

THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 16 NUMBER 12
A DATA PUBLICATION
PRICE TWO SHILLINGS

July 1963

Economy Tape Recorder

Also featured

Converting Battery Portables
to Transistor Operation

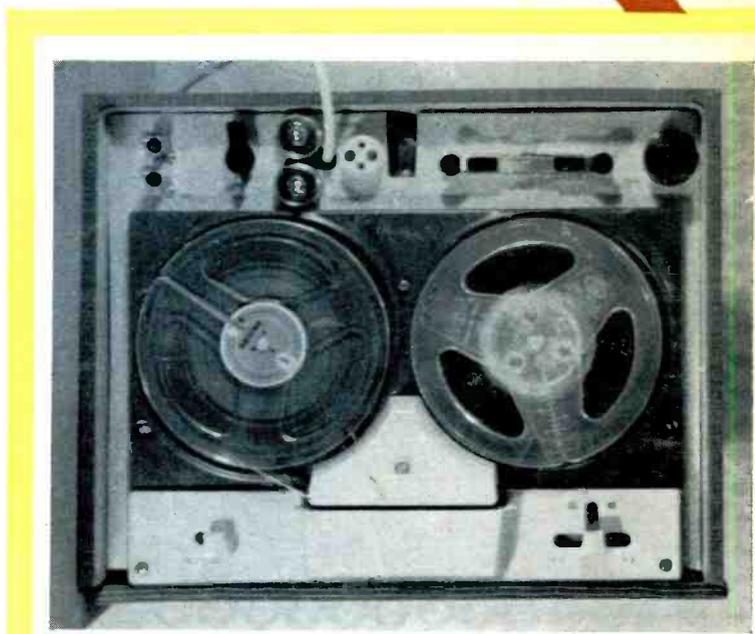
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Small Kitchen Radio for
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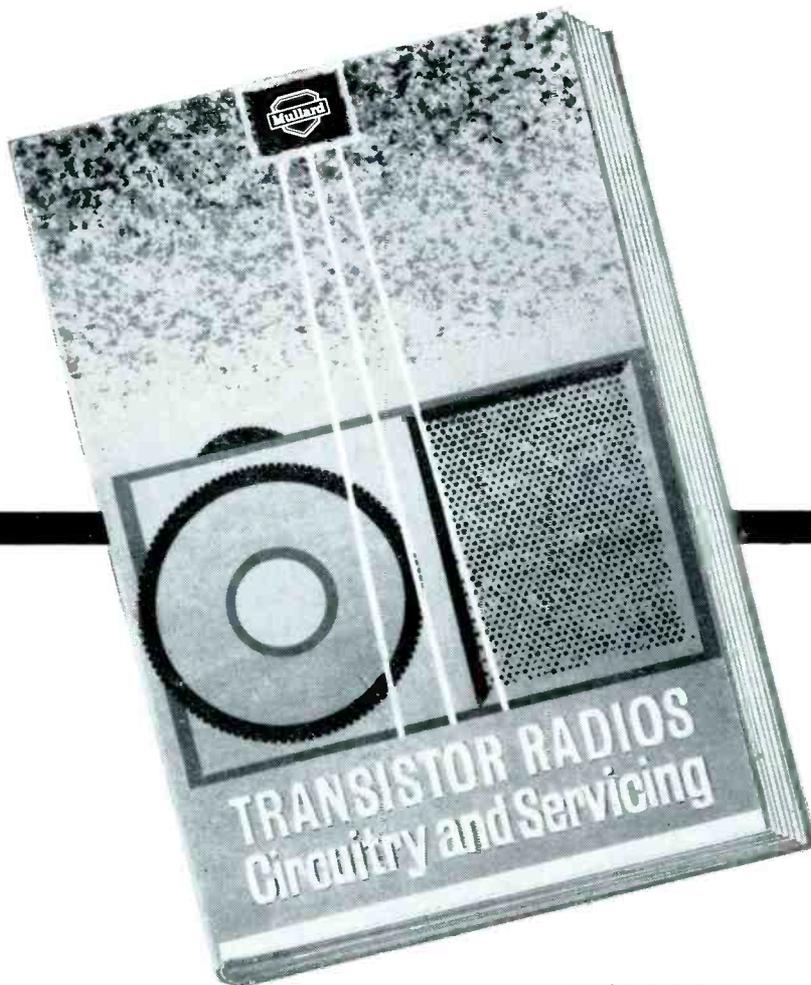
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Starting with a description of the basic properties of semi-conductors, the book explains the action of a transistor in detail and without recourse to complex mathematics. The circuits used in transistor radios are described, and the techniques for servicing these sets are considered.

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Mfrs.' end of production Surplus Offer

A 24 gns. Tape Recorder offered at the bargain price of only 15 gns. plus 10/- Carr. Supplied in 3 Units already wired and tested. A modern Circuit for quality recording from Mike, Gram or Radio, using latest B.S.R. Twin Track Monardeck Type TD2.

Valve line-up—EF86, ECL82, EM84, EZ80 and Silicon Diode.

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2 tone Cabinet and 8" x 5" Speaker. Size 14" x 10 1/2" x 7 1/2" £3 10 0 + 5/- Carr.

Wired Amplifier complete with 4 Valves, front Panel, Knobs, etc. £5 12 6 + 3/6 Carr.

B.S.R. Monardeck Type TD2 £7 7 0 + 4/6 Carr.

Accessories: Mike, Tape, empty Reel, screened Lead and Plugs, Instructions, etc. £1 0 0 + 2/- Carr.

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1R5	7/6	ECL82 10/6	PCF80 9/6	50/12V	1/9	16+16/450V 5/6
155	7/6	ECL80 10/6	PCL83 12/6	50/50V	2/-	32+32/275V 4/6
354	7/6	EF80 8/-	PCL84 12/6	100/25V	2/-	50+50/350V 6/6
3V4	7/6	EF86 12/6	PL81 12/6	8/450V	2/3	60+250/ 275V
DAF96	9/-	EL84 8/6	PL82 9/6	16+16/450V 5/6	100+300/ 275V	12/6
DF96	9/-	EY51 9/6	PL83 10/6	32+32/450V 6/6	275V	12/6
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DL96	9/-	EZ81 7/6	PY81 9/6			3/6
ECC81	8/-	GZ32 12/6	PY82 7/6			
ECC82	8/-	EM84 9/6	U25 12/6			

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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
5 1/2" 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/-, 5 1/2" 2/-, 7" 2/3. Plastic Spool Containers 5" 1/9, 5 1/2" 2/-, 7" 2/3

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

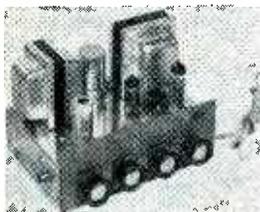
Phono Plugs 1/-. Phono Sockets (open), 1/-, Ditto Closed, 1/6. Twin Phono Sockets (open), 1/6.

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.

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MULLARD "3-3" HI-FI AMPLIFIER



3 VALVES 3 WATT

3 ohm and 15 ohm Output
A really first-class Amplifier giving Hi-Fi quality at a reasonable cost. Mullard's latest circuit. Valve line-up: EF86, EL84, EZ81. Extra H.T. and L.T. available for Tuner Unit addition. This is the ideal companion Amplifier for FM tuner units.

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

COMPLETE KIT (incl. valves, all components, wiring diagram and special quality sectional Output Trans.) ONLY £6.19.6 carr. 4/6.
Complete wired and tested, 8 gns. Wired power O/P socket and additional smoothing for Tuner Unit, 10/6 extra.

Bronze Escutcheon Panel, Printed Vol., Treble, Bass, On/Off, supplied with each Kit.
Recommended Speakers—R. & A. 12" with tweeter £2/6, WBFH10-12 £4.7.6, Goodmans Axietee £5.5.0, Axiom 10 £6.5.0. Carr. extra

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

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

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 2 1/2" E.M.I. 17/6. Goodmans 3 1/2" 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 gilt anodised metal 1/2" x 1/2" diamond mesh, 4/6 sq. ft., multiples of 6" cut. Max. size 4' x 3' 47/6 plus carr.
TYGAN FRET (cont. pat.) 12" x 12" 2/-, 12" x 18" 3/-, 12" x 24" 4/-, 18" x 18" 4/6

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Single Players carr. 3/6
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Collaro Jnr. 65/-
Auto-Changers carr. 5/-
Garrard AT6 Mono 9 gns.
Garrard 'Auto-Slim' £6.15.0
B.S.R. (UA14) £6.10.0

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Contemporary style, rexine covered cabinet in mottled red and white polka dot. Size 18 1/2" x 13 1/2" x ht. 8 1/2", fitted with all accessories including baffle board and anodised metal fret. Space available for all modern amplifiers and auto-changers, etc. Uncut record player mounting board 14" x 13" supplied.
Cabinet Price £3.3.0 Carr. and Ins. 5/-

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Twin stage ECL82 with vol. and neg. feedback tone control. A.C. 200/250V with knobs, etc., ready wired to fit above cabinet. £2.17.6. P. & P. 1/6. 6" Speaker and trans, 22/- P.P. 2/-

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BONDACOUST Speaker Cabinet Acoustic Wadding 12" wide, any length cut 1/6 ft., 4/- yard.

