_6 OC81 (Mullard)

Potentiometer

RV_1 Integral part of printed circuit board

Capacitors

C_1	40pF ±2.5pF, 125V wkg.
C_2	0.1μF ±10%, 30V wkg.
C_3	0.01μF ±10%, 30V wkg.
$*C_4$	250pF ±2½%, 125V wkg.
C_5	0.01μF ±10%, 30V wkg.
C_6	155pF ±2%, 125V wkg.
†C_7	10μF, 16V wkg.
$*C_8$	250pF ±2½%, 125V wkg.
C_9	0.1μF ±10% 30V wkg.
†C_{10}	2μF, 10V wkg.
C_{11}	3,900pF ±20%
C_{12}	0.047μF ±10%, 30V wkg.
C_{13}	0.047μF ±10%, 30V wkg.
$*C_{14}$	250pF ±2½%, 125V wkg.
†C_{15}	160μF 10V wkg.
C_{16}	0.047μF ±10%, 30V wkg.
$*C_{17}$	0.047μF ±10%, 30V wkg.
†C_{18}	5μF 2.5V wkg.
C_{19}	0.047μF ±10%, 30V wkg.
†C_{20}	125μF 25V wkg.
C_{21}	0.01μF ±10%, 30V wkg.
C_{22}	0.047μF ±10%, 30V wkg.
C_{23}	160μF, 10V wkg.
CV_1, CV_2	Tuning capacitors
CT_1	3–40pF trimmer
CT_3	0–25pF trimmer
CT_2, CT_4	Fitted to tuning capacitor

Diodes

D_1	OA79 (Mullard)
D_2	OA91 (Mullard)

All components are available from Lasky's Radio.

Inductors

L_1, L_2 L_3, L_4	On ferrite rod
IFT_1, IFT_2, IFT_3	470 kc/s
T_1	Driver transformer
T_2	Output transformer
Osc. coil	

Batteries

Four of Ever-Ready Penlight Type U7 or U12

Switches

$S_{1(a)}$, (b), (c) Integral part of printed circuit board

Miscellaneous

Printed circuit board
Cabinet
Speaker 3Ω
Audio Socket
Cord Drive Mechanism
Wire
Systoflex

* Integral part of i.f. transformers.

† Electrolytic capacitors.

is applied direct to the base of TR_2 (Mullard AF117). Applied to the base of TR_2, via the secondary winding of IFT_1, is the a.g.c. voltage obtained from the detector load RV_1 and decoupled by R_{12} and C_7. A standing negative bias voltage for TR_2 is provided by the potentiometer network R_6, R_{12}, RV_1. As signal strength increases, the voltage at the junction of RV_1 and R_{12} goes positive, causing TR_2 to receive a lower bias and to reduce gain accordingly. In consequence, an a.g.c. loop is set up. On reception of a very strong signal, the reduced bias on TR_2 causes its collector to go sufficiently negative for diode D_1 to conduct, whereupon the latter, in combination with R_5, damps the primary of IFT_1 and further reduces gain. As may be noted, the addition of D_1 and R_5 to the circuit results in an a.g.c. system which can handle a very wide range of signal voltage amplitudes.

The amplified i.f. signal from TR_2 is fed, via IFT_2 to the base of TR_3 (Mullard AF117). The signal appearing across the secondary of IFT_3 is then rectified by D_2 and passed to the volume control RV_1. It will be noted that, by using alloy diffused transistors in the i.f. amplifier, it has been possible to obviate neutralising components. This feature results in a significant reduction in circuit complication as well as in cost.

Audio voltage at the required level is next taken from the slider of RV_1, via capacitor C_{18}, to the base of TR_4 (Mullard OC81D), the driver transistor. The audio signal is now applied via T_1, the driver transformer, to the respective bases of TR_5 and TR_6 (Mullard OC81's) operating in push-pull. The resultant audio output is fed to the speaker via the output transformer T_2, the headphone jack being included in the secondary winding of this transformer. Insertion of the jack into the socket automatically mutes the speaker.

Diode D_1 is a Mullard OA79 whilst D_2 is a Mullard OA91. The speaker is a 3in circular unit having a high flux density and an impedance of 3Ω. The sound output is 330mW. The L_3 winding on the ferrite rod is used for the car aerial input, if required. Switch $S_{1(d)}$ is ganged with RV_1.

The voltages shown ringed in Fig. 1 are approximate, and were measured under no signal conditions on the medium waveband.

All components shown within the dotted lines representing the i.f. cans are, in fact, included within these components as received.

Construction—Practical Hints

When dealing with transistors, the wire lead-outs should not be bent at a point less than 1.5mm from the seal. When soldering these components into circuit, a heat shunt should be used.

A base or emitter circuit component should never be disconnected or shunted by a low resistance, e.g. by using a milliameter, with the receiver operating. When making current measurements first switch off the receiver then break the circuit at the point where the reading is required. Insert the milliameter, switch on the receiver and read the

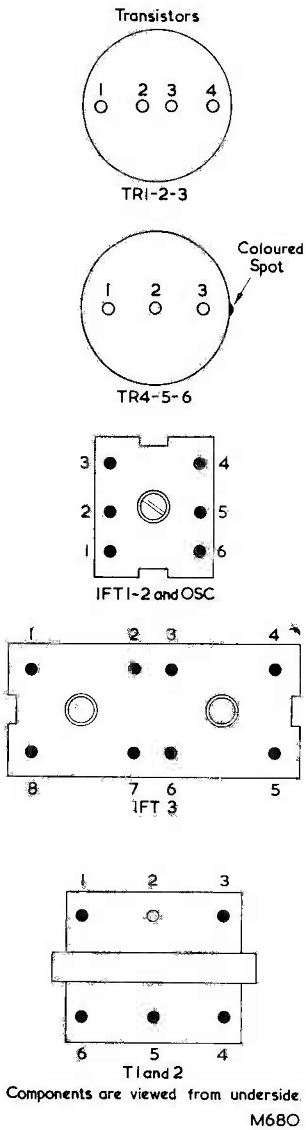


Fig. 2. Base connections of the i.f. transformers, driver and output transformers, oscillator coil and transistors. All components are viewed from the underside

current from the meter, then switch off and re-connect the circuit.

The use of ohmmeters on ranges which incorporate batteries having a voltage greater than 1.5 is another pitfall to be avoided. When mains or battery operated test instruments are to be employed, connect them to the circuit via an isolating capacitor. Precautions should also be taken when earthing instruments—especially when two such instruments are used in conjunction with each other.

The polarity of the h.t. supply should never be reversed.

When dealing with the printed circuit board, it is possible that blistering will take place if heat is applied for too long a period. Since this blistering can lead to breaks in the printed circuit care should be taken, when soldering components, not to prolong the application of the soldering iron unduly. Ideally, a low temperature iron having a small bit should be used. 60/40 resin cored solder must, of course, be employed.

Assembly Instructions

All components are mounted on top of the printed circuit board. Fig. 2 shows the base connections for the i.f. transformers, the oscillator transformer, the a.f. transformers and the transistors. Fig. 3 illustrates the copper side of the board whilst Fig. 4 shows the top of the board—the positions of the various components being printed on the board itself except for that of R_7. The position of this component is shown in Fig. 4.

Before soldering the components to the printed circuit, all wire lead-outs should be cleaned, inserted into the correct holes, and shortened to a suitable length.

All components are mounted on top of the printed circuit board except the following: C_{11}, C_{15}, C_{20} and C_{21}. These capacitors are soldered, beneath the printed circuit, directly on to the respective copper sections after all the other components have been mounted and soldered.

Sequence of Assembly

Resistors.—Note from Fig. 4 those resistors which are to be mounted vertically. (See standard colour code in Fig. 5.)

Capacitors.—Solder all capacitors into circuit except those mentioned above. Note particularly those capacitors which are mounted vertically on the board and ensure correct polarity of the electrolytic components. Electrolytic capacitors which are mounted vertically should have the positive (+) end nearer the printed circuit board. It will be found necessary to remove the tuning knob from the board in order to solder C_1 into circuit.

I.F. Transformers and Oscillator Coil.—Owing to the fact that the pins of these components are offset it is not possible to insert them into the board incorrectly. Do not force these pins into position —only a light pressure is required to seat them effectively. The double-size i.f. transformer can (IFT_3) should be mounted in such a position that the dust core is situated nearest C_{16}.

Identify the transformers and coil as follows: IFT_1 green spot, IFT_2 pink spot, IFT_3 double can size; the oscillator coil has no can and is contained within a yellow plastic casing.

Do not solder the following pins as they do not connect to the printed circuit (see Fig. 2): IFT_1 pins 3 and 5, IFT_2 pins 3 and 5, and IFT_3 pins 2, 6 and 8. All can lugs should be soldered.

Transistors.—Insert these into the correct location on the printed circuit board. Insert to about ¼in from the board and shorten the wire lead-outs as

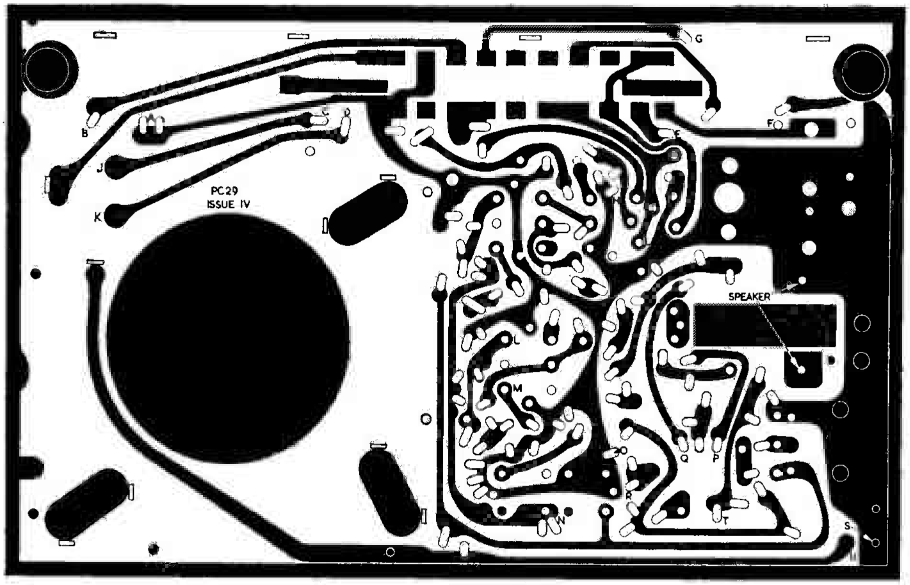


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Fig. 3. The printed circuit side of the board, showing the points to which each component should be soldered

necessary, covering these with Systoflex whilst remembering that sufficient lead-out length must be available for the application of a heat shunt during soldering. Ensure correct positioning of the various transistors in the following manner. For TR_1, TR_2 and TR_3 (all AF117) the spot on the printed circuit legend should be positioned between leads 3 and 4. For TR_4 (OC81D) and TR_5 TR_6 (OC81) the red spot on the side of the component corresponds to the spot on the printed circuit legend.

Diode.—Mount D_1 vertically with the positive (indicated by a coloured band) furthest away from the board. (Note here that D_2 is an integral part of IFT_3.)

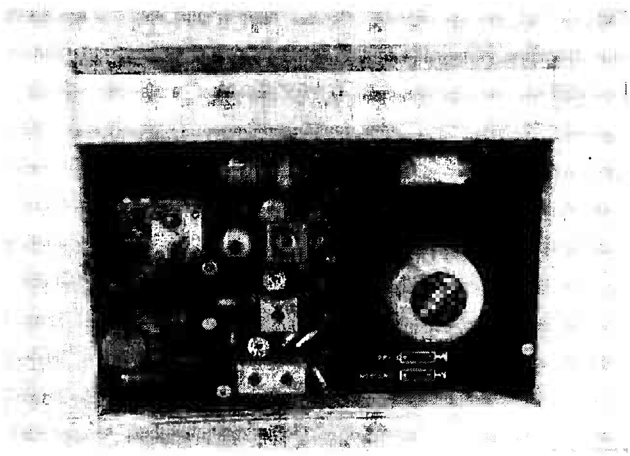
Transformers T_1 and T_2.—Carefully mount these (see Fig. 2 for pin locations), bend over the small metal lugs, and solder into the correct position (see Fig. 4).

Trimmer CT_1 and CT_3.—Mount and solder into circuit CT_1 and the twisted wire trimmer CT_3—this latter being soldered across C_6. The wires forming this trimmer should not be disturbed or the insulation will be damaged.

CV_1, CV_2 and RV_1.—The tuning capacitor should now be fixed to the board by means of the two bolts provided—see Fig. 4. The volume control RV_1 together with its associated control knob is already fitted to the board upon receipt and the three tags of the potentiometer should now be soldered to the copper sections into which they are already inserted.