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Osc. Coil—1/8" diam. M/VV. 5/3
Osc. coil M. & L.W. 5/9
Midget Driver Trans. 3.5:1 6/9
Diato O/Put Push-pull 3 ohms 6/9
Elect. Condensers—Midget Type 12V 1mfd-50mfd, ea. 1/9. 100mfd, 2/-, Ferrite Aerial—M. & L.W. with car aerial coupling coil, 9/3.

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

Tuning Condensers. J.B. "000" 208+176pF, 8/6. Ditto with trimmers, 9/6. 365pF single, 7/6. Sub-min. 1/2" DILEMIN 100pF, 300pF, 500pF, 7/-, Midget Vol. Control with edge control knob, 5kΩ with switch, 4/9, ditto less switch, 3/9.

Speakers P.M.—2" Plessey 75 ohms, 15/6. 2 1/2" Continental 8 ohms, 13/6. 7" x 4" Plessey 35 ohm, 23/6.

Ear Plug Phones—Min. Continental type, 3ft. lead, jack plug and socket, High Imp. 8/-. Low Imp., 7/6.

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OC81	7/6	GEX34	2/9
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SPECIAL OFFER

OC44	15/6	OC81D	15/-
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SB-10U



DX-40U



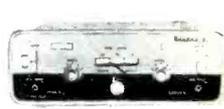
GD-1U



S-33



COLLARO



TA-1S

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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O-12U



S-3U



C-3U



AG-9U



"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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GARRARD AUTO/RECORD PLAYER, Model AT-6. With Ronette 105 cartridge. **£13.12.1** With Decca Deram pick-up **£14.6.1**

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4 W-B TRANSISTOR PORTABLE RECEIVER. Model RSW-1. In a handsome leather case it has retractable whip aerial and socket for car radio use. Covers Med., Trawler and two S wave bands. **£19.17.6**

HI-FI SINGLE CHANNEL AMPLIFIER. Model MA-12. 12W output, wide freq. range, low distortion. **£11.9.6**

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



MA-12



RSW-1

250

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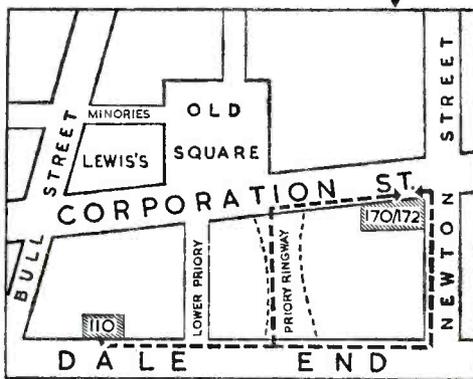
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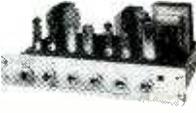
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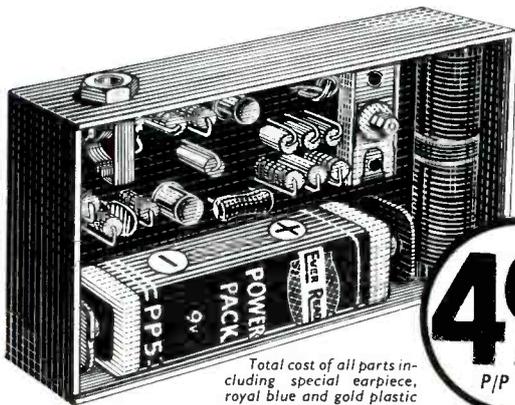
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TECHNICAL QUERIES must be submitted in writing. We regret that we are unable to answer queries, other than those arising from articles appearing in this magazine; nor can we advise on modifications to the equipment described in these articles.

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

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Converting Battery Portables to Transistor Operation

By T. Snowball

There must be many constructors who have available one of the four valve battery portables which were popular some years ago. These receivers have good cabinets, speakers, and other components, and their main disadvantage is heavy battery expenditure as compared with transistor receivers. In this article our contributor describes the steps needed to convert a battery valve receiver to transistor operation, and he deals, in particular, with his own conversion of a typical receiver, in which many of the original components are retained. Conversions of this nature are not, of course, possible with printed circuit battery valve receivers (unless the reader is prepared to build a new chassis). Also, they should only be undertaken by those constructors who fully appreciate the principles involved and who have the technical ability to carry out the work involved.

THIS ARTICLE IS WRITTEN FOR THE CONSTRUCTOR who wishes to make a transistor radio on a small budget and who has available, or can obtain, one of the small valve battery portables popular a few years ago. These sets, with their 1.5V valves, often had quite good cabinets, and their size is no drawback these days since most of the transistor sets which give reasonable reproduction are housed in cabinets at least as large.

Depending on the amount of work the constructor is technically able to carry out, the conversion could be carried out for as little as £3 without buying any sub-standard components. The only new parts that are essential are the transistors, a new volume control, and various capacitors and resistors.

The modified circuit consists of a fairly normal mixer stage, followed by a "cascode" transistor i.f. stage. The signal is then detected and fed to an emitter follower feeding the volume control. From

this point the signal is passed to the a.f. and output stages. These stages can employ a standard push-pull Class B circuit, using driver and output transformers; or they can use a special complementary output circuit employing a more expensive transistor but no driver transformer, and which may, therefore be of similar cost.

Circuit Details—The Mixer Stage

It helps, with this stage, to have the original circuit, but if this is not available a copy should be made to enable the switching to be correctly rewired. In the modified mixer aerial stage the normal transistor circuit techniques are used; that is, matching from the high impedance of the aerial tuned circuit into the low impedance of the mixer base. In Fig. 1, which shows the complete circuit of the modified receiver, forward bias for the mixer, TR₁, is provided by R₁ and R₂, the emitter time constant (R₃C₆) being chosen to prevent squegging and to provide d.c. stabilising. The oscillator coil is loosely coupled to the transistor in order to maintain its Q, and the i.f. is extracted from the collector circuit. If a frame aerial is used, an additional coupling winding (L₃) of 2 to 3 turns must be interwound with the existing windings. The added turns need not be neatly wound, and it is in fact better if they cover both the Medium and Long wave portions of the frame aerial. If the set is rather more modern and has a ferrite rod aerial, approximately 10 turns should be wound on the centre of the rod near the Long wave winding. This can then be slid along the rod in order to obtain the best coupling.

In redesigning the oscillator coil, the original coupling winding will have to be removed and replaced by the collector and emitter coupling coils. Since the usual valve oscillator coil has only a dust core, and not a pot core as in the normal transistor



The battery portable receiver modified to transistor operation by the author

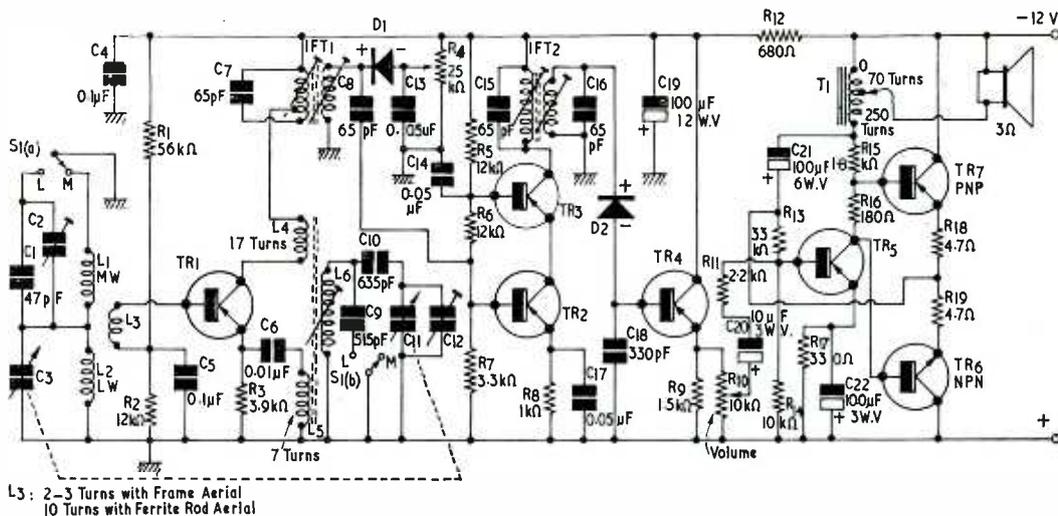


Fig. 1. The modified receiver circuit, employing a complementary output stage. The aerial and oscillator circuit shown will vary with different receivers

Components List (Fig. 1)

Resistors

(All fixed resistors 10% $\frac{1}{4}$ watt, unless otherwise stated. Some resistors may be obtained from the original receiver circuit.)

R ₁	56k Ω
R ₂	12k Ω
R ₃	3.9k Ω
R ₄	25k Ω pre-set pot.
R ₅	12k Ω
R ₆	12k Ω
R ₇	3.3k Ω
R ₈	1k Ω
R ₉	1.5k Ω
R ₁₀	10k Ω pot, log track, vol. control (with switch if required)
R ₁₁	2.2k Ω 20%
R ₁₂	680 Ω 20%
R ₁₃	33k Ω
R ₁₄	10k Ω
R ₁₅	1.8k Ω
R ₁₆	180 Ω
R ₁₇	330 Ω
R ₁₈	4.7 Ω
R ₁₉	4.7 Ω

Transistors

TR ₁	OC44, XA102, AF117, GET874
TR ₂	OC45, XA101, GET873
TR ₃	AF117, SB305
TR ₄	OC71, NKT255, GET114
TR ₅	OC71, NKT254, GET114, OC81D
TR ₆	OC140, NKT751
TR ₇	OC72, NKT257, OC81

Capacitors

(Some capacitors may be obtained from the original receiver circuit)

*C ₁	47pF
C ₂	Trimmer
C ₃	Aerial tuning
C ₄	0.1 μ F
C ₅	0.1 μ F
C ₆	0.01 μ F
*C ₇	65pF
*C ₈	65pF
*C ₉	515pF
*C ₁₀	635pF
C ₁₁	Oscillator tuning
C ₁₂	Trimmer
C ₁₃	0.05 μ F
C ₁₄	0.05 μ F
*C ₁₅	65pF
*C ₁₆	65pF
C ₁₇	0.05 μ F
C ₁₈	330pF
C ₁₉	100 μ F 12V wkg. electrolytic
C ₂₀	10 μ F 3V wkg. electrolytic
C ₂₁	100 μ F 6V wkg. electrolytic
C ₂₂	100 μ F 3V wkg. electrolytic

* Capacitor values in receiver modified by author. Alternative values in other other receivers should be retained.

Diodes

D ₁	OA5, OA10, OA47
D ₂	OA70, OA81, GEX35

Inductors

- L₁, L₂ Existing frame or ferrite rod aerial
- L₃ Additional coupling winding
- †L₄, L₅ Additional coupling windings
- †L₆ Existing oscillator tuned coil
- †IFT₁ Existing first i.f. transformer (modified)

coil, the coupling co-efficient will be low. In consequence, with the average oscillator coil, the collector winding (L₄) needs to have approximately 17 turns and the emitter winding (L₅) 7 turns. A fine gauge of wire (32–38 s.w.g.) should be used, and the additional windings should be positioned at the earthy end of the existing coil. The padding and band switching components remain the same as in the valve circuit. If the constructor feels uncertain about this modification, he can purchase a normal transistor oscillator coil. (Some receivers may have oscillator coils having both medium and long wave windings. In this instance, it will probably be simpler to replace such a coil with a normal transistor oscillator coil and use the padded oscillator circuit shown in Fig. 1.)

In the collector circuit of TR₁ is an i.f. transformer tuned to 470 kc/s, whereupon we now enter on the design of the modified i.f. circuit.

The I.F. Stage

In the i.f. stage the ultimate requirement is to find a circuit which will use the existing transformers without modification and which will, at the same time, provide adequate sensitivity and selectivity without excessive expenditure on transistors and other components. In practice, this was found to be impossible, but the circuit used by the author

- IFT₂ Existing second i.f. transformer
- T₁ Existing output transformer (re-wound)

† If modifications to the oscillator coil and first i.f. transformer are not to be undertaken, standard transistor components may be employed. The oscillator coil could, for instance, be Weyrad P50/1, and the first i.f. transformer Weyrad P50/2.

meets all the above points with the exception that the first i.f. transformer needs two simple modifications.

The i.f. transformers, as used in a valve receiver, must have high impedance circuits feeding and loading them in order to provide adequate power gain and selectivity. Such transformers do not fit readily into transistor circuits because the impedance values normally encountered are:

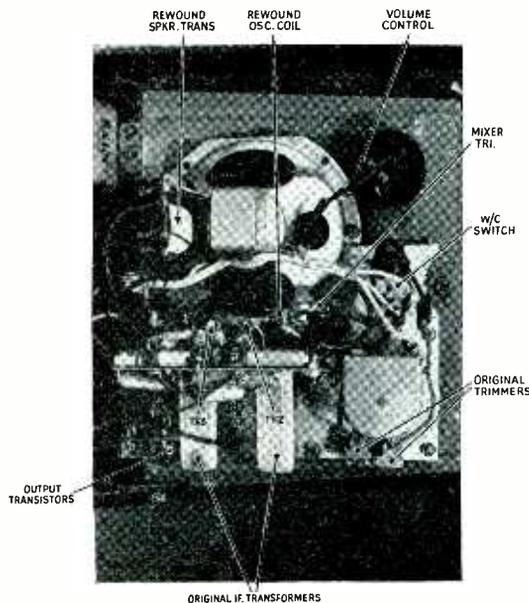
Mixer Z_{out} ≈ 35kΩ I.F. Amplifier Z_{in} ≈ 1kΩ

I.F. Amplifier Z_{out} ≈ 30kΩ Detector Z_{in} ≈ 2.5kΩ. Because of these low impedances, direct connection of valve i.f. transformers into transistor circuits would cause excessive loss of gain. In the normal two stage i.f. transistor amplifier, tapped transformers are employed, these giving an overall gain of approximately 60dB from the i.f. input to the diode detector.

However, by using a "cascode" i.f. stage (which gives high Z_{out}) together with a diode plus emitter follower detector stage (which gives high Z_{in}) it becomes possible to use the second i.f. transformer unmodified. We thus obtain a single i.f. stage with a Z_{in} of approximately 1kΩ and a Z_{out} of approximately 500kΩ, providing about 45dB gain up to the diode. The emitter follower (TR₄ in Fig. 1) will give another 12 to 17dB, thus giving an overall gain at least equal to the normal configuration. Of course, this arrangement uses one extra transistor, but it is only a simple audio type.

Because of the very high gain in the "cascode" stage, a low feedback transistor is necessary for the grounded base position (TR₃), suitable types being the Mullard AF117 or surface barrier types such as the SB305, etc. The feedback in the grounded emitter stage (TR₂) is negligible, as the voltage gain is very low. This stage mainly offers current gain, and a normal i.f. type, such as the OC45 or XA101, is satisfactory.

The first i.f. transformer is still a problem, but by tapping the primary and using capacitive coupling with the secondary, matching can be carried out without a loss of selectivity or gain. As the first transistor in the cascode stage looks, to the i.f. transformer secondary, as 1kΩ with a capacitance of 800pF across it¹, a very convenient method of obtaining impedance matching into the tuned circuit consists of connecting the tuning capacitor direct to the transistor base, as shown in the diagram. This gives a capacitive tap of approximately 10:1



Showing the component layout of the modified receiver

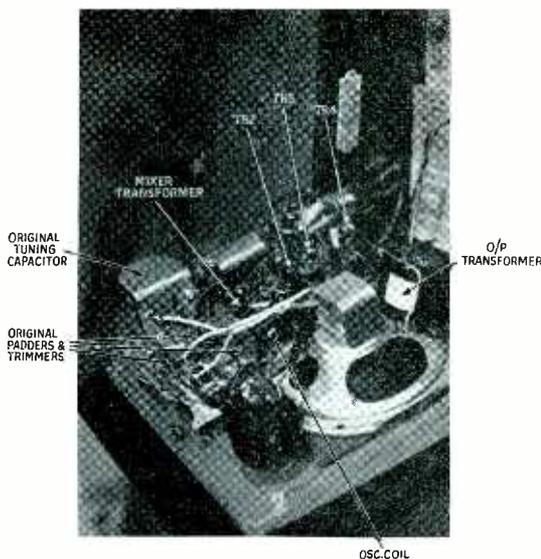
¹ See, for instance, the characteristics for a typical i.f. transformer such as the OC45. At V_{ce}=6V and I_e=1mA, this has an r_{b'e} of 1.3kΩ, and a c_{b'e} of 1,000pF. (The low value of r_{bb'} in series has little effect on circuit operation.) Under the conditions in the cascode circuit, input impedance would be approximately 1kΩ and 800pF.

without disturbing the resonant frequency. The tuning capacitance now becomes 65pF in series with 800pF, this being equal to 61pF, which can easily be allowed for by a slight readjustment of the transformer core.²

In the mixer collector circuit it was found necessary to tap the primary of the first i.f. transformer. Theoretically, the position of the tap can be calculated but, unless items such as Q, bandwidth and transistor Z_{out} , are accurately known, this is quite a difficult job. Practically any tap from the whole coil to a centre tap will probably be suitable, but the author used about 30 to 50%. This is arrived at by stripping the i.f. transformer and unwinding about $\frac{1}{4}$ to $\frac{1}{2}$ of the primary coil, and then rewinding. Neatness of rewinding is not of prime importance and the whole job should only take half an hour or so. Care is needed to identify the dead end of the coil, which is, of course, the inner end. This is the end which is untouched when modifying and which is connected to the negative supply rail. Also, on the secondary winding, the tuning capacitor has to be disconnected from the tuned circuit at the earthy end and brought out for connection to the base of TR₂, as just described. Once again, a standard transistor i.f. transformer could replace the valve component if the constructor thinks this is easier than carrying out the modification.