Aerial Rod and Coils.—Note the correct position of these coils from Fig. 4. Assemble the coils to the

Rear view of the receiver with the completed printed circuit board mounted into position



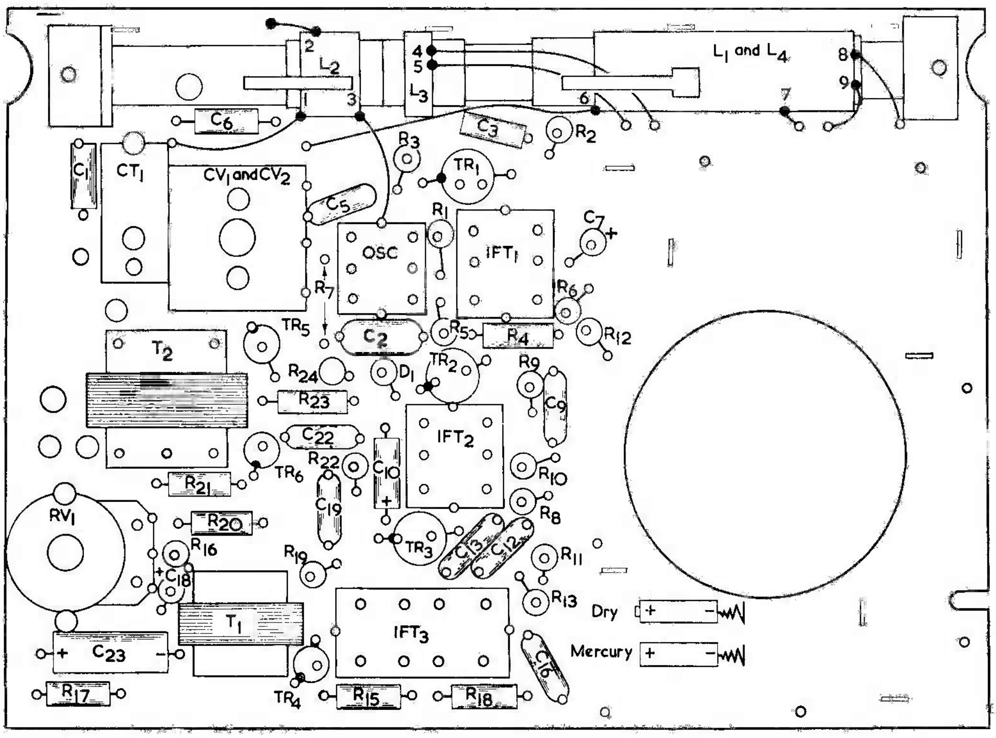


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Fig. 4. The reverse side of the printed circuit board showing the printed legend

rod as shown and slip the rod into the two brackets already fitted to the board as supplied. Connect the coils in the following manner. L_1 start to point A (No. 9 on legend); finish to point E (No. 6 on legend). L_4 start to point B (No. 8 on legend); finish to point A (No. 7 on legend). L_2 is the small coil having three connections. Start (inner wire) to point H (No. 3 on legend); centre tap (twin wires) to point G (No. 2 on legend); finish (outer wire) to point F (No. 1 on legend). L_3 is the small coil having two connections. Start (inner wire) to point D (No. 5 on legend); finish (outer wire) to point C (No. 4 on legend).

Note that L_1 and L_4 are wound on the same former and start together. L_4 is the smaller of the two coils and is composed of four complete turns only. The L_1 winding finishes at the far end of the former.

Remaining Capacitors.—The remainder of the capacitors (C_{11}, C_{15}, C_{20}, and C_{21}) may now be soldered to the copper pattern, these components appearing on the copper side of the board.

C_{11} is soldered from point L to point M (see Fig. 3), the actual circuit connection being from pin 4 to pin 6 of IFT_2.

C_{15} is connected across points N and O with the positive connection at point O. (From pin 7 of IFT_3 to earth line.)

C_{20} is connected across points R and S with the positive connection to point S. (From emitter of TR_4 to earth line.)

C_{21} is soldered across points P and Q. (From pin 4 to pin 6 of the driver transformer T_1.)

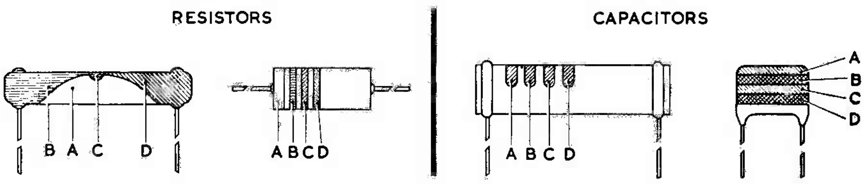
Next, solder a length of p.v.c. insulated wire from points T to U (from primary centre-tap of output transformer T_2 to the h.t. negative rail).

Fit and solder into position the four battery holders, covering the connections of the holder nearest the corner of the printed circuit board with a suitable insulating tape in order to prevent the holder shorting to the speaker when the whole assembly is fitted within the case.

Fit the plastic drive drum to the tuning capacitor spindle after having first fitted the small circlip to the drive drum spindle.

Assemble the drive cord mechanism as shown in Fig. 6. The final positioning of the two small white plastic beads which provide the tuning indication can be made during final tests and adjustments. Secure the beads to the nylon cord by sliding a length of thin wire into the bead hole together with the cord.

Solder short lengths of p.v.c. insulated wire to pins 1 and 2 of the audio socket (see Fig. 7). Secure both the audio socket and the speaker to the cabinet, mounting the speaker with the tags



Colour	A (Body)	B (Tip)	C (Dot)	D (Tip)	
	1st Fig. Res. in ohms 1st Fig. Cap. in pF	2nd Fig. Res. in ohms 2nd Fig. Cap in pF	Multiplier of Res. Multiplier of Cap.	Tolerance ± Resistors	Tolerance ± Capacitors (over 10pF)
Black	0	0	1	–	20 %
Brown	1	1	10	–	1 %
Red	2	2	100	–	2 %
Orange	3	3	1000	–	2 1/2%
Yellow	4	4	10000	–	–
Green	5	5	100000	–	5%
Blue	6	6	1000000	–	–
Violet	7	7	10000000	–	–
Grey	8	8	–	–	–
White	9	9	–	–	10%
Gold	–	–	–	5%	–
Silver	–	–	–	10%	–
None	–	–	–	20%	–

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Fig. 5. Standard colour code

nearest to the audio socket. Connect the two wires now on the socket to the speaker tags.

Solder two 6in lengths of p.v.c. insulated wire from the points on the printed circuit marked "SPKR". Solder one wire to pin 3 of the audio socket and the other to pin 1, or the speaker tag to which this pin is already connected.

Solder two 3in lengths of p.v.c. insulated wire to points J and K on the printed circuit. To the free ends of these wires connect the small metal clips which will fit over the aerial and earth sockets already in position on the case side.

Place both the backing material and the L-M-Off indicator into position over the switch knob, the latter being already fitted to the case as supplied.

Fit into position the four batteries and ensure correct polarity. The spring wire connector is negative. Switch on, and test and align as described in the instructions under "Alignment Procedure".

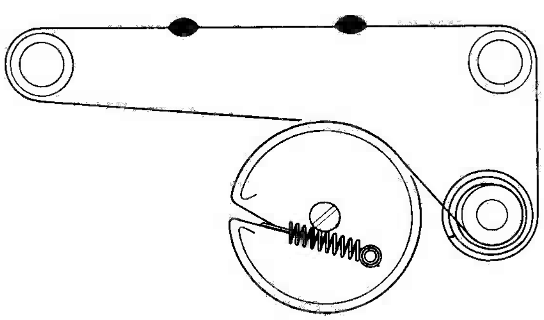

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Fig. 6. Showing the method of cord drive assembly

Fitting to the Cabinet

The aerial and earth clips should be connected to their respective socket points and the complete assembly eased into the case. It is immaterial which lead is selected as the aerial or earth. Allow the tuning and volume control "tyres" to clear their respective holes. Secure the printed circuit to the case by means of three self-tapping screws passed through the holes provided in the board and thence into the moulded plastic pillars. Fit the back of the case and the receiver is complete.

Alignment Procedure

The i.f. transformers and the oscillator coil are pre-aligned but may require some peaking. In all probability only the oscillator coil will require adjustment, this being needed to bring received stations into line with the dial calibration.

Before alignment, set the volume control to maximum and use the lowest signal level from the generator consistent with reasonable output from the receiver (say 50mW, or 0.4V a.c., across the speech coil). This will avoid a.g.c. action.

A modulated signal generator with a frequency

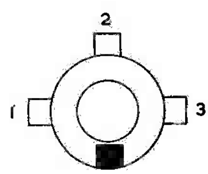

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Fig. 7. The audio socket viewed from the tags

TABLE

Operation	Waveband	Generator	Receiver	Adjust for Max. Output
1	M.W.	525 kc/s	CV_1, CV_2 closed	Osc. coil
2	M.W.	1,600 kc/s	CV_1, CV_2 open	Osc. trimmer CT_4
3		Repeat operations 1 and 2		
4	M.W.	600 kc/s	500 metres	M.W. aerial coil
5	M.W.	1,420 kc/s	212 metres	M.W. aerial trimmer CT_2
6		Repeat operations 4 and 5		
7	L.W.	155 kc/s	CV_1, CV_2 closed	L.W. osc. trimmer CT_3
8	L.W.	175 kc/s	1,710 metres	L.W. aerial coil
9	L.W.	265 kc/s	1,130 metres	L.W. aerial trimmer CT_1
10		Repeat operations 8 and 9		

coverage of 155 to 1,600 kc/s, together with an output meter of 3Ω impedance (or a voltmeter to read 0–1V a.c. across the speech coil) and a non-ferrous trimming tool suitable for adjusting the i.f. and oscillator coils are required ideally for correct alignment.

Dealing with the i.f. alignment, (1) switch the receiver to the medium waveband and fully open the tuning capacitor; (2) set the signal generator to 470 kc/s and couple to the base of the mixer (TR_1) via a blocking capacitor (see earlier note); (3) align each i.f. transformer for maximum output.

For the r.f. alignment, the signal generator should be loosely coupled to the ferrite rod aerial by a loop of insulated wire placed at a convenient distance from the set. Maximum pick-up will be obtained with the loop at right angles to the ferrite rod. Adjust the positions of the coils on the ferrite rod until best results are obtained, finally fixing the various windings permanently into position by means of Durofix or a similar adhesive. The accompanying Table lists the complete r.f. alignment.

Royal Navy Buys Variable Depth Sonar Equipment

The Royal Navy has bought a new device known as Variable Depth Sonar which was developed and produced for the Royal Canadian Navy by EMI-Cossor Electronics Ltd. of Dartmouth, Nova Scotia, Canada. This consists of a sonar transducer—transmitter and receiver—towed astern of a ship. By varying the length of tow, the depth of the transducer can be controlled, and it is possible to lower it beneath any temperature layers below which may be lurking submarines which are undetectable by normal sonar.

Problem of temperature layers, which refract and reflect the normal sonar beam, has long been an acute one, and many a submarine escaped during the war by hiding beneath these layers. This new device will make the submarine's task a much more difficult one.

The Navy intends to fit this equipment in some of the Leander Class of frigate and the first ship of this class, HMS *Leander*, will be carrying out sea trials of the device next summer.

Although the equipment has had extensive trials in Canada, *Leander* is the first European frigate to be fitted, and the outcome of her trials is awaited with considerable interest by other NATO nations, many of whom are considering purchasing it.

Book Reviews . . .

HIGH FIDELITY HOME MUSIC SYSTEMS. By William R. Wellman. 241 pages, 5½ x 8¼in. Published by D. Van Nostrand Company Ltd. Price 51s.

This book, the second edition of which is under review here, offers the novice a useful introduction to high fidelity equipment. The author explains the technicalities of audio reproduction in a very clear manner, and he employs a down to earth attitude which is welcome in the somewhat esoteric field of hi-fi.

The range of subjects covered includes loudspeakers and enclosures, record reproducers, radio tuners, tape recorders, amplifiers and stereo. There is, also, an interesting and detailed chapter devoted to installations in the home.

Mr. Wellman is an instructor in Technical Electronics in New York and, in consequence, the book tends to reflect conditions in America rather than in England. This is not a serious disadvantage, however, and the book can be recommended as offering a considerable amount of practical information which will be particularly appreciated by the beginner.

RADIO AND TELEVISION TEST INSTRUMENTS. By Gordon J. King, Assoc. Brit.I.R.E., M.I.P.R.E., M.T.S. 175 pages, 6 x 9in. Published by Odhams Press Ltd. Price 25s.

"There must be a great many test instruments collecting dust simply because their users are not fully conversant with every possible use to which they may be put." This sentence, taken from the Foreword of the book under review, certainly describes a true state of affairs, as most readers will agree. It also highlights the necessity for a publication which clearly explains the function and use of test equipment.

Radio and Television Test Instruments deals fully with all test gear likely to be found in the service workshop and, indeed, the laboratories of quite a few electronic manufacturers. A point which adds value to the text is that the circuits of manufactured test equipments are published. Thus, we find the circuit diagrams of the Avo Model 8 testmeter, the Heathkit Valve Millivoltmeter AV-3U, the Cossor F.M. Alignment Generator Model 1324, and so on. Especial attention is paid to the oscilloscope, a servicing tool which is by no means called into use as frequently as it could be.

This book is aimed mainly at the service engineer and is written by an author who is fully conversant with the practical problems of this calling. It will prove to be a valuable publication also for the beginner and for anyone else whose interests lie in the field of practical electronics.

HANDBOOK OF ELECTRONIC TABLES AND FORMULAS. Compiled and edited by Donald Herrington and Stanley Meacham. 126 pages, 5½ x 8½in. Published by George Allen & Unwin Ltd. Price 15s.

Howard W. Sams "Photofact" service data sheets for domestic radio and television receivers are well known in the United States because of the care and attention to detail with which they are planned. In consequence, it is of interest to examine this book, which was, apparently, originally published in America by Howard W. Sams & Co. Donald Herrington and Stanley Meacham are members of the Howard W. Sams Engineering Staff.

The Handbook deals with its subject in a very competent manner and justifiably demonstrates the intention of the compilers to produce a book which would make it unnecessary to refer to three or four separate publications for any particular range of information.

There is, however, one snag, this being that the book is reproduced in its American form. The fact that American spelling and terminology are retained (i.e. "liter", "tubes", "ground", etc.) is no inconvenience, but English readers may be a little disconcerted to find that the two and a half pages devoted to "Test-Pattern Interpretation" refer to the "Indian Head" test card, that the television frequency table refers to American channels, and that winding wire information refers to American gauges only. Apart from these points (which may be an advantage to anyone working on export equipment, for instance) the Handbook is comprehensive and can afford a useful addition to the book-shelf of the engineer or amateur enthusiast.

RADIO DATA REFERENCE BOOK. Compiled by G. R. Jessop, A.M.Brit.I.R.E. (G6JP). 136 pages, 5½ x 8¾in (including 5 pages for Notes and 6 pages advertisements). Published by the Radio Society of Great Britain. Price 12s. 6d.

The compilation of a book of electronic facts and figures is an exercise which, to be successful, has to meet three basic requirements. Firstly, the information presented must conform with accepted standards for the figures quoted and the terminology employed. Secondly, each subject dealt with must be treated as widely as possible without losing conciseness of presentation. Thirdly, the range of subjects covered must be sufficiently broad to satisfy all the foreseeable requirements of the readers at whom it is aimed.

The book under review satisfies all these requirements, and it does so at a price which, so far as the reviewer is aware, is significantly lower than any comparable work at present available. Also the field covered is noticeably more extensive than is usual with reference books of this nature.

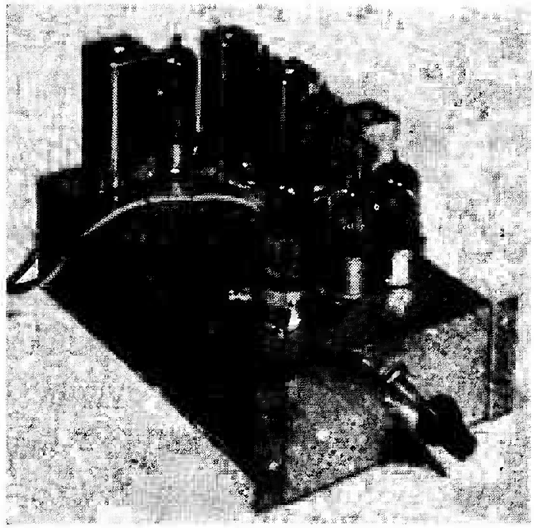
Attention has been paid to the presentation of data in the form of curves, and these give information on such matters as noise diode factors, yagi design, a.c. rectifier ripple and feeder line impedance. There are, also, numerous tables, charts, circuit diagrams and abacs. Apart from purely electronic subjects, the book includes log, trigonometrical and square root tables, properties of materials, conversion factors and metereological data.

Radio Data Reference Book is published with stiff covers and employs a very clear type face and well laid out diagrams. It may be recommended with complete confidence as an excellent source of data for the professional engineer and the amateur enthusiast.

The "Crystella" Crystal-Controlled F. M. Tuner

Part 2

By **SIR JOHN HOLDER, Bart.**



Sequence of Construction

After the chassis, shown in Fig. 7, has been made, work will be found easier if carried out in the following order:

(1) Assemble the main components except for the partition-screen and side-pieces. See Fig. 5 and 6 which show coil, crystal holder and valveholder orientation.

(2) Make all connections between chassis and valveholders. Use earthing tags under valveholder bolts nearest to pin 9 in each case. An additional earthing tag is required at the opposite side of V_2, for chassis connections associated with the triode portion.

(3) Carry out heater wiring, using insulated wires run in pairs close to chassis.

(4) Fit the longer portions of the h.t. positive wiring, using insulated wire. (It is as well to use a distinctive colour such as red, here).

(5) Fit all bypass capacitors, making sure that these are close to chassis and to the points which they decouple.

(6) Carry out the rest of the wiring. As far as possible, avoid positioning components over the valveholders.

(7) Add the partition-screen, L_4 and the side-pieces.

All wiring should be as short as possible—a "hot" wire of more than ½in length is to be regarded as a long one. However, those between V_1 and V_2 must of necessity be longer.

Adjustment of the Front-End.

The intermediate frequency coils and ratio detector are approximately adjusted when supplied and their slugs should not be moved until the oscillator is working satisfactorily.

First, check the whole of the wiring very carefully. For success with this tuner, two things are necessary: *correct connections and an accurately constructed oscillator coil.* Given these two, and reasonable handiwork, there is very little which can prevent the tuner from working.

Next, test that there is no short-circuit between h.t. positive and chassis, also between h.t. positive and heaters. The meter should indicate about 2MΩ between h.t. positive and chassis.

Connect up and switch on. If the oscillator coil has been properly constructed, it is more than likely that a signal will be heard on first switching on. Connect a 25 volt voltmeter to Test Point 1. (See "Adjustment of I.F. Coils").

A reading of at least 5 volts should be obtained when a signal is being well received, this reading depending, also, on the adjustment of the i.f. coils and on the h.t. voltage. Use the meter reading to adjust the oscillator coil L_3. If the latter fails to oscillate on the Light Programme, squeeze the turns together. If it fails to oscillate on the Home Service, open out the turns.[4] Always arrange the adjustment such that the lengths of the two halves of the coil are the same. Continue until the meter gives a good reading on both programmes.

Having obtained the best adjustment for the oscillator coil, adjust L_2 slug. The starting point should be with the slug in the centre of the coil. If it should be found that the coil takes charge on one of the programmes, causing blocking or howls, the slug should be withdrawn somewhat. The adjustment is not very critical. A large alteration may affect the oscillator and entail a slight readjustment of L_3.

Adjustment of I.F. Coils

Connect a 100kΩ resistor temporarily to the junction of R_{15}, R_{16} and C_{26}. The free end of this resistor will be called Test Point 1. Test Point 2 is the junction of R_{19}, C_{16} and C_{17}, whilst Test

[4] The Light Programme will be the lowest of the three frequencies to be received, and the Home Service the highest.—EDITOR

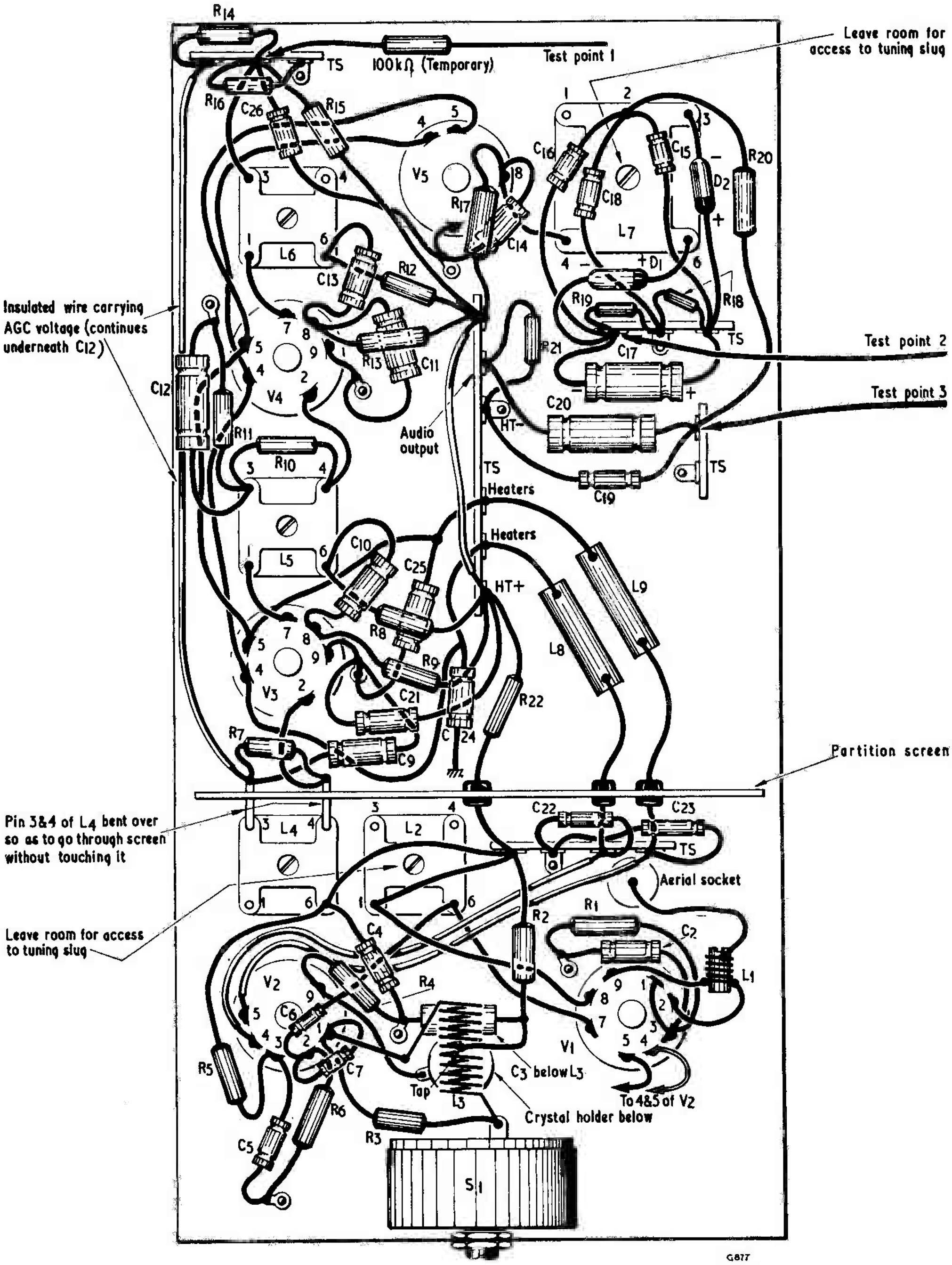


Fig. 5. The below-chassis layout of the Crystella. Wires shown in heavy line are insulated. For reasons of clarity a large number of connections are omitted. The earthy lead of C_{21} connects to a chassis tag adjacent to pin 9 of V_3

Point 3 is the junction of R_{20}, C_{19} and C_{20}, as shown in Fig. 1.

Apply the 25 volt meter to Test Point 1 (negative to the Test Point) and adjust all i.f. cores except those of the ratio detector, for highest reading. Care should be taken not to screw the slugs into the centre of the coils where a false maximum will be obtained. As set by the makers, they will