A.G.C. is obtained in two ways. Firstly, the detector diode (D₂) is connected so as to turn on the emitter follower (TR₄) as signal level increases. This has two effects. Firstly, the signal handling capabilities are increased and, secondly, the impedance that the emitter follower presents to the diode is reduced as signal level increases. This reduced impedance damps the second i.f. transformer, thus lowering the gain and broadening the bandwidth on strong signals. The latter are normally local stations, which will benefit from the wider bandwidth and be reproduced with increased fidelity. The amount of damping is affected by the emitter load R₉, and the value of 1.5kΩ was arrived at by experiment. This may seem rather an incorrect approach, but the aim here is to present a load of 1MΩ or more to the tuned circuit and, since the transistor has to start at a very low current, the normal design parameters are not applicable. To determine the required value for R₉, this resistor is experimentally reduced in value, whilst listening to a weak station, until it just starts to affect the sensitivity. Larger signals will then cause damping by the lower input impedance which they themselves cause. On large signals the emitter follower will present an impedance of $\alpha' R_E$, or approximately 50kΩ, to the diode. This will be reflected on the tuned circuit as approximately 25kΩ damping.

² The method of connection described here assumes that the secondary of the first i.f. transformer has a parallel tuning capacitance of 65pF, as occurred with the receiver converted by the writer. A match which is sufficiently accurate for all purposes should, in practice, be given for secondary tuning capacitances ranging from 50 to 120pF.



Another view of the receiver

The a.g.c. action provided by the diode and emitter follower is only moderate, and for very strong signals overloading can occur in the i.f. stage. In consequence, a second method of obtaining a.g.c. is incorporated, and it is carried out by the reverse biased diode, D₁, connected to the secondary of the first i.f. transformer. The back bias is adjusted while listening to a weak signal until sensitivity is just affected. Larger signals will then cause the diode to conduct and drop in impedance, thus damping the first i.f. transformer secondary and reducing gain. The amount of a.g.c. action given by this circuit depends on the diode impedance changing rapidly as the signals increase in amplitude. Diodes with steep forward characteristics are best, and suitable types are the OA5, OA10 or OA47.

The Audio Stages

The volume control could have a value of 1.5kΩ and thereby save a component by also acting as emitter load for TR₄, but such a value is unlikely to be obtainable in practice. A standard value of 10kΩ is, therefore more suitable from this point of view. Also, it gives a higher driving impedance, at positions other than maximum gain, for the a.f. stages, and thus ensures correct current drive. The 2.2kΩ resistor, R₁₁, supplements the volume control resistance in the case of maximum volume.

The output stage after the volume control can either be a complementary output circuit, as in Fig. 1, or a standard single ended push-pull circuit. Both give approximately 250mW for the same current consumption. If the constructor has a suitable driver transformer available, the choice will be decided for him. In either case the original valve transformer will have to be rewound, in order to drive the 3Ω speaker from the transistor output impedance.

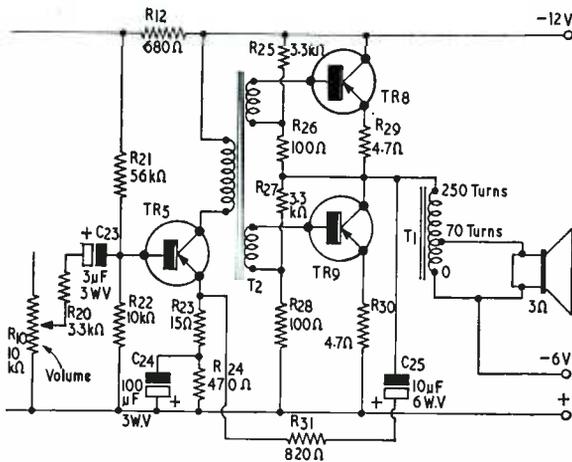


Fig. 2. An alternative output stage using a conventional Class B circuit

Components List (Fig. 2)

Resistors

(All fixed values 10% $\frac{1}{4}$ watt, unless otherwise stated)

- R₁₀ As Fig. 1
- R₁₂ As Fig. 1
- R₂₀ 3.3k Ω 20%
- R₂₁ 56k Ω
- R₂₂ 10k Ω
- R₂₃ 15k Ω
- R₂₄ 470 Ω
- R₂₅ 3.3k Ω
- R₂₆ 100 Ω
- R₂₇ 3.3k Ω
- R₂₈ 100 Ω
- R₂₉ 4.7 Ω
- R₃₀ 4.7 Ω
- R₃₁ 820 Ω 20%

Capacitors

- C₂₃ 3 μ F 3V wkg. electrolytic
- C₂₄ 100 μ F 3V wkg. electrolytic
- C₂₅ 10 μ F 6V wkg. electrolytic

Inductors

- T₁ As Fig. 1
- T₂ Driver transformer, separate secondaries

Transistors

- TR₅ As Fig. 1
- TR_{8, 9} OC72 or OC81, matched pair

Designing for an output of 250mW with a supply of 12V, and allowing 1.5V minimum for each transistor and emitter resistor, it can be assumed that a swing of 9V peak-to-peak will be supplied to the output transformer.

$$\text{Watts} = \frac{(V_{r.m.s.})^2}{\text{Load Resistance}}$$

$$\therefore \text{Load Resistance} = \left(\frac{9}{2\sqrt{2}}\right)^2 \times \frac{1}{250 \times 10^{-3}} = 40\Omega$$

From this figure of 40 Ω , the design of the output transformer can proceed. In other words, the transformer should present an impedance of 40 Ω at the lowest frequency which the speaker can reproduce which, in this case, will be about 130 c/s.

For $X_L = 40\Omega$ at 130 c/s (where $X_L = L\omega$ and $\omega = 2\pi f$)

$$L = \frac{X_L}{2\pi f} = \frac{40}{2\pi \times 130} = 50\text{mH}$$

This inductance can easily be obtained from the previous speaker transformer because, with the normal core section of approximately $\frac{1}{2}$ in square, an inductance of 50mH is given by only 250 turns.

The matching required is 40 Ω to 3 Ω , or a ratio of $\frac{40}{3} = 3.6:1$, so an autotransformer winding is most

suitable. With 250 turns as the complete winding, a tap is therefore required at 70 turns to feed the speaker.

A low resistance is required in the windings if the transformer is to be efficient, and this is achieved by making the 250 turns fill the bobbin. It should be found that wire from 26 to 32 s.w.g. will be suitable.

The normal push-pull circuit has been explained many times but the complementary stage is rarely dealt with and a circuit description may help.

In Fig. 1 the two output transistors, TR₆ and TR₇, are each passing a small current determined by the voltage drop across the 180 Ω resistor R₁₆, which separates the bases. This voltage drop is, in turn, set by the collector current of the driver stage.

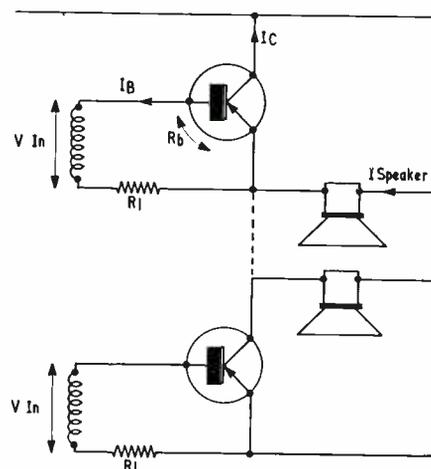


Fig. 3. Illustrating the need for matched transistors in the Class B output stage

TR₇, the p.n.p. transistor, handles the negative parts of the signal, and TR₆, the n.p.n. transistor, the positive parts. If the junction of TR₆ and TR₇ needs to sit at 6V above the positive supply line, the V_c of TR₅ is 5.7V. The 33kΩ and 10kΩ resistors, R₁₃ and R₁₄, will then give a base potential of

$$\frac{6 \times 10}{43} = 1.4V. \text{ So TR}_5 \text{ emitter voltage becomes}$$

$$1.2V, \text{ giving an } I_c \text{ of } \frac{1.2}{0.33} = 3.5mA. \text{ It then follows}$$

that the total collector resistance to provide a V_c of 5.7V is $\frac{12-5.7}{3.5 \times 10^{-3}} \approx 2k\Omega$. This is made up by the

1.8Ω load resistor, R₁₅, and the 180Ω bias resistor, R₁₆, which prevents crossover distortion. The 33kΩ resistor R₁₃ provides, therefore, both d.c. feedback to give temperature stability and a.c. feedback to improve quality. The output signal which exists at the emitters of TR₆ and TR₇ is "boot-strapped" to the speaker transformer and the top of the driver load via C₂₁, thus keeping constant the a.c. voltage across the collector load.