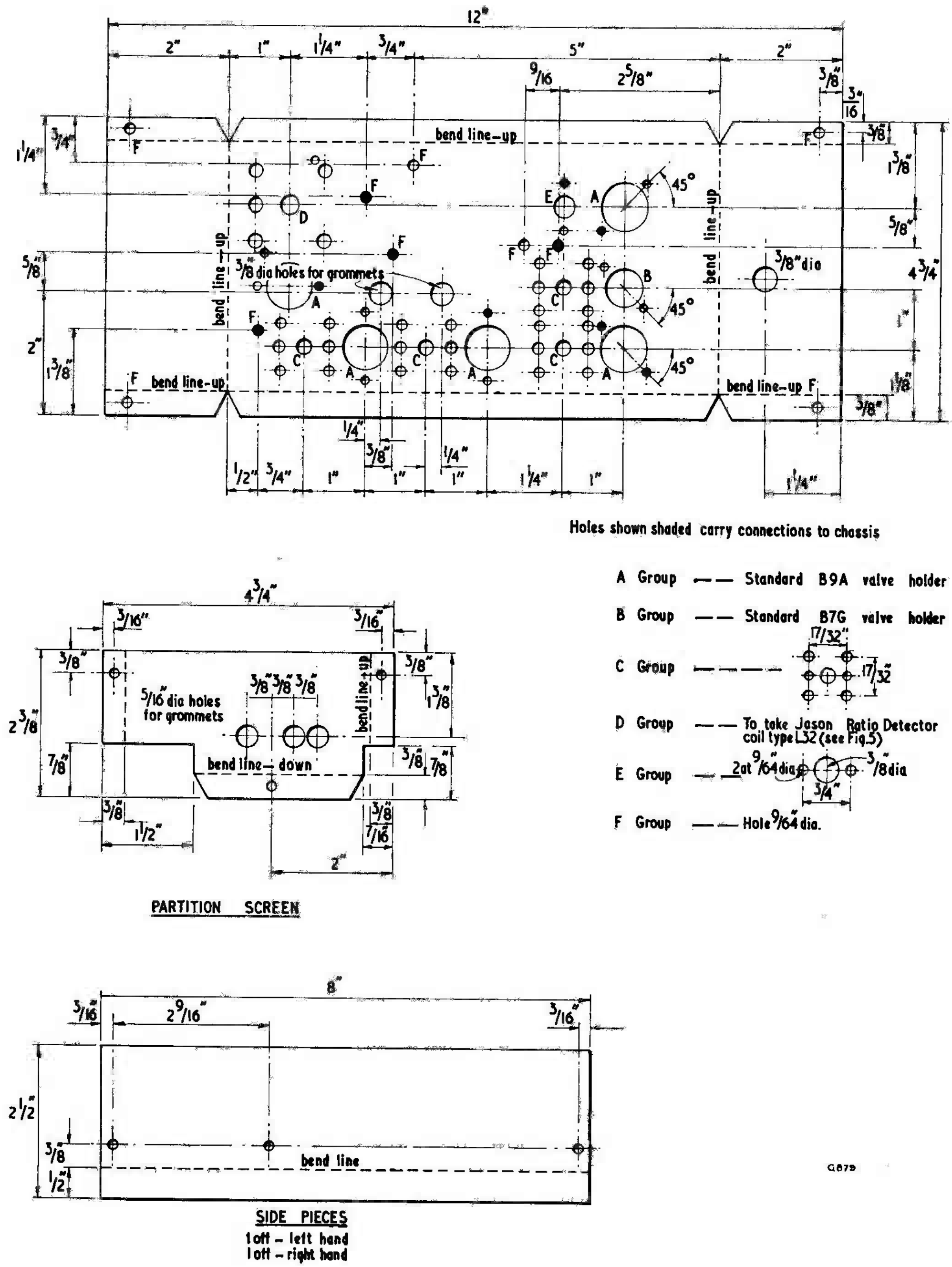


Fig. 7. The dimensions of the chassis, sidepieces and partition screen

probably require withdrawing slightly. With those that show a maximum over a broad band, the correct setting is at the centre of the band.

Adjustment of Ratio Detector

Next transfer the meter to Test Point 2 (negative to the Test Point) and adjust both cores of the ratio detector coil for maximum reading, taking particular care over the primary.

Now transfer to Test Point 3 (polarity unimportant) and adjust the secondary so that the meter reading is zero. The meter should swing to either side of zero as the core passes through the correct setting.

Checking Oscillations

If L_3 has been correctly constructed it is extremely unlikely that no signals will be received. Failure will be more likely due to some other fault, which can either be found by inspection or which will be indicated by a grossly incorrect h.t. voltage at some point. A faulty valve-pin contact may occasionally be experienced.

If a grid connection to a valveholder is tapped with a screwdriver, a "pop" heard in the loudspeaker will indicate that this valve and all stages after it are functioning. By working back through the various stages in this way, the offending one can be located.

If there is any doubt as to whether V_2 is oscillating, connect a voltmeter (250 volt range) between the tap on L_3 and chassis. There should be a distinct increase of volts when the circuit is oscillating, as compared with when the crystal switch is in the "off" position. More sensitive tests involving the measurement of grid current exist, but these should not be necessary.

It must be emphasised that it is not a circuit which has to be humoured. Given a reasonable chance, it will go at it with a zest, so to speak. In fact anyone who had set-up a non-crystal controlled tuner cannot fail to be struck by the ease with which this unit is adjusted.

Power Supply

The tuner requires a high tension supply of 50mA at 170 volts, and a heater supply of 1.5 amps a.c. at 6.3 volts, transformer-centre-tap, or one side, connected to h.t. negative (chassis).

Although designed for 170 volts h.t., voltages from 150 to 200 may be used except that, for the higher voltage, R_2 should be raised to 22kΩ and R_5 to 39kΩ.

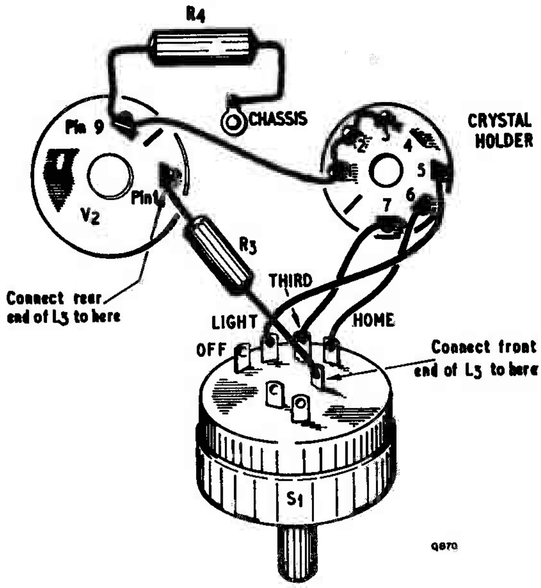


Fig. 6. Connections to crystal holder and switch (remainder of switch contacts are not used)

Note

If L_3 is grossly maladjusted or wrongly dimensioned, oscillation may occur on the wrong frequency and a programme or alien transmission may be heard, but this condition is easily recognised by microphonic noises which occur when L_3 or the chassis is tapped with a screwdriver.

(Conclusion)

New E.M.I. C.R.T. with Internal Magnetic Deflection

A new cathode ray tube with internal magnetic deflection is announced by EMI Electronics Ltd.

The tube has, in place of the normal Y plates, a set of deflector coils made by a printed circuit technique and positioned in the same axial position as were the electrostatic plates which they replace.

If the coils are introduced inside the tube they can be brought closer together and so produce a higher sensitivity of deflection than coils of the same type outside the tube. It is possible by this means to produce a high sensitivity with a low inductance coil. The signal or timebase can then be obtained from transistor circuits which will provide the current required at a comparatively low voltage.

In this tube the magnetic set of deflectors is followed by an electrostatic plate system into which the higher frequency signal can be fed. Alternatively, by using a centre tap on the magnetic deflectors these can also be used for electrostatic deflection. In this case, however, higher capacitance is involved and cross-talk may occur.

Further development of this principle is being undertaken with a view to increasing the efficiency of the internal coils.

AN E.H.T. CONVERTER

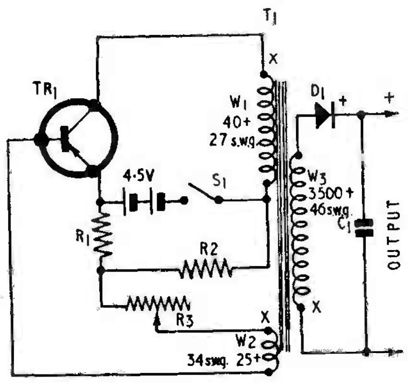
by J. G. RANSOME

This transistorised converter will produce a high voltage low current supply from a dry battery

THIS CIRCUIT WAS DESIGNED TO PRODUCE THE e.h.t. voltage for a miniaturised oscilloscope. The output of the converter is approximately 1,000 volts at 100μA and so, obviously, the unit will have to be run into a fairly high impedance network.

Operation

The operation of the converter is quite simple. The circuit associated with transistor TR_1 and transformer windings W_1 and W_2 oscillates at a frequency of 2 to 3 kc/s, producing a rather "spiky" waveform in the transformer. A stepped-up voltage appears across W_3 and is rectified by D_1, the d.c. potential thus obtained charging C_1 to about 1,000 volts.



X represents start of winding

.E269

Components List

R_1	27Ω 10% ¼ watt
R_2	270Ω 10% ¼ watt
R_3	0–100Ω pot
C_1	0.5μF 1,000V d.c. wkg
TR_1	OC72
S_1	s.p.s.t. switch
D_1	K3/40 (S.T.C.)
T_1	Transformer (see text)
Battery 4.5 volt	

Construction

The only really important component is the transformer. In the original an old speaker transformer was used, this being stripped of its original windings and rewound to the required specification. The transformer core should have a cross-sectional area of 1 square inch with a length of about 1.5in.* and is wound as follows:

Winding W_1 consists of 40 turns of 27 s.w.g. enamelled wire close-wound on the transformer bobbin. This will occupy one layer and the start and finish of the winding should be noted. This first layer is then covered with a single layer of insulation tape. W_2 is wound over the tape and consists of 25 turns of 34 s.w.g. enamelled wire, close-wound as before. This winding should be covered with a double layer of insulating tape, a note again being made of which end of the winding is the start and which the finish. On to these two windings is then wound W_3, which is made up of 3,500 turns of 46 s.w.g. enamelled wire. The wire is again close wound and each layer, as it is completed, should·be varnished and insulated from the next by a layer of interleaving paper. (Tissue paper was employed in the prototype.) Having completed the winding operations, the laminations should be re-fitted, ensuring that they are well clamped. For best results the laminations should be interleaved (i.e. with alternate E's and I's) when reassembled. The unit is a little less efficient if the laminations are butt-jointed (i.e. all the E's on one side and all the I's on the other side) but should still prove quite satisfactory.

The rest of the circuit may now be constructed around the transformer as shown in the accompanying diagram, remembering that the windings on the transformer should be wired with the polarity shown or the transistor will fail to oscillate. The usual precautions with regard to the soldering of the leads on the transistor should be exercised.

Switching On

R_3 should be set so that maximum resistance is in circuit and the unit switched on. R_3 should then be

* However, successful transformers have been wound with core lengths from 1 to 2.5 inches. (Core length infers the length of former the core can accommodate.)—*Editor*.

advanced so that about half its resistance is in circuit and capacitor C_1 short-circuited with a screwdriver, whereupon a fairly heavy spark should be obtained. If no spark can be obtained in this way, then the circuit is not oscillating and the connections to either W_1 or W_2 (but *not* both) should be reversed.

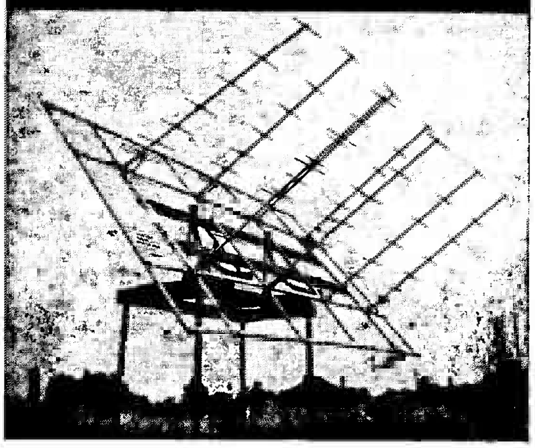
When the unit is operating satisfactorily, R_3 should be adjusted to give maximum output as measured across C_1. Unfortunately, the voltage across C_1 cannot be measured by conventional means because of the low current capacity of the unit, and an electrostatic voltmeter must be employed However, if one of these instruments is not to hand or cannot be borrowed (the normal course of things!) then R_3 should be set so that the resistance in circuit is about 20Ω, final adjustments being made *in situ*. R_3 is used to compensate for changes in battery voltage.

When the transformer is connected up as shown in the diagram, the start of winding W_3 connects to the negative side of the reservoir capacitor. This gave the best results with the prototype, but experimenters may try reversing the connections to winding W_3 if they wish.

The current drawn from the 4.5 volt battery depends on the load, and varies between 20 and 30mA.

A Radio Astronomy Receiver

for the Advanced Constructor



Part 4. The Sun and other Radio Sources

By Frank W. Hyde
F.R.S.A., F.R.A.S., M.S.E.

This is the fourth of a series of four articles written by the foremost amateur authority on radio astronomy in this country. These articles cover the construction and assembly of a complete radio telescope installation.

If the instructions in the first three articles have been carried out successfully the complete radio telescope will now be ready to go into operation. There are certain factors which will determine the type of work that can be carried out, the first of these being the location of the telescope. If this is erected in a very much built up area the actual clearway may be restricted. Under the severest conditions this restriction may be caused by tall buildings surrounding the location, in which case the work would be restricted to that part of the sky visible within a few degrees of the zenith. Even under these conditions it is still possible to make interesting observations and no one should be deterred by reason of a restricted location.

The Most Powerful Source

For the type of telescope which has been described the Sun must be regarded as the most powerful source accessible, since the Sun is available for a considerable part of the day; that is to say, it is available to radio astronomers though it may not be visible to the naked eye or to the optical telescope. It follows then that it will be possible in some cases to observe the Sun during the early morning, at mid-day or at sunset and there may be locations which are fortunate enough to observe the Sun throughout the whole of the period. The Sun may be observed from the time it rises until the time it sets and it will thus be visible to the telescope, at various points of the compass, depending upon the time of the year and the time of the day. The point of rising will vary between south of the east and north of the east, according to the time of the year. Similarly, it will set south of the west and north of the west, according to the time of the year.

There is still another variation and this is in altitude. Altitude also varies according to the time of the year. It will be clear, therefore, that only in exceptional cases will the Sun not be visible at some time or another for a considerable part of the year for observation.

Since the telescope is fully steerable, regular observations will be possible in most cases. Much of the work that the amateur can do will be confined to the measurement of day-to-day or week-to-week variations in the strength of the radiations together with observations of the change of character of the trace which is produced on the pen recorder, or on the graph built up from the readings of the meter. These changes will enable deductions as to the state of the medium through which the radiations have passed; that is, the ionospheric layers of the atmosphere. These variations will give a clue to variations of polarity of the radiations, the electron density of the ionosphere and the general activity of the Sun itself.

The Sun—Radiations

In the previous series of articles a brief sketch of the Sun was given.[1] As it is now to be the subject of special study a few more details about the radiations of the Sun will be useful.

The Sun is a sphere of highly compressed gas which is visible as a bright disc some 864,000 miles in diameter. This disc is called the photophere. It has a well-defined edge because there is a sharp change of temperature level between this edge and the surrounding gas of the Sun's atmosphere. It is the Sun's atmosphere with which the radio astronomer is principally concerned. The enormous temperatures at the centre of the Sun are the result of the production of energy by atomic fusion. About 50% of the mass of the Sun consists of hydrogen and, of what remains, a large proportion is composed of helium. The Sun is therefore one vast reactor, or power station; it radiates energy by convection from its central core to the surface of the photosphere. From this surface, energy escapes as radiation in all parts of the spectrum. The nuclear processes going on in the interior of the Sun consume about four million tons of the mass each second. The energy is conveyed from the central zone by the reactive transfer of photons, which move from atom to atom on their journey outward. Outside this radiating core is the convection zone, which extends to within a few thousand miles of the photosphere. Energy is conveyed by upward motion of the heated material through a very steep temperature gradient and the actual thermal conduction is negligible.

The surface of the photosphere appears to have a temperature of the order of 6,000° Kelvin.

Immediately next to the photosphere is the chromosphere and this extends outward for a distance of 12,000 miles. Its name is derived from the slightly pinkish colour which this section presents, and it is therefore called the "chromosphere" or "coloursphere".

The lower layer of the chromosphere, extending about 600 miles, is known as the reversing layer and in this region there are many atoms which have lost only one electron. They are therefore in a state of ionisation. Under these conditions an atom can absorb visible light, and continual activity is therefore observable in this area due to electrons jumping from one level to another in the atom. The result is the production of intense ultra-violet radiation, which eventually reaches the upper atmosphere of the Earth and contributes to the production of the ionosphere.

This intense energy welling up from the centre of the Sun is absorbed principally in the chromosphere. The temperature in the region of the chromosphere varies and there seems to be three distinct levels —from 10,000° Kelvin to 1,000,000° Kelvin. The outermost layer of the chromosphere marks the beginning of the corona.

The corona is not visible optically except at the time of the eclipse or by the use of a special telescope called a coronagraph. When a projected image of the Sun is examined it is found that the disc is brighter in the centre than it is at the edges. This "limb-darkening", as it is called, arises from the fact that when we look at the centre of the disc we do in fact look *into* the interior of the Sun, but when we observe the edges we look through the very much lower temperature level and they therefore appear darker. It is also possible to observe the granulation which appears as light and dark patches rather like rice grains distributed over the surface. These small areas are of the order of 700 miles in length and have an average life of about three minutes. This is the visible evidence of the activity of convection from below the photosphere, and the bright areas are probably the tops of hot rising columns of gas which bring up energy from the interior. The darker and brighter areas suggest that there is a temperature difference of the order of 200° Kelvin. There are great geyser-like projections which are continually emerging from the surface of the Sun into the chromosphere. These are known as spicules and, into the chromosphere, they pour photons which eventually escape into the outer corona and outer space.

The excited state to which the chromosphere is subject produces also a number of absorption lines known as Fraunhöfer lines. These lines are valuable since they enable us to determine the basic elements making up bodies such as the Sun. Prominent in the spectrum of the Sun are such elements as calcium, strontium, hydrogen, helium, iron and titanium.

For the radio astronomer the corona extends outward for distances greater than ten times the diameter of the Sun. The radio Sun is therefore of very much greater extent than the visible Sun. The corona itself varies continually, because it is agitated from below due to the activity from inside the Sun

[1] "Radio Astronomy," parts 1 to 6, October 1961 to March 1962. —EDITOR.

itself and the activity of the chromosphere. Vast streams of energy are sent out in all directions and this activity is constantly varying. At the time of sunspot minimum the rays and plumes have their greatest extension around the equator, while at the period of sunspot maximum the rays are much shorter and more uniformly distributed. There are well-defined areas near to the poles of the Sun which are quite clear; the streamers follow the Sun's magnetic field and this accounts for these clear areas.

The regular cycle of activity varies between 10 and 11.2 years and at the moment the period of the quiet Sun is in being. This does not mean that there is no activity, but merely that there are not such violent outbursts of flares and other manifestations as occur at the peak of the sunspot cycle.

Sunspots

The sunspots are the visible signs of the enormous areas of turbulence taking place within the Sun itself; they are sometimes quite small and scarcely visible on the surface of the photosphere, while at other times they become so large in extent that they appear in chains as much as 100,000 miles long. Usually they become apparent in a well-defined belt around the equator of the Sun. At the time of maximum activity they appear in a narrow belt nearer to the equator than at the time of minimum activity, and during the period of sunspot minimum they extend quite high in the north and southern hemispheres of the Sun. Occasionally a number of small sunspots coalesce and striking effects are produced at these times; bright bands of light appear and there are also changes of shape, whilst some spots appear to have a light bridge across a dark spot.

A large outbreak of sunspots does not necessarily mean that there will be a high level of radiation so far as the radio astronomer is concerned. Sudden outbursts of radiation are due to flares. These are terrific outbursts of gas and sometimes they appear above sunspots. The reason for this is thought to be that, because of the intense magnetic fields which are set up in these regions, great spouts of gas can be ejected from the Sun complete with their own magnetic field. They shoot out, together with particles, into interplanetary space, occasionally pouring into our upper atmosphere and causing intense changes and modifications. Sometimes these flares reach out only to a certain distance, after which they fall back again to the surface of the Sun.

From time to time over the surface of the Sun there appear prominences. These are vast clouds of hot and tenuous gas which attain extremely high temperatures and may be enormous in extent. The prominences bear a relation to the sunspot cycle and, about two years before maximum, seem to be larger and more numerous in the higher latitudes of the Sun. These priminences, which appear in high and low latitudes, are called quiescent; they are often of great length and rise to enormous heights, the average height varying anywhere between 50,000 and 250,000 miles. In exceptional cases they have been observed at heights of more than 500,000 miles. The prominences may last for only a few hours or may remain for several weeks; some appear suddenly to blow up and disappear within a few hours. These ragged plumes are ejected with speeds of the order of 50 to 250 miles a second. Their composition is very similar to that of the chromosphere itself and often there is the addition of other metallic vapours. On occasions there are rapid transformations, and they disintegrate occasionally into several separate components which vanish one by one while they still continue to arise from the chromosphere.

By the use of the coronagraph special records can be made of the movement of these prominences. They seem to be more frequently noticeable between the latitudes of 20° and 40° north and south. The zones move toward the equator during the course of the sunspot cycle, dying out at sunspot minimum and then appearing again at the high latitudes at the beginning of each new cycle.

Another type of prominence is called "eruptive". These appear suddenly and last sometimes only a matter of seconds. In movement they attain enormous speeds of up to 100 miles a second and some slow up as they reach regions 20,000 to 30,000 miles above the chromosphere. They are then pulled back into the Sun with increasing velocity, and such a display of activity may last for twenty minutes or more. Some are so violent that they go right out into space without any visible sign of return. These give rise to short wave radio bursts which begin at the high frequencies and, as they die away, fall rapidly to a lower frequency level. Excitation of the gas in the corona by the disturbances caused by clouds of ionised material travelling outward at high speed would seem to be the process responsible.

Radio Emissions

Radio emissions can be detected from the Sun at all times but they are subject to enormous changes and variations. After continuing at one level for several days, or even weeks, there may suddenly be an increase in the level of radiation many hundreds of times that of the normal level. These radiations produce the conditions which are called "noise storms". The appearance of flares and prominences are very often followed by these noise storms.

Before the formation of a sunspot the magnetic field develops rather like a great magnet below the surface of the Sun, and this may be as great as 30,000 miles in length. This great magnet rises up to the surface of the Sun and its magnetic field projects through the photosphere and activates the gas in the chromosphere. The gas is heated by the hydro-magnetic waves and they travel up the magnetic lines of force, the process culminating in a spot on the surface of the Sun. The spots are darker than the surface because the temperature at these points is lower than the surrounding regions, and they mark the position of the greatest concentration of the magnetic field. The gas above the

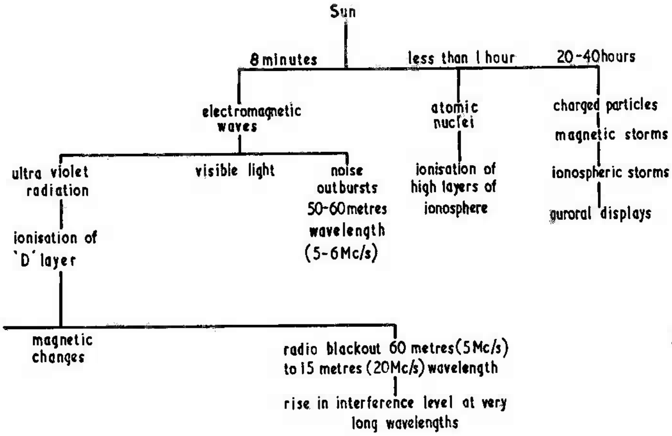


Fig. 26. Some effects of flares on the Sun

spot is very much hotter and there is violent activity. The glowing clouds of gas which are suspended high up in the corona are supported by the magnetic field and it is during this time that the flares may come into being. The vast cloud of gas, ejected at an enormous speed, drags the magnetic field out with it into the chromosphere and it sometimes drags the field out until it reaches the Earth. It gives rise to a wide range of radio emissions as well as to x-rays and cosmic rays. Fig. 26 shows the effects of flares from the Sun.

The electro-magnetic radiation may be divided into three parts. The first of these is the ultra-violet light which falls upon the ionosphere, causing ionisation of the "D" layer. The second gives rise to variations in the magnetic field of the Earth and causes fade-outs in radio communication between the frequencies of 5 Mc/s and 20 Mc/s. The third type is associated with interference on very low frequencies of 10 to 15 kc/s. Enormous outbursts of radio noise are apparent at 60 Mc/s. These, together with visible light, arrive at the Earth some eight minutes after the outbursts have begun on the Sun. Other effects are given by cosmic rays created during the process and which consist of atomic nuclei; these again cause ionisation in the upper atmosphere. The ionisation occurs from 20 to 40 hours after the appearance of the flare.

Magnetic storms are ionospheric storms, and under severe conditions result in the appearance of the Aurora Borealis.

Electro-magnetic radiations have simultaneous effects but the delayed effects caused by particles may go on for some days after the origin of the outbursts.

In the previous series of articles mention has been made of the special radio telescope built by Christiansen and Matthewson in Australia to study radio waves from the surface of the Sun.

Fig. 27 shows the profile of the radiations from the Sun, giving the extent at the various frequencies.

It will be clear that there is plenty for the amateur radio astronomer to study. Records can be made of the activity and these compared with other kinds of activity such as Aurora and reports of flares, or sunspots.