This combination of transistors provides high gain, with good quality and simple circuitry.

An alternative to the complementary output stage is the standard single-ended Class B arrangement, and a suitable circuit is given in Fig. 2. It will be noted that the driver transformer, T₂, requires two separate secondaries. The circuit of Fig. 2 employs the same modified output transformer as is used in Fig. 1.

Construction

The original chassis, complete with tuning capacitors, wavechange switch, and i.f. transformers, etc, should be retained for the modification. The valveholders should be left in place because they act as convenient tagboards for the resistors, transistors and other new components.

Modification of the oscillator coil, the first i.f. transformer and the speaker transformer has already been described, and needs no further comment here. A new volume control is required, and this may need to have an on/off switch attached. With the writer's receiver such a switch was not necessary, as the receiver had a lid-operated on/off switch.

Type PP1 batteries, or equivalents, will probably be the best fit within the cabinet, and should give a life of several months. However, since the output stage is Class B, consumption will rise with volume, and decrease battery life.

It may be stated that a conversion of the type described in this article is quite possible with most types of 1.5V battery valve portables, and that only moderate expenditure is involved. The sensitivity of the modified receiver will be up to standard but the a.g.c. will not, perhaps, be as good as with a normal transistor set. The conversion also calls for technical skill and should not be

attempted unless the constructor has sufficient experience to be able to carry it out successfully.

Output Transistor Matching

Since many constructors will be unfamiliar with the complementary output stage described above, it is felt that some additional notes discussing output transistor matching would be of value. These notes are appended for general interest, and deal with the fact that matched output transistors are not required for the circuit of Fig. 1.

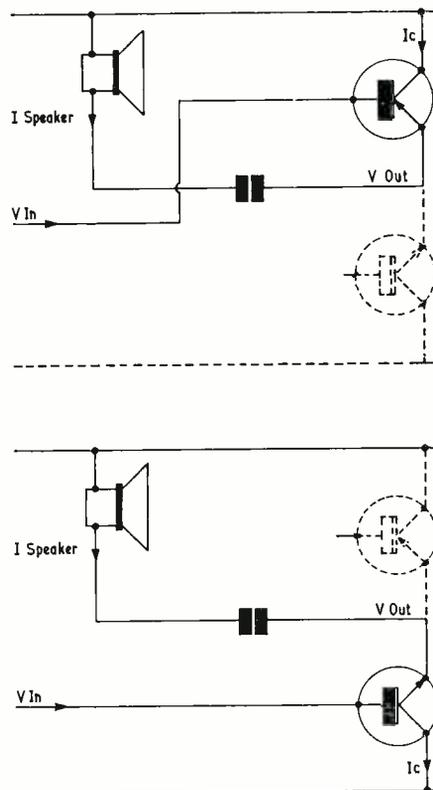


Fig. 4. In the complementary output stage, the transistors function as emitter followers and do not require to be closely matched

In the normal push-pull Class B output stage it is well known that the two transistors should be matched. Fig. 3 shows the circuit divided into separate parts, and demonstrates that

$$I_{spkr} = I_c = \alpha' \times I_b$$

$$\text{But } I_b = \frac{V_{in}}{R_b + R_1}$$

$$\therefore I_{spkr} = \frac{\alpha' V_{in}}{R_b + R_1}$$

This shows that the output current definitely depends on the transistor α' and on R_b, which is the transistor base resistance. In consequence, a

matched pair of transistors is definitely helpful in the normal output stage, where each transistor handles opposite halves of a sine wave.

Fig. 4 illustrates the complementary output stage, this being also split up in order to simplify the explanation. Because each transistor is used as an emitter follower giving a voltage gain of 1, the V_{out} is equal to V_{in} .

$$\therefore I_c = \frac{V_{out}}{\text{Load } Z} = \frac{V_{in}}{\text{Load } Z}$$

$$\text{As } I_c = I_{spkr}, I_{spkr} = \frac{V_{in}}{\text{Load } Z}$$

This demonstrates that, irrespective of transistor parameters, the output current will be the same on each half of the input sine wave.

The result is that matched transistors are not essential for correct operation of the complementary output stage. This is, of course, a desirable state of affairs because identical characteristics in n.p.n. and p.n.p. transistors would, in practice, be difficult to obtain.

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.

G.E.C. VHF Set Type SR/838 (20).—P. L. Grieverson, 46 Clarence Crescent, Sidcup, Kent, wishes to obtain the service sheet and also to purchase the missing 5-pin crystal or obtain information on where these may be obtained.

* * *

G.E.C. Osram 912 Plus.—B. Murphy, 265 Wickham Street, Welling, Kent, requires to buy or borrow the construction handbook.

* * *

HRO Receiver.—A. R. Brackenborough, 41 Poets Corner, Margate, Kent, would like to obtain the circuit for the power back of this receiver.

* * *

R107 Receiver.—E. J. Reichmann, 45 Thirlmere Drive, St. Albans, Herts, wishes to buy or borrow the circuit diagram or manual of this receiver.

* * *

Philips MW/LW/VHF Radio Type B3G75U.—C. Thompson, "Mere Close", Hull Road, Hornsea, Yorks., requires the circuit diagram and components list.

Wavemeter Type W1191.—M. J. Walker, Ainsdale, Prospect Road, Farnborough, Hants., would like to obtain the details of operation and conversion data to modern valves.

* * *

Uher Tape Recorder.—C. E. Rees, 83 Mirador Crescent, Upton Lea, Slough, Bucks., wishes to borrow the service manual or any other information on this recorder. Identification marks on chassis: Nr. 23808, Per 5, Gerat, Typ. 95.

* * *

No. 19 Transreceiver.—R. McDonald, 59 Wheatland Lane, Wallasey, Cheshire, requires the circuit and any details of modifications for mains operation.

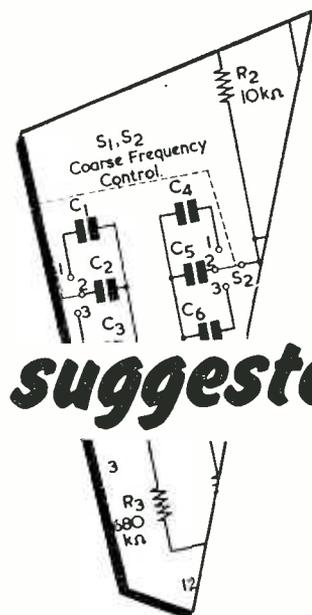
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R3683 Set.—G. Ponty, B.P.99, Brussels 4, Belgium, would like to receive the circuit diagram and any other information.

* * *

BC342N and Indicator Unit No. 95.—F. D. Pinfold, 16 Bellfields Street, Little Bowden, Market Harborough, Leics., requires the loan of the service manuals.

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



suggested circuits

No. 152 Adding Bottom-End Coupling to Ferrite Rod Aerial Circuits

IT IS COMMON PRACTICE FOR commercially manufactured mains-operated valve radio receivers to employ a ferrite rod aerial for the medium and long wave bands. This course is adopted even when such receivers are radio-grams, or fall into the "table receiver" category. One reason for employing ferrite rod aeri- als instead of coupling coil assemblies is that the ferrite rod enables signal pick-up to be achieved with single medium and long wave windings only. In consequence, wavechange switching requirements are simplified. Further advantages are that the ferrite rod windings offer a high Q (thereby guarding against second channel interference) and that they allow the receiver to be completely self-contained. Often, no external aerial coupling circuit is provided at all.

Despite the advantages offered by the use of a ferrite rod aerial, it is quite frequently desirable to obtain greater sensitivity, this being particularly true when reliable reception of transmitters such as Radio Luxembourg is required. In some localities, increased sensitivity may be needed, even, for satisfactory reception, on medium or long waves, of B.B.C. transmitters.

An external aerial is required for the increased sensitivity. If this is reasonably long, and is positioned at a good height well clear of

earthed objects and sources of interference, a very considerable improvement in performance may be realised. The problem then arises of obtaining an adequate coupling between the aerial and the ferrite rod input circuit in the receiver.

Aerial Coupling Methods

A typical medium and long wave ferrite rod aerial circuit is shown in simplified form in Fig. 1. In this diagram, both the medium and long wave coils are connected to the tuning capacitor on long waves, whilst on medium waves the long wave coil is short-circuited. The tuned circuit selected by the wavechange switch is coupled to

the signal grid of the frequency-changer by way of a capacitor, a.g.c. being applied via the grid resistor. The use of a grid capacitor and resistor is common in current receivers, because it eases a.m./f.m. switching problems when an f.m. band is fitted. We are concerned here, however, only with the medium and long wave circuits, and can ignore any a.m./f.m. switching which may be incorporated.