Practical Observations

To put the radio telescope into practice, therefore, make a start with the Sun. For those with a southern aspect the telescope should be set so that the aerial faces due south. Here it should be mentioned that due south by the compass is subject to a magnetic variation. At the present time, 7° should be allowed for this variation, the telescope being set 7° west of south. The altitude of the Sun can be obtained from the *Nautical Almanac* which is available in most libraries, or from the *Handbook of the British Astronomical Association.* The centre of the beam of the telescope should be set on this point in altitude. The telescope should be fixed in this position and observations commenced two hours before and continued until two hours after mid-day. As mentioned before, this does not necessarily mean that the presence of the observer is required, since the record can either be made with the pen recorder or with the tape recorder. The tape recorder results must, of course, be

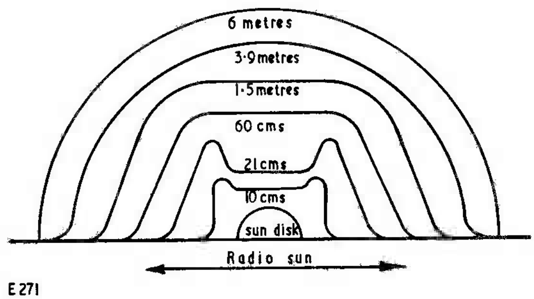


Fig. 27. Idealised curves of the radio Sun at differing wavelengths

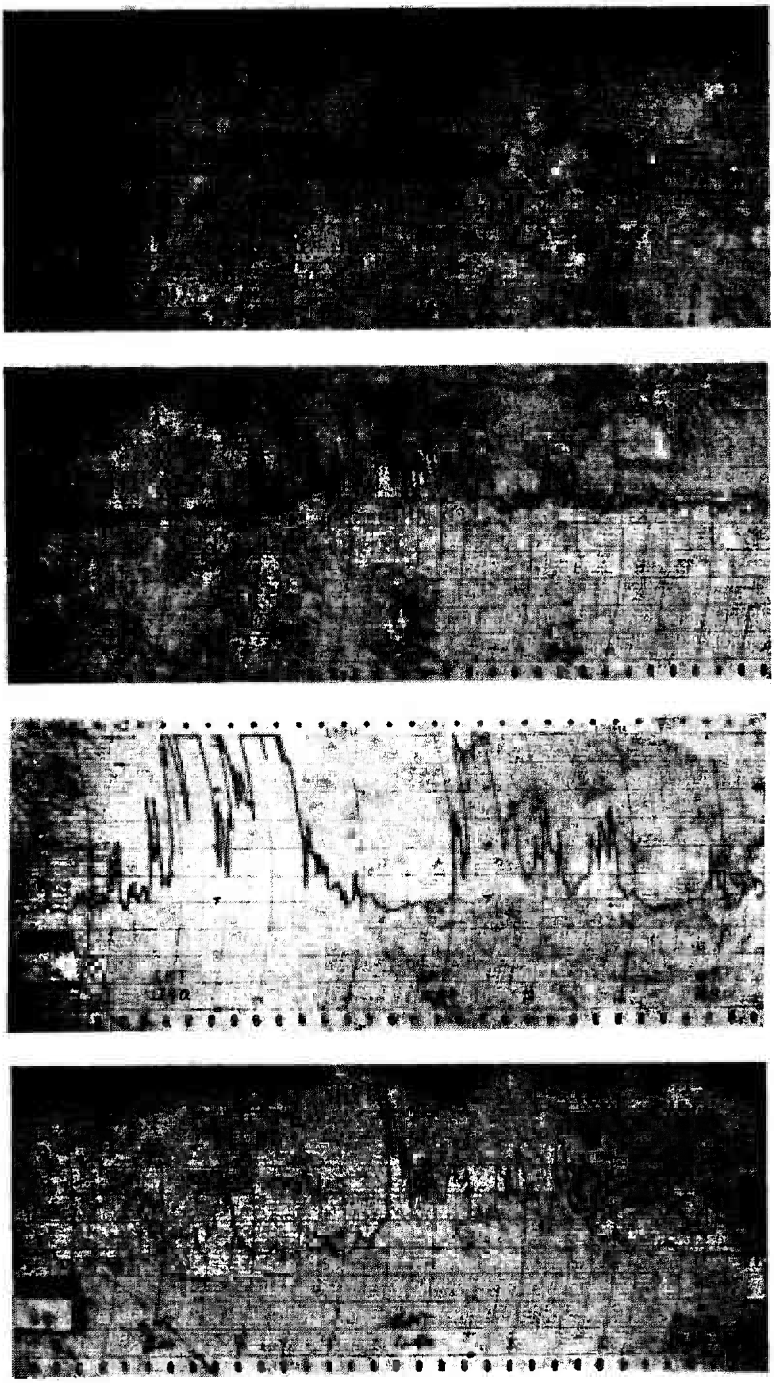


Fig. 28. Showing the level of continuing radiation changes. That at (a) shows the remarkable scintillation effect; (b) a preliminary of considerable scintillation effect followed by rather random excursions due to prevalent activity; (c) some very wide ranges of activity; and (d) differing levels of change

processed and the results compiled in the form of a graph.

The position of the telescope can be left undisturbed for at least a month. The maximum change of altitude which is likely to take place will be not more than 10° and this is well within the beam width of the aerial in altitude.

The amatuer radio astronomer may use the results of observations purely for his own interest, or he can combine with a group who are carrying out similar measurements and add his contributions to the pool. The author will be glad to receive the records of such observations and pass them on to the British Astronomical Association. If the observer is fortunate enough to have more than the southernly aspect then there are other observations of the Sun that can be made. For example, if an easterly or westerly aspect is available then, in the former case, a record of the change in level of radiation from the existing background can be observed as the Sun rises; and in the case of the latter aspect, as it sets. This would provide further useful information about the ionosphere because, in these two positions, the longest path of travel is presented to the radiations arriving from the Sun.

If these radio observations can be combined with optical observations then an even greater field of interest presents itself. The observer may be fortunate enough to be in contact with optical observers and the knowledge gained could then be pooled. There are in fact a number of Sun observers with optical telescopes scattered throughout the country.

The level of radiation changes continually, as has already been stated, and reference to the charts in Fig. 28 will give some idea of the extent of this variation. The top two traces indicate considerable activity, that at (*a*) showing the remarkable scintillation effect, while that at (*b*) has a preliminary of a considerable amount of scintillation which is followed by quite wild excursions due to the activity going on. The variation of the peaks is in some cases due to Faraday rotation, and in some cases to the original random polarisation of the radiations. At (*c*) some very wide ranges of activity are observable, and in some places it has gone beyond the limit of the pen recorder. The trace at (*d*) also shows different levels of change. While these traces have been selected as representing rather more spectacular appearances of the radiations, it is quite often the case that there is no more to be seen than that shown at the beginning of (*b*) or even the central portion of (*a*). These charts were made at approximately fortnightly intervals between September and December, 1962.

Other Radio Sources

The positions for other radio sources have been given in the previous series of articles and exploration of these is well worthwhile. The Sagittarius area of the Milky Way can often be quite spectacular.

It is the repetition of observations which is important in this connection, and comparisons should be made at intervals when the areas of radiation can be seen to precess in time, this being one indication that what has been observed is, in fact, extra-terrestrial radiation and not mere changes in the ionosphere itself. It is a good plan to run the receiver for several of the observation periods with no aerial connected in order to determine the random variations due to the receiving system itself.

It will be apparent that a pen recorder is a very desirable item of equipment. These can now be purchased for as little as £40, but this may be rather more than the newcomer to this fascinating field is prepared to spend. There is a very excellent amateur designed pen recorder by J. R. Smith. Details of this appear in the *Memoir of the British Astronomical Association*[2] where the author and a number of other contributors cover the field of radio astronomy for amateurs.

The author is at present designing another amateur pen recorder and it is hoped that this may be offered in detail at a later date.

[2] Radio Telescopes: Obtainable from the British Astronomical Association, General Editor, John Heywood, Director of the Radio Electronics Section.

(Conclusion)

RADIO topics

TRANSISTOR RECEIVERS TEND TO appear in a number of different shapes and sizes these days but they have always, in this country at any rate, been immediately recognisable as radios. If the two illustrations which accompany my contribution this month can be taken as a prediction for the future, it may well be that this state of affairs is coming to an end.

The photographs, which came from New York, illustrate a new novelty which has been introduced to the American market by the Japanese firm of Toshiba (Tokyo Shibaura Electric Company), and they illustrate a transistor radio which is built into an imitation baseball. The accompanying news release states that "a sportsman can now take into the field a ball—the one for his particular sport—containing a miniature transistor radio . . . useful for the odd moments of rest during the game!"

Novelty Radios

Despite its unconventional guise, the radio illustrated has a perfectly normal superhet specification apart from the fact that the nominal output power, at 100mW, is a little lower than that which is usually offered by a loudspeaker transistor receiver. Frequency coverage is from 540 to 1,600kc/s (550 to 190 metres), the i.f. is 455 kc/s, and the circuit employs six transistors powered by a 9 volt battery. There is a built-in ferrite aerial, and the case has an outside diameter of 3in. An earphone socket is fitted which provides speaker muting, and the total weight is 7.8ozs with the battery. The tuning and volume controls are inset into the side of the ball, and are readily visible in the photographs. The receiver may be carried by looping the attached cord around the finger, or it may be placed on a three-legged stand which is made up in the form of three baseball bats. The retail price in the States is $30 (approximately ten guineas).

The firm of Toshiba does not stop at radios in the shape of baseballs. Similar receivers may be obtained disguised as tennis balls, hockey balls and cricket balls. What "W.G.G." would have had to say about the last I hesitate to think!

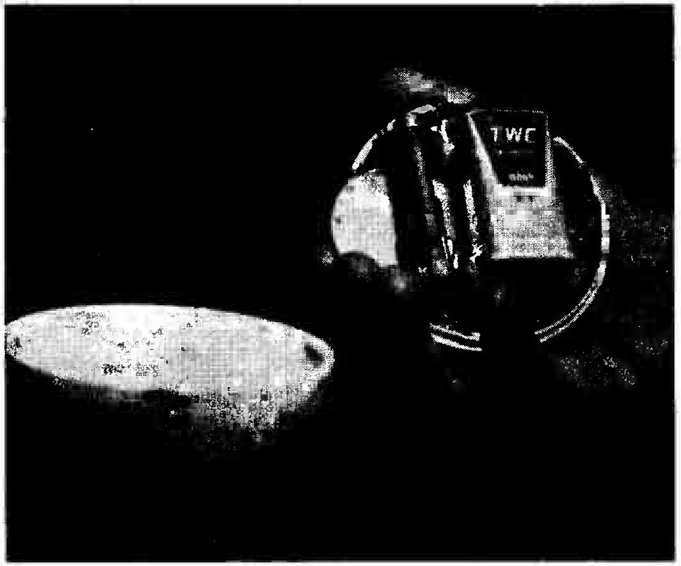
All in all, I think that this is quite a welcome innovation. Miniature broadcast band transistor radios are now pretty well as stabilised in design as was the four-plus-one pre-war valve superhet, and there seems no reason at all why they shouldn't appear in novel and ornamental cases. There's nothing like a bit of completely inconsequential variety to brighten things up a bit in these days of excessively "functional" presentations.

New Horticultural Hall

If rumour is correct, it is quite possible that this year's Radio Hobbies Exhibition will be held at the New Horticultural Hall, Westminster. I wonder if this Show will see the repetition of a peculiar sight which is reported to have taken place at the New Horticultural Hall a few years ago, when the Annual London Medical Exhibition was in progress. It seems that, before the Exhibition opened, a crowd of representatives always congregated around one particular stand where they sampled, out of small paper cups, copious draughts of medicine. The amazing popularity of this tonic, which kept the stand salesmen up to the mark all day, was apparently due to its 16% alcoholic content!*

A New Hazard

The standard British colour coding



The interior of the radio. Despite the unconventional case, the layout and design follow standard lines *(Photos: B.I.P.S.)*

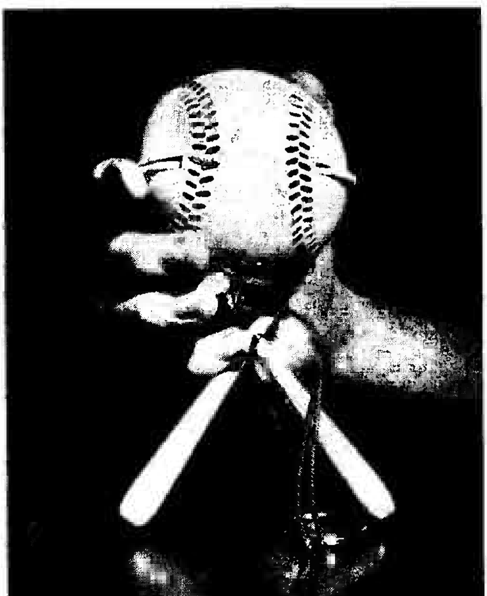
for three-core-flexible electrical appliance cords is, as readers will be aware, Red for Live, Black for Neutral, and Green for Earth. There are, however, a number of imported appliances on sale in this country which employ a different coding, this complying with Continental practice. A typical instance (on which there appear to be one or more variations) is Black for Live, Green for Neutral, and White for Earth.

It is quite possible that an inexperienced person connecting up a lead coded in the Continental manner would put the black lead to neutral and the green lead to earth. He might then assume that the remaining white lead was a variant on red, and connect it to the live terminal. The result would be that the metalwork of the associated appliance would assume live mains potential, this being the most dangerous state of affairs that could possibly exist with domestic equipment.

There are no regulations in this country preventing the sale of appliances having non-standard mains cord coding, despite the considerable danger which can result if they are incorrectly connected to the mains plug. A lot of useful work in this respect is being carried out by Consumers' Association, which refuses to recommend any electrical products they may test which have wrongly coded mains cords but, apart from this, little appears to be done.

Because of the prevailing situation I would suggest that, whenever you purchase any domestic electrical appliance which may be of Continental origin, you check that the apparent earth lead really *is* an earth lead. It is far, far, better to be safe than sorry.

And remember—the domestic mains supply wired into our houses is a killer.



A transistor radio in a "baseball". The stand is made up in the form of three baseball bats

* I am indebted, for this fascinating item of information, to *The Natural History of Quackery* by Eric Jameson (Michael Joseph Ltd.)

You Live and Learn

Over the years, I have rather tended to look upon the connections which are made between valve pins and the corresponding sockets in valveholders as being, like Caeser's wife, above suspicion. Indeed, I have considered such connections as being one of the last reasons for receiver failure. Because of this I must confess that, when a good friend of mine recently told me that he had cleared a completely dead television receiver by cleaning the pins of the turret tuner valves, I raised a mental eyebrow. Nevertheless, I stored the information away in the Recorder memory banks for future use.