A convenient method of coupling the external aerial to the ferrite rod coils consists of adding an aerial coupling winding to the rod assembly. However, this solution is not as advantageous as it may, at first sight, appear. A single coupling winding cannot offer op-

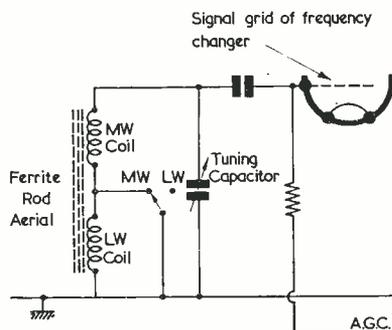


Fig. 1. A typical ferrite rod aerial circuit. Trimming capacitors, and any a.m./f.m. switching which may be fitted, are omitted for simplicity

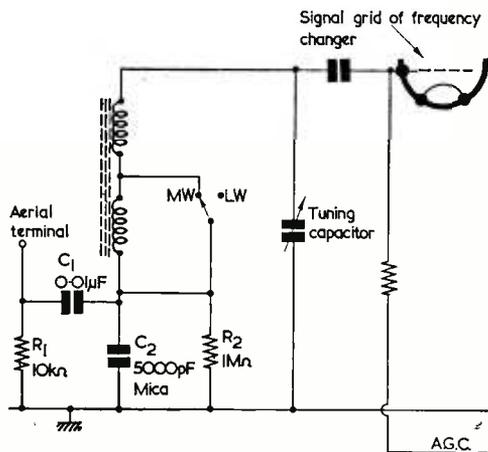


Fig. 2 Adding a bottom-end coupling circuit.

imum coupling for both medium and long wave bands, nor can it employ, for both bands, the resonant technique familiar with normal aerial coupling coils. (This resonant technique consists of so winding the coupling coil that, in combination with the aerial-earth capacitance, it is broadly resonant below the lowest frequency in the band, thereby boosting signal transfer at this end.) To obtain optimum coupling for both bands, two coupling coils are needed on the ferrite rod, whereupon additional wavechange switching becomes necessary.

An interesting and very simple alternative method of coupling the aerial to the ferrite rod consists of using a bottom-end circuit, as in Fig. 2. Circuits of this type are beginning to appear in commercially manufactured receivers, and they lend themselves particularly well to the instance where it is desired

to add aerial coupling to an existing receiver. As may be seen, all that is required is to insert a capacitor (C_2) and resistor (R_2) at the chassis

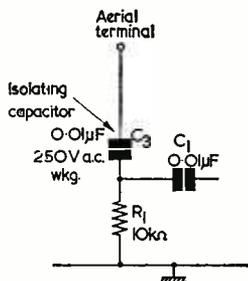


Fig. 3. An isolating capacitor has to be added to the circuit of Fig. 2 if the receiver has a "live" chassis

Fig. 4. A typical instance in which a.g.c. is applied via the ferrite rod windings

end of the ferrite rod tuned windings, and to add the anti-mains-modulation components R_1 and C_1 .

The circuit shown in Fig. 2 is suitable for receivers whose chassis are isolated from the mains. If the receiver has a chassis connected to one side of the mains, an isolating capacitor is necessary, as shown by C_3 in Fig. 3. The component employed here should have an a.c. working voltage of 250.

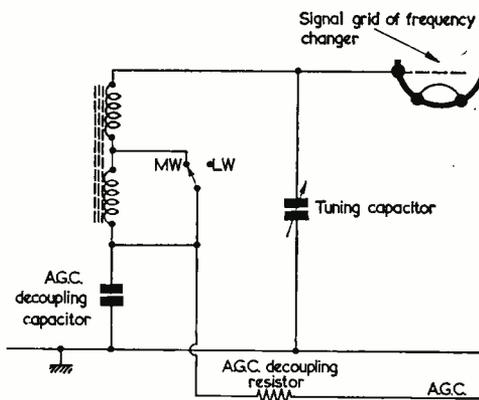
If, in the existing receiver, the a.g.c. voltage is applied to the ferrite rod windings, the circuit employed will be similar to that shown in Fig. 4. All that is then

required is to change the a.g.c. decoupling capacitor for a value more suited for bottom-end coupling and to add R_1 and C_1 , as in Fig. 5. R_2 of Fig. 2, which is included merely to maintain a d.c. connection between the ferrite rod windings and chassis, is not now needed, since its function is carried out by the a.g.c. decoupling resistor (in series with the a.g.c. diode load). If the circuit of Fig. 5 is employed with receivers having "live" chassis, an additional isolating capacitor (C_3 of Fig. 3) must be added.

The Bottom-End Circuit

The bottom-end input circuit offers an effective coupling into the capacitance across the ferrite rod coils, the degree of coupling varying according to the tuning capacitance. Maximum coupling is offered at the low frequency end of the band, where tuning capacitance is greatest.

Because of the low input impedance of a bottom-end coupling circuit, it is desirable to have a reasonably good earth (or counter-



poise) connection. Such a connection is automatically provided with mains-driven equipment, and is given, in the case of "live" chassis receivers, by the mains wiring in the house. With receivers employing isolating transformers, the capacitance between chassis and mains wiring (via the self-capacitances of the mains transformer) is usually high enough to offer an adequate earth coupling. In some receivers, a capacitor of around $0.01\mu\text{F}$ may, in any case, be connected between chassis and one side of the mains. Battery receivers should, preferably, be provided with an external earth connection.

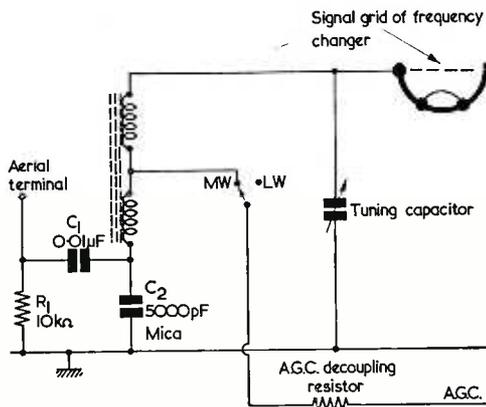


Fig. 5. Converting the circuit of Fig. 4 to incorporate bottom-end coupling. C_2 replaces the a.g.c. decoupling capacitor

Bottom-end circuits are sometimes liable to cause mains-modulation, this being recognisable by a 50 c/s hum on received carriers. With a receiver employing a "live" chassis, this effect may frequently be cleared by reversing the mains input. The fault can be cleared in the same

manner with receivers employing isolating mains transformers, although it may be helpful here to use an earth connection as well. In severe cases, mains modulation may be eradicated by reducing the value of R_1 (to a minimum of $2k\Omega$) or C_1 .

Alignment

The introduction of the bottom-end capacitor will necessitate a slight readjustment of the coil positions on the ferrite rod for optimum tracking. This readjustment is preferably carried out with the external aerial disconnected, since the receiver is then operating with smaller signal inputs. The ferrite rod coils should be positioned for optimum signal strength at the low frequency end of each band, the appropriate trimmers being slightly readjusted, if necessary, at the high frequency end. It is advisable to use weak signals for this operation, in order to prevent the effects of adjustment from being excessively masked by a.g.c. action. Alternatively, a modulated signal generator, whose output is connected to a loop of some ten turns of wire held in line with the ferrite rod, may be employed instead of received signals. Since the effect of the bottom-end capacitor will be to slightly reduce the capacitance across the ferrite rod coils, these will have to be adjusted towards the centre of the rod. The oscillator core and trimmers will not, of course, require any adjustment.

Small Kitchen Radio for Local Reception

By J. G. RANSOME

Our contributor describes a simple and inexpensive receiver capable of offering an adequate performance in areas where the local Medium wave broadcast band transmitters are received at good strength. Pre-set tuning enables two stations to be selected

NEARLY EVERYONE INTERESTED in radio or electronics as a hobby is asked at one time or another to build "a little set—just for the kitchen". The usual requirements are that the set should be able to receive the two local stations with reasonable volume and that, above all, it should be very cheap to build. The set described here cost the author exactly three shillings to construct (the price of the knobs), all the remaining components being found in the junk box. However, even if every item is bought, the building cost should not exceed two to three pounds including the price of the

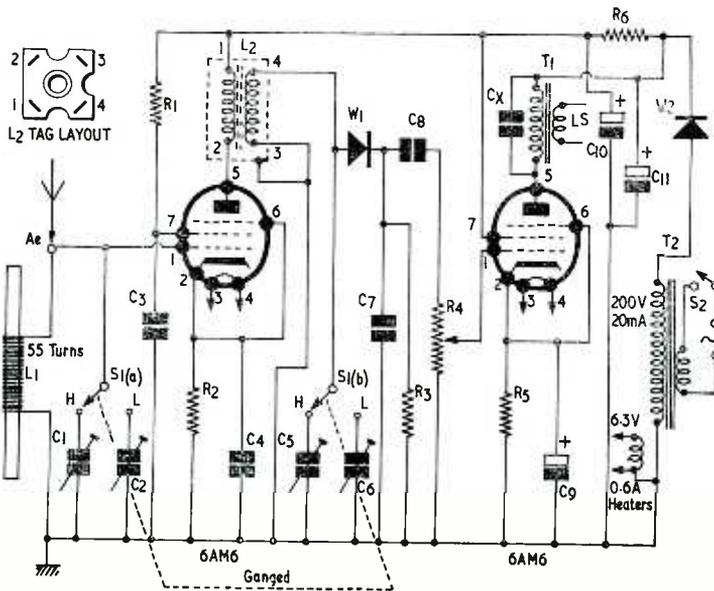
cabinet. The circuit is in no way critical as far as component values are concerned.