It didn't take me long to be converted to my friend's way of thinking. Shortly afterwards, I tackled a television receiver which had the disconcerting habit of losing e.h.t. at odd moments. Whilst the e.h.t. was off the line output transformer still sang away merrily at 10,125 c/s, giving the impression that the line output valve and booster diode were continuing to carry out their functions in correct manner. The e.h.t. rectifier, an EY86, was hidden away in the line output cage, and I couldn't tell whether its heater was alight or not during the periods of failure. Nevertheless, I decided, before going to any further trouble, to remove it and clean up its pins. The process took a few seconds only, and the set has worked perfectly ever since! The fault had obviously been caused by an intermittent contact between one of the heater pins and its socket, this causing the heater to become intermittently extinguished with a consequent loss of e.h.t.

A little later, I encountered a second television set which had an irritating vertical jiggle on the picture. The vertical timebase would lock solid for half an hour at a time, after which there would be several minutes of quite noticeable jitter before the fault cleared up again. The cure was to pull out the vertical timebase triode-pentode, a PCL83, and clean its pins. Result? Complete cessation of jitter!

I must point out that, in both these cases, the cleaning operation on the pins was of a very quick and skimpy nature. I used a small flat carborundum contact file measuring 4 x ½in, and I did little more than lightly touch the pins of the suspected valve with it. Also I applied it only to the pin surfaces which faced adjacent pins. The fact that this simple operation cleared the two snags I've just described gives me the impression that the film which caused the intermittent connections must have broken away in the same manner as rosin can be made to break away from a soldered joint.

I should add that, in the case of the vertical timebase triode-pentode, there was no jitter when I rocked the valve in its holder. For obvious reasons I did not try rocking the EY86!

Bathythermograph Slug Speeds Measurement of Ocean Temperatures

A device for determining temperature variations at different depths of water has been developed and produced by EMI-Cossor Electronics Ltd. of Dartmouth, Nova Scotia. The bathythermograph slug, as the device is known, was originally designed for helping to locate enemy submarines, but it is also of considerable value in gathering oceanographic data.

Conventional method of employing ships to obtain temperature readings is both slow and expensive. By dropping bathythermograph slugs from aircraft, temperature readings over large areas of ocean can quickly be taken.

The bathythermograph package is dropped from the aircraft and, upon hitting the water, the resultant impact releases the slug which, after a delay of one minute, sinks through the water at five feet per second. A temperature-sensitive device within the slug detects changes in sea water temperature and transmits an acoustic signal.

A standard sonobuoy, which may have been dropped for the purpose or is already floating on the water, detects the signal which modulates the sonobuoy transmitter. After demodulation by the aircraft's receiver, the signal is applied to a translator unit. The output from this unit drives a pen recorder which provides a graph of temperature *versus* depth. The depth factor is introduced as elapsed time from the release of the slug.

Power for the electronic circuit is provided by a sea water-activated battery which remains inert until it makes contact with the water when the slug is released. Use of this type of battery enables the slug to be stored for several years before use.

The translator unit in the aircraft operates from a 28V d.c. supply. Transistor circuits minimise the effects of sea noise and multipath interference on the recorded trace. Self-calibration facilities are provided.

Great advantage of using the slug for submarine detection is that most of the methods currently employed are based on measurements of primary or reflected sound energy from the enemy vessel, and such data must be modified by compensation for temperature variations at different depths which influence the propagation speed and path of the sound waves. The bathythermograph slug provides a reliable means of obtaining information regarding these temperature variations, so enabling the target's position to be accurately determined.

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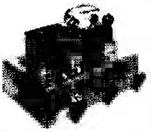

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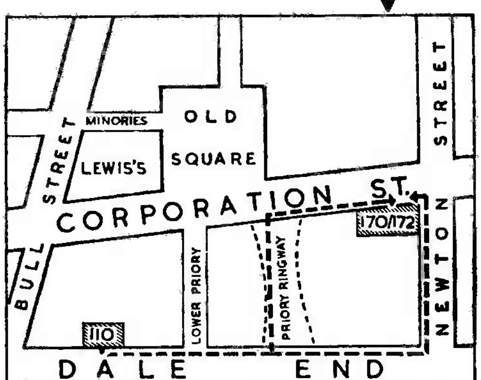

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continued on page 629

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GARRARD AUTOSLIM De-luxe (AT6) (Mono PU) ...	**£11.9.0**	**£2.6.0**	12 of	**16/11**
GARRARD AUTOSLIM De-luxe (Stereo/Mono PU) ...	**£12.5.4**	**£2.9.4**	12 of	**18/-**
B.S.R. UA14 (TC8 Mono PU)...	**£6.19.6**	**£1.7.6**	12 of	**11/-**
B.S.R. UA 14 Monarch (TC8S Stereo/LP/78)	**£7.19.6**	**£1.11.6**	12 of	**12/4**
B.S.R. UA16 (TC8 Mono PU)..	**£7.19.6**	**£1.11.6**	12 of	**12/4**
B.S.R. UA16 (TC8S Stereo/LP/78)	**£8.19.6**	**£1.15.6**	12 of	**13/8**
SINGLE RECORD PLAYERS				
B.S.R. TU12 (TC8 Mono PU)...	**£3.17.6**	**£1.4.6**	3 of	**21/-**
B.S.R. GU7 (TC8 Mono PU) ...	**£4.18.8**	**£1.8.8**	3 of	**£1.6.8**
GARRARD SRP10 (Mono PU)	**£5.9.11**	**£1.12.11**	3 of	**29/-**
TRANSCRIPTION UNITS				
GARRARD 4HF (GC8 PU) ...	**£16.12.6**	**£3.6.6**	12 of	**£1.4.5**
PHILIPS AG1016	**£12.12.0**	**£2.10.0**	12 of	**18/6**

Many of the above can be supplied for stereo working. See our Gramophone Equipment List for details.

● LOUDSPEAKERS

GOODMANS: Axiette 8″, **£5.5.7; Axiom 10″, £6.5.11; 12″, Axiom 201, £10.7.0; 12″, Axiom 301, £14.10.0; 12″, Audiom 51 Bass, £8.14.0; 12″ Audiom 61 Bass, £13.14.0; Trebax Tweeter, £6.4.0; X05000 Crossover unit, £1.19.0.**

WHITELEY: HF1016 10″, £7.0.0; HF1012 10″, £4.7.6; HF816 8″, £6.0.0; T816 8″, £5.13.6; T10 Tweeter, £4.8.3; T359 Tweeter, £1.10.6; CX3000 Crossover unit, £1.11.6; CX1500 Crossover unit, £2. H.P. Terms available on all speakers.

● P.W. STRAND, MAYFAIR & SAVOY UNITS

We stock parts for the P.W. Strand Amplifier, Mayfair Pre-amplifier and Savoy F.M. Tuner. Detailed price lists are available.

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AVO Model 8 with leather carrying case	**£27.18.0**	**£5.12.0**	12 of	**£2. 0.11**
AVO Model 7 Mark II ...	**£21. 0.0**	**£4. 4.0**	12 of	**£1.10.10**
AVO Multiminor	**£9.10.0**	**£1.19.0**	12 of	**14/4**
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TAYLOR MODEL 127A ...	**£10.10.0**	**£2. 2.0**	12 of	**15/8**
CABY A-10	**£4.17.6**	**£1. 7.6**	3 of	**£1. 6.8**
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CABY M-1	**£2.14.0**	—	—	—

Full details of any of the above supplied free on request
The AVO Models 7 and 8 are both latest models from current production—not to be confused with Government Surplus.

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GILSON: W0696A, W0696B, **50/6**, post 2/6. W0710, **55/6**, post 2/6. W0892, **62/3**, post free; W0767, **27/-**, post 1/6. W01796A, **57/6**, post 2/6. W01932, **84/-** post free.

PARTRIDGE: P3667, 75/-; P4131, **65/-**; P5202, P5203, **£5.18.6.** All post free.

PARMEKO: P2629, **47/6**; P2642, **45/-**; P2643, **47/6**. All plus post 2/9. P2641, **29/6**, post 2/-; P2928, **16/-**, post 2/-; P2932, **41/-**, post 2/6.

ELSTONE: OT/ML, **45/-**, post 2/9; OT/3, **25/-**, post 2/6.

● MAINS TRANSFORMERS

GILSON: W0741AB, **63/-**, post free; W0839, **48/9**, post 2/9; W01328 **58/6**, post 3/6; W01288, **58/-**, post 3/6; W01566, **80/-** post free; W01341 (Choke), **36/-**, post and packing 2/-.
PARMEKO: P2631, 35/3, post 2/9; P2630, **54/9**, post 3/3; P2644, **76/6**, post free; P2930, **41/-**, post 3/-; P2931, **56/9**, post 3/3.
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● TERMS OF BUSINESS
Cash with order or C.O.D. We charge C.O.D. orders as follows: Up to **£3**, minimum of 3/2. Over **£3** and under **£5**, 1/6. Over **£5** and under **£10**, 1/8. Over **£10**, no charge. **Postage extra on CASH orders under £3 except where stated. Postage extra on overseas orders irrespective of price.**

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Please note: Postal business only from this address
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are available on any item. Repayments may be spread over 3, 6 or 12 months. Details as follows: Three months; Deposit 6/- in the £. Service charge 5 per cent but minimum charge of 10/-. Six and Twelve months: Deposit 4/- in the £. Service charge 10 per cent, but minimum charge 20/-.

SMALL ADVERTISEMENTS

continued from page 627

TRADE—*continued*

PANL, recognised for many years as the unique one-coat black crackle finish. Brush applied, no baking. Available by post in eighth-pint cans at 3s. 9d. from G. A. Miller, 255 Nether Street, London, N.3.

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JOIN THE INTERNATIONAL S.W. LEAGUE. Free Services to members including Q.S.L. Bureau. Amateur and Broadcast Translation. Technical and Identification Dept.—both Broadcast and Fixed Stations, DX Certificates, contests and activities for the SWL and transmitting members. Monthly magazine, *MONITOR*, containing articles of general interest to Broadcast and Amateur SWLs, Transmitter Section and League affairs, etc. League supplies such as badges, headed notepaper and envelopes. QSL cards, etc., are available at reasonable cost. Send for League particulars. Membership including monthly magazine, etc., 21s. per annum.—Secretary, ISWL, 12 Gladwell Road, London, N.8.

continued on page 631

Model 8 Universal AVOMETER

Designed for Dependability

The Model 8 Universal AvoMeter is a high sensitivity multi-range a.c./d.c. electrical testing intrument providing thirty ranges of readings on a 5-inch hand calibrated scale. Range selection is effected by two rotary switches for a.c. and d.c. respectively.

The instrument has a sensitivity of 20,000 ohms per volt on d.c. voltage ranges and 1,000 ohms per volt on a.c. from the 100-volt range upwards, and meets the accuracy requirements of B.S.S.89/1954 for 5-inch scale length portable industrial instruments. It is robust, compact, and simple to operate, and is protected by an automatic cut-out against damage through inadvertent electrical overload.

VOLTAGE		CURRENT	
D.C.	A.C.	D.C.	A.C.
2.5V	2.5V	50µA	100mA
10V	10V	250µA	1A
25V	25V	1mA	2.5A
100V	100V	10mA	10A
250V	250V	100mA	—
500V	—	1A	—
1,000V	1,000V	10A	—
2,500V	2,500V		

RESISTANCE	
First indication 0.5Ω	
Maximum indication 20MΩ	
0—2,000Ω 0—200,000Ω 0—20mΩ	using internal batteries
0—200MΩ	using external batteries
DECIBELS −15 dB to +15 dB	

Various external accessories are available for extending the above ranges of measurement. Leather carrying cases are also available if required.

Dimensions: $8\frac{1}{8}$" x $7\frac{1}{4}$" x $4\frac{1}{2}$". Weight: $6\frac{1}{2}$ lb.

Write for fully descriptive Folder or for complete Catalogue of AVO Instruments.

AVO LTD

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Tel: VICtoria 3404 (12 lines)

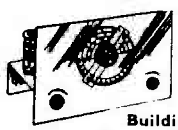
SMALL ADVERTISEMENTS

continued from page 629

TRADE—*continued*

THE INTERNATIONAL HAM HOP CLUB is a non-profit-making organisation open to RADIO AMATEURS AND SHORT WAVE LISTENERS. OBJECT: To improve international relationships through an organised system of hospitality. MEMBERS offer overnight hospitality to visiting members, subscription 10s. per annum. ASSOCIATE MEMBERS invite radio amateurs to visit their stations. Associate membership 5s. per annum. FAMILY EXCHANGE holidays arranged, also FRIENDSHIP LINKS between radio clubs. The Club's official journal is free to both Full and Associate Members.—Hon. Gen. Secretary: G. A. Partridge, G3CED, 17 Ethel Road, Broadstairs, Kent.

ALUMINIUM, BRASS, COPPER AND BRONZE. In sheet, rod, strip, tube, also Stainless Steel sheet. Any size cut. Complete price list, 1s.—Slater Metals (N.F.) Ltd., 17 Slater Street, Liverpool 1.



LISTEN TO THE WORLD on TELSTAR our 1-VALVE SHORT WAVE RADIO Receives speech and music from all over the world. Price includes valve and one coil covering 40–100 metres. Can be extended to cover 10–100 metres. Can be converted to 2 or 3 valve and all-mains speaker use. **Total Building Costs 35/–**, P. & P. 2/–. *Send 2/– for wiring diagram and parts list.*

R.C.S. PRODUCTS (Radio) Ltd., 11 Oliver Road, London, E.17

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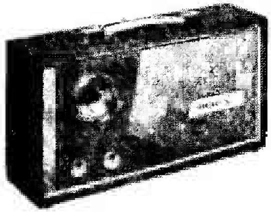
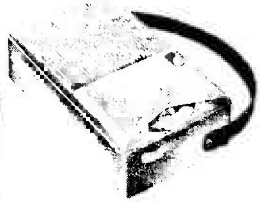
P.W. BEST SETS

P.W. POCKET S'HET

Case 5½ x 3½ x 2 **12/6**

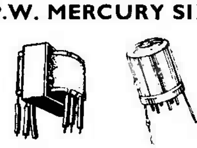




Case 14½ x 7¼ x 3¼ **48/–**

P.W. MERCURY SIX

3 IFS and Osc. **22/–**
Driver and Output **16/3**



For above and all similar transistor circuits

CONSTRUCTIONAL BOOKLETS 2/6 each

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CRYSTAL DIODES STILL ONLY 1/– each.

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450V wkg., wire ended. 32mfd. **3/–**; 16mfd. **2/6**; 8mfd. **1/9**; 1mfd. **2/5**; 8+8mfd. **2/11**; 8+16mfd. **3/–**; 16+16mfd. **3/4**; 24+24mfd. 350V **4/–**; 50mfd. 12V **1/6**; 100mfd. 6V **1/5**.

Mullard capacitors, Polyester/Foil/ and miniature electrolytics. *Send S.A.E. for full details of this exciting new range.*

Full component list **6d.**

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SPECIAL OFFER. New, standard ½MΩ only, d.p. switch **Volume Control, 2/9** ea. **Standard L.F.** Transformers, 3:1 c.t. sec., **12/–** ea.; 5-1 c.t. sec., **12/6** ea. **Midget L.F. Intervalve Transformers,** 3:1 ratio, **7/9** ea.; 5:1 ratio, **8/–** ea. **Midget L.F. Smoothing Chokes,** 5H, 40mA, **6/–** ea.; 10H, 30mA, **6/–** ea. **Repanco L.F. Transistor Transformers,** TT45, TT46, TT47, TT49, **5/–** ea. **Silicon Rectifiers,** 125V r.m.s. in 500mA, **8/–** ea.; 250V r.m.s. in 500mA, **11/9** ea. **Metal Rectifiers,** 250V r.m.s. in at 250mA, **16/–** ea.; 125V r.m.s. in at 60 mA, **6/–** ea.; 125V r.m.s. in at 120mA, **8/–**. **L.T. Rectifiers,** 18V r.m.s. in 1A, **8/9** ea.; 22V r.m.s. in at 2A, **15/–**. **Meter Rectifiers, 10/9** ea. for 1, 5 or 10mA movements—state which required. **Micro Switches,** button or lever types, s.p.d.t. contacts rated 5A, 250V a.c. at **6/–** and **6/9** ea. respectively. **Morse Keys,** ex W.D., with normal and back spacer contacts, **2/9** ea. **Caby Test Meter,** 13 ranges, to 1,200V, a.c. and d.c., to 300mA d.c., to 100k resistance, only **54/–** ea. **Jackson C804 Short Wave Variables,** 25pF, **6/9** ea.; 50pF, **6/9** ea.; 75pF, **7/3** ea.; 100pF, **7/3** ea.; 150pF, **9/–** ea. **Jackson Caliband Dial,** a mechanical bandspread dial, ratios 6:1 and 48:1, complete ready for own calibration, **28/–** ea. **Acos 40 Xtal Mike, 20/3** ea. **Acos 45 Xtal Mike, 21/9** ea. **Japanese Stick Mike,** metal screened body, built-in switch, complete cable, lavalier cord, etc., a beautiful job, **39/6** ea. **Miniature Panel Meters,** clear plastic cases, jewelled bearings, accuracy 2%, silvered dials, black numerals, 0–50μA, **39/6** ea.; 0–500μA, **32/6** ea.; 0–1mA, **27/6** ea.; 0–5mA, **27/6** ea. **Model 200H Multitester,** 19 ranges, to 2,500V d.c. at 20,000 ohms per volt, to 1,000V a.c. at 10,000 ohms per volt, plus current, resistance and capacitance ranges. A superb buy at **110/–**. **Slide Switches,** sub-miniature, **2/3** ea.; miniature, **2/6** ea. **Miniature Edge V.C.,** 3k, 5k or 10k, less switch, **3/4**; same values, with d.p. switch, **5/4** ea. **Group Panels,** miniature 6-way, **9d.** ea.; 18-way, **2/6** ea. **Tagstrips,** 3 tags, **3d.** ea.; 7 tags, **5d.** ea.; 28 tags, **1/4** ea. **Osmor Chassis Cutters,** cut 2 sizes with one punch and die. No. 1 ¾″ & ⅞″, **23/–**; No. 2 1″ & 1⅛″, **26/9**; No. 3 1¼″ & 1½″, **27/3**; No. 4 1¾″ & 2″, **36/3** ea.

Terms of business: Cash with order; C.O.D. 3/– extra; postage extra under £3 total value. General list stamp please.

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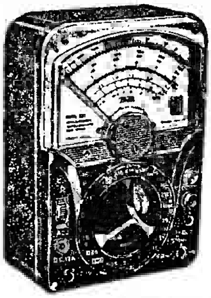

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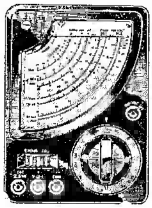
Model 500

8 Ranges D.C. volts to 1 kV. 7 Ranges A.C. volts to 1 kV. 5 Ranges D.C. current to 12 amps. 3 Range resistance to 60 meg. Short circuit buzz test. Output meter dB, etc., etc. Size 6½" x 4¼" x 2¼". With Leads, Batteries and Instructions.



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20,000 ohms per Volt
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Resistance to 6 meg.
Capacity and dB ranges.
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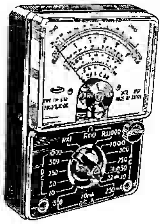

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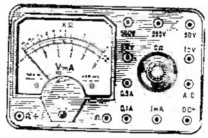
0/10/50/250/500/1,000 volts D.C.
0/10/50/250/500/1,000 volts A.C.
0/500μA/10/250mA., D.C.
Resistance 0/10K/100K/1 meg.
Capacity and dB ranges, etc.
Size 5" x 3½" x 1½" with batteries, test leads and instructions.



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Ideal pocket sized multi-tester for all radio and domestic work.
Size 36" x 2⅜ x 1¼" with battery, leads and instructions.

All Meters Fully Guaranteed for 6 months. Full Service Facilities.

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0–1 milliamp	D.C.	27/6
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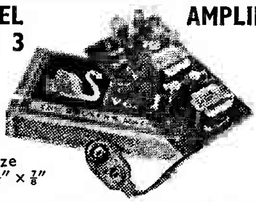

Size 3" x 1¾" x ⅞"

A ready-built miniature 250mW push-pull amplifier incorporating input and output transformers, 4 transistors, 9 volt battery snap cord, speaker and column connection leads. Ideal for use with record players, intercoms, hearing aids, tape recorders, etc. Complete with full instructions and circuit diagram.

PRICE 52/6 P.P. 1/6.

SUITABLE 2½ in. SPEAKER **16/6**

LIGHTWEIGHT HEADPHONES

● 2,000 OHMS **12/6**

● 4,000 OHMS **14/6**

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RUN YOUR RADIO OR AMPLIFIER FROM MAINS. BATTERY ELIMINATORS AND CHARGERS.

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4-Valve Amplifier with 2 watts output per channel to 3 ohms. Ready built, complete with Dials, Sockets and Knobs. Full tone, volume and balance controls. Crystal input. 220/250 volt mains input.

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Suitable 8" x 5" Speakers **49/6** Pair.

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Complete with 5 valves. In new condition. These sets are sold without guarantee but are serviceable.
7.4 to 9 Mc/s. **22/6** P.P. 2/6
Headphones **7/6** pair. Junction Box **2/6.**
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Tubular unit which plugs into earphone socket of any transistor radio. Performance increase is fantastic. Ideal for home or car.
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Speaker output from G.P.O. phone **£5.10.0**

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0/500μA 1⅞" square, d.c.	... ...	39/6
0/1mA 2" square, d.c. ...	... ...	27/6
0/1mA 2¼" f. round, d.c.	... ...	30/–
0/500μA 2¼" f. round, d.c.	... ...	20/–
2½–0–2½mA 2¼ f. round, d.c. ...	... ...	12/6
0/5mA 1⅞" square, d.c.	... ...	27/6
0/40/120mA 2¼", d.c. ...	... ...	10/–
0/15 volts 2¼" M.I., a.c.	... ...	8/6
0/300 volts 1⅞" square, d.c.	... ...	27/6

BATTERY RECORD PLAYERS

● 6-7½ volt Garrard turntable with crystal pick-up. Plays 45 r.p.m.

55/– P.P. 1/6.

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

● G.C. 2-speed 9V. Plays 45 and 33 r.p.m. **5 gns**

● B.S.R. 4-speed 9V. **£6.** 16, 33, 45 & 78 r.p.m.

HENRY'S RADIO LTD

PADdington 1008/9
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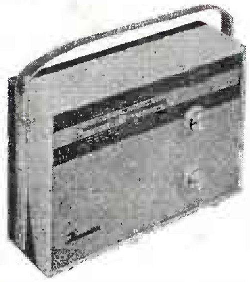

The fabulous 'Contessa' Mk. III

★ ***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

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NOW FITTED RECORDING SOCKET AND CAR AERIAL SOCKET

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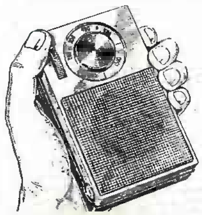

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TRANSFIVE PORTABLE as previously advertised. All parts **£5.19.6,** p.p 2/6.

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Special offer of brand new 6-transistor pocket radio. With leather case and phone. Tested and ready to use. **£5.10.0**
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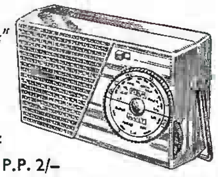
NEW 44 PAGE 10¾" x 7¼" ILLUSTRATED CATALOGUE FULL OF COMPONENTS AND UNITS. 1/- POST FREE

"QUINTET" MEDIUM AND LONG WAVE POCKET RADIO

PUSH-PULL SPEAKER OUTPUT



Size 5¼" x 3" x 1¾"

Red or Blue with Gold trim

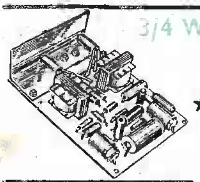
Total Cost
79/6 P.P. 2/-

New Improved 5-Transistor and Diode Medium and Long Wave Printed Circuit Loudspeaker Radio. Features Ediswan transistors and plainly marked printed circuit with carded components. Now with better quality and greater sensitivity. Excellent results with full station separation guaranteed. Including Radio Luxembourg. Push-pull output up to 200mW. Fitted phone/record socket and car aerial socket.

Leaflet on request.

Full after-sales service and guarantee.

3/4 WATT TRANSISTOR AMPLIFIER



★ 1½ watt peak output.

± 3dB 70 c/s to 12 kc/s.

Output to 3 ohm speaker.

9 volt operated.

Details on request.

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

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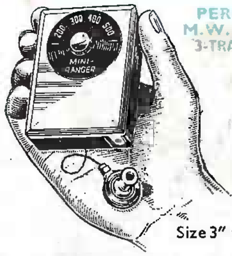
IT'S TINY BUT POWERFUL "MINIRANGER"

PERSONAL M.W. RADIO 3-TRANSISTOR, 2-DIODE



Size 3" x 2" x ¾"

The smallest printed circuit transistor radio available for home construction. Full coverage of Medium waves and top band without any aerial or earth. Fitted calibrated dial, volume control and 9 volt battery. All stations including Radio Luxembourg are received with amazing clarity. Pre-tinned printed circuit clearly marked with component details.

● **Simple to Build** ●

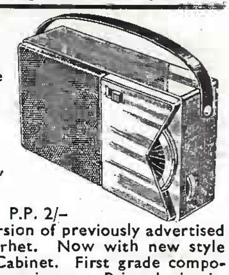
Guaranteed Amazing Results

TOTAL COST OF ALL PARTS **49/6** P.P. 1/6

● Designed for your top jacket pocket ●

Circuit Diagram Free on Request

Medium and Long Wave Superhet Radio



Size 5¾"x3⅜"x2"

£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 2½" quality speaker and new illustrated building instructions.

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