The design is centred around two 6AM6 type valves, for the only reason that they were to hand. Any suitable substitutes could be used as alternatives, such as the EF80 or our two old friends the EF50 and the SP61. Using substitutes may involve finding optimum values for the bias resistors in the circuit, but those shown should be found useful as a basis for experiment. V_1 is used as a conventional tuned r.f. amplifier. This stage feeds, via L_2 , the detector diode W_1 . The a.f. from the diode

is then passed on to V_2 which acts as a normal audio amplifier, the output being delivered to a small 5in loudspeaker. For a t.r.f. set this little radio is remarkably selective—this being probably due to the high Q factor of the coils used.

Construction

The aerial coil L_1 consists of 55 turns of 28 s.w.g. (or thereabouts) d.s.c. wire on a length of $\frac{3}{4}$ in diameter ferrite rod. The length of the ferrite rod is not very important, but it should not be less than 3in in length and preferably about 6in. The ferrite rod should first be fitted with a paper sleeve and the wire wound on to this. If Litz wire is to hand this may be used, and it has the advantage of raising the Q factor of the coil to a very high order. With one experimental coil of this nature a Q of 300 has been achieved. The coil should be fixed to one end of the ferrite rod by means of glue or a rubber band. Because of the very high gain of the circuit, L_2 should be screened as effectively as possible from L_1 to prevent instability due to r.f. feedback. In the original set L_2 was screened by using a



Components List

Resistors

- R₁ 47kΩ ¼ watt
- R₂ 150Ω ¼ watt
- R₃ 220kΩ ¼ watt
- R₄ 1MΩ pot, log
- R₅ 150Ω ¼ watt
- R₆ 2.2kΩ 1 watt

Coils and Transformers

- L₁ See text
- L₂ QHF11 (Osmor)
- T₁ 80:1 for 3Ω speaker
- T₂ Secondaries 200V, 20mA; 6.3V, 0.6A

Rectifiers

- W₁ Germanium Diode
- W₂ 250V, 20mA

Capacitors

- C₁ 300pF pre-set trimmer
- C₂ 100pF pre-set trimmer
- C₃ 0.01μF, paper, 350V wkg.
- C₄ 0.1μF, paper, 350V wkg.
- C₅ 300pF pre-set trimmer
- C₆ 100pF pre-set trimmer
- C₇ 200pF mica
- C₈ 0.01μF, paper, 350V wkg.
- C₉ 25μF, electrolytic, 12V wkg.
- C₁₀, C₁₁ 16+16μF, electrolytic, 350V wkg.
- C_x (See text)

Switches

- S_{1(a), (b)} d.p.d.t.
- S₂ On/off (may be ganged with R₄)

Valves

- V₁, V₂ 6AM6

screening can be removed from an old television receiver. A suitable alternative method is to mount L₁ above the chassis and L₂ below. Even with these precautions it may be found that there is a certain amount of feedback. This is not necessarily a bad thing, since it tends to increase sensitivity and sharpen the tuning. As far as the rest of the circuit is concerned, this may be constructed on the usual lines.¹

The Mains Transformer

With regard to the mains transformer specified for the T₂ position, some expense could be spared by using the all-too-frequent a.c./d.c. type dropping resistance type of

¹ The values shown for C₁, C₂, C₅ and C₆ allow for reception of one station near the high frequency end of the Medium wave band and one near the centre. In most cases, this will cater for the Light Programme on Medium waves, and the Home Service at a lower frequency. Alternative values for these trimmers will, of course, allow different sections of the Medium wave band to be covered.—EDITOR.

circuit. However, since a suitable transformer only costs about ten shillings it was felt that it was not worth the risk of using a "live" chassis for the sake of a few pence, especially when it is considered that the set will probably be operated by wet hands.

It must be emphasised that this is purely a local station set and is quite unsuitable for distant reception. The set will work quite well in areas close to the local transmitter, but for areas of weaker signal strength an aerial will have to be used. If an aerial is to be used it is advisable to do the final trimming on the set with this in position, since it will be found that the aerial has an effect on the optimum settings of the trimmers.²

The set may be housed in a cabinet of almost any shape and, if due regard is paid to component

² A short aerial (up to some six feet or so in length) may be connected directly into circuit as shown in the diagram. Longer aerials should preferably be connected via a series capacitor having a value around 25 to 50pF.—EDITOR.

NEW B.B.C. TV STATION FOR SOUTH WALES

The B.B.C. announces that a contract has been placed with E. Turner & Sons Ltd. of Cardiff for the construction of the building to house the new high-power Band III transmitter which is to be installed at the existing station at Wenvoe, near Cardiff, as part of the plan to separate the B.B.C. television service for Wales from that for the West of England.

Contracts have also been placed with British Insulated Callenders Construction Co. Ltd. for the supply and erection of a 620ft mast, and with Electric and Musical Industries Ltd. for the transmitting aerial. It is expected that the new station will be completed early in 1964.

High Impedance Input Circuit for Crystal Microphones

by G. E. Dixey, M.I.R.E., A.M.S.E.

IN THE DAYS BEFORE TRANSISTORS WERE IN COMMON usage the problem of designing a stage with a sufficiently high input impedance to be used with a crystal microphone was not a particularly difficult one. An input impedance of several megohms is readily achieved with a conventional cathode follower circuit.

However, transistor circuits in general are characterised by comparatively low values of input impedance ranging from the very low input impedance of the common-base circuit, through the medium value of input impedance (several $k\Omega$) of the common-emitter circuit to the moderately high (several hundred $k\Omega$ with careful design) of the common-collector (emitter follower) circuit. The emitter follower circuit is the transistor counterpart of the cathode follower, but is not nearly as efficient.

Several questions arise:

- Why must a crystal microphone feed into a high input impedance?
- What are the limitations of a common-collector stage for achieving a high input impedance?
- How can these limitations be overcome?

Let us take question (a) first.

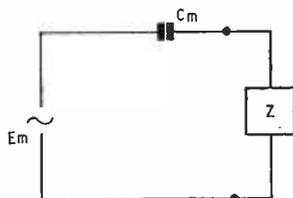


Fig. 1. Representation of a crystal microphone where it is equivalent to capacitor C_m in series with a generator E_m , the generator representing the voltage developed by the microphone

Fig. 1 is a representation of a crystal microphone, where it is seen to be equivalent to a capacitor C_m in series with a generator E_m , the generator representing the voltage developed by the microphone. The reactance of C_m varies inversely with frequency and is the source impedance of the microphone. When connected to a load Z (the input impedance of the amplifier), the reactance of C_m and Z form a potential divider. So long as Z is much greater than the reactance of C_m a large proportion of the voltage developed by the microphone appears across the input of the amplifier. However, as soon

as the reactance of C_m becomes comparable with Z a very appreciable portion of the microphone output voltage is lost across C_m . Since the reactance of C_m is greatest at low frequencies this results in a loss of bass response.

Solutions

There would appear to be two alternative solutions to this problem.

- Make C_m large enough so that its reactance is always small compared with the amplifier input impedance over the frequency range of interest.
- Make the input impedance Z of the amplifier very large.

The value of C_m is dictated by the design of the microphone and, in any event, cannot be made to have a particularly large value, so we are still left with the problem of designing an amplifier with a high input impedance.

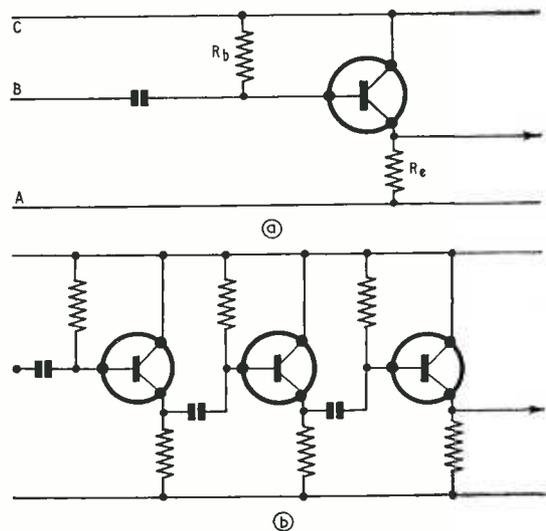


Fig. 2 (a). Common-collector stage and (b) cascaded common-collector stages

To illustrate just how large Z ought to be, consider a practical case.

A typical crystal microphone may have a capacitance of 500pF. Our amplifier may need to be such that its response is no more than 3dB down at a frequency of 40 c/s. Thus, for these conditions to be satisfied, the reactance of the microphone

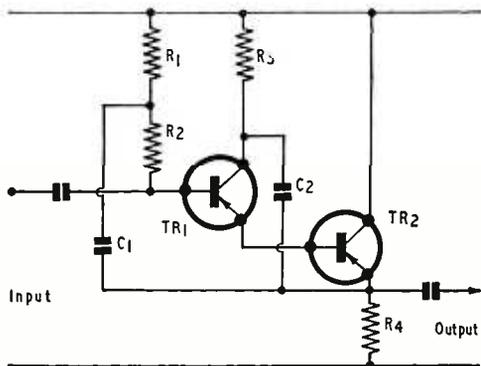


Fig. 3. A "boot-strapped" input circuit

capacitance will be equal to the amplifier input impedance at 40 c/s. The reactance of 500pF at this frequency is $8M\Omega$, and this must then be the input impedance of our amplifier.

This value of input impedance will never be realised using conventional transistor circuitry.

We should now consider question (b), and see why the common-collector stage does not give the required results.

Consider Fig. 2 (a). Here we have a conventional common collector stage. The input impedance is seen between points A and B (or between B and C, since A and C have the same a.c. potential), and is equal to R_b in parallel with the input impedance of the transistor itself. The value of R_b will be dependent upon the collector-base d.c. voltage and the bias current required, and, within reason, can be made large by having a high value of supply voltage and by running the transistor at a low collector current. However, practical considerations apart, little is gained in having a large value of R_b if it is to be shunted by the input impedance of the transistor. This latter has a theoretical maximum dictated by the characteristics of the particular transistor chosen and is equal to $\frac{1}{h_{22}}$, the reciprocal

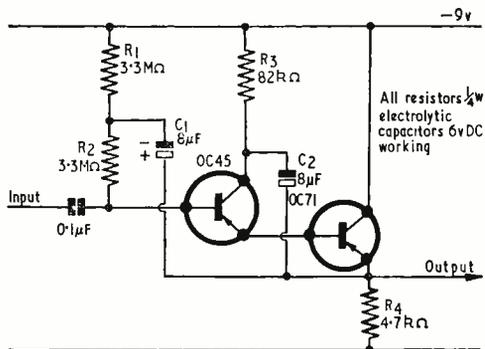


Fig. 4. Practical circuit capable of extremely good results

of the transistor's collector admittance.* This is unlikely to exceed $1M\Omega$ in practice, and will often be much less.

Since the input impedance of a common-collector stage is dependent upon the impedance of the stage into which it feeds it is possible to cascade these stages (Fig. 2 (b)), but this only allows us more nearly to approach the theoretical maximum. If some means can be found to increase, artificially, the values of $\frac{1}{h_{22}}$ and R_b , it should be possible to increase the input impedance of the stage.

Boot-Strapping

The technique employed to achieve this is termed "boot-strapping". There is nothing particularly new about the principle involved, since it has been successfully employed in timebase circuits in many oscilloscopes.

Fig. 3 shows a circuit with two boot-strapped connections. A two stage amplifier is used, the stages being d.c. coupled in such a manner that the collector current of the first stage flows through the base circuit of the second. The first stage is "starvation fed" through a very high-value resistor, and is biased such that the collector current is purely the leakage current (I'_{co}) of that stage. A transistor is chosen for this stage that has the lowest possible leakage current combined with a high value of current gain.

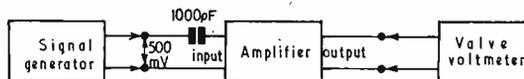


Fig. 5. Measurement of input impedance

Now to explain the action of the boot-strapping.

The bias resistor for the first stage is split into two equal parts, and the junction a.c. coupled via C_1 to the emitter of the second stage, i.e. to the output of the amplifier. Thus, since the input and output circuits are coupled by a low impedance connection, the output voltage of the amplifier is made to follow the input voltage and the overall gain of the amplifier is unity. Further, since the base of TR_1 and the emitter of TR_2 are at the same a.c. potential, no component of alternating current flows through R_2 , and it acts just as if it were open circuited.

In practice, the gain of the amplifier is very slightly less than unity, and there is a slight difference of potential between these points, so that the bias resistor behaves, not as an open circuit, but at least as a very high resistance.

Similarly, the collector of TR_1 is boot-strapped to the output so that there is virtually no a.c. potential between these points, and very little a.c. flows in the collector circuit of this stage. The effect, in this instance, is to cause an apparent

* See Appendix.

increase in $\frac{1}{h_{22}}$.

Thus, boot-strapping has effectively increased the two factors that limit the input impedance of the stage.

A Practical Circuit

Fig. 4 is a practical circuit capable of extremely good results. An OC44 or OC45 has been chosen for the first stage, since these transistors have very low leakage currents coupled with high α' values. In case it should be thought strange that an amplifier whose gain is reduced to unity should require the use of a high gain transistor it should be remembered that, as in a negative feedback amplifier where the efficiency depends upon the gain without n.f.b., so in a boot-strapped input stage does efficiency depend upon the amplifier's inherent gain before the boot-strapping is applied.

The second stage may be an OC71 or similar transistor, since the requirements here are not so stringent.

The amplifier depicted does not have a high order of temperature stability, but this need not assume any undue importance provided that a few obvious precautions are taken.

First, if the amplifier is to be used in conjunction with equipment employing valves, it should be mounted in a well ventilated situation away from the direct heat of the valves and "hot" components.

The temperature stability of the amplifier may be considerably improved if a silicon transistor is used in the first stage. The Mullard OC202 is a suitable type, but the average user may not feel that the extra expense is justified, particularly as the reason for employing such a transistor disappears if the amplifier is not likely to be subjected to wide temperature variations.

A feature of high impedance input stages is that they are susceptible to hum pick-up, and for this reason the input lead should be well screened. If the amplifier is mounted clear of hum-producing components such as transformers, or is built on a small separate chassis and mounted in a tin box which is earthed, no trouble should be experienced.

Performance of the Amplifier

The following data refers to the circuit shown in Fig. 4, and since three identical models have been built and tested by the author they may be taken as typical of results that will be obtained if this circuit is built.

Input impedance—10M Ω

Frequency response—better than ± 1 dB between 15 c/s and 50 kc/s.

This frequency response is the basic response of the amplifier with a 0.1 μ F input capacitor; it does not take into account the characteristics of the microphone. Nevertheless, it is obviously a good start to have a "flat" amplifier.

Measurement of the Input Impedance

Since some readers will want to measure the input impedance of the finished amplifier the correct method will be outlined here, since an incorrect

approach is likely to yield misleading results.

It is common practice to measure input impedances by injecting a signal into the amplifier and noting the output reading, then wiring a variable resistor in series with the input and adjusting it until the output has fallen to half its original value. The value of resistance is then equal to the input impedance of the amplifier.

Such a method is not, however, particularly easy to apply to the measurement of very high impedances, and that given here is often preferred.

Referring to Fig. 5, note that a 1,000pF capacitor is wired in place of the normal input capacitor. A signal at 1 kc/s is injected into the amplifier (at about 500mV), and the output read on a suitable high impedance voltmeter, preferably a valve-voltmeter. The frequency is now decreased (maintaining constant input voltage to the amplifier) until the output has fallen by 3dB (to 0.707 of original value). The reactance of the capacitor is then equal to the input impedance.

i.e. Input impedance equals $\frac{1}{2\pi fC}$

Naturally, the high impedance input circuit described in this article has more applications than

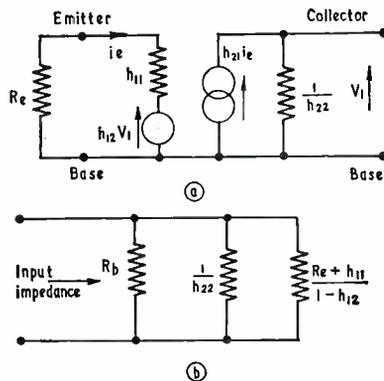


Fig. 6 (a). Equivalent circuit of Fig. 2 (a) and (b) second equivalent circuit

with crystal microphones, and readers may well find other uses to which it can be put.

Appendix

A note on the limit imposed by $\frac{1}{h_{22}}$.

The common-collector circuit of Fig. 2 (a) may be redrawn as an equivalent circuit in terms of the common base parameters as shown in Fig. 6 (a).

It is possible to neglect R_b and $\frac{1}{h_{22}}$ and arrive at a value of input impedance which applies to the transistor alone.

This input impedance is given by the formula $\frac{R_e + h_{11}}{1 - h_{12}}$, which is derived by obtaining expressions

for the input voltage and current in Fig. 6 (a).

We can now draw a second equivalent circuit (Fig. 6 (b)) which shows that the common-collector circuit can be resolved into three parallel elements,

R_B and $\frac{R_e + h_{11}}{1 - h_{12}}$ may be made as large as we wish

(subject to practical considerations) but $\frac{1}{h_{22}}$ is set

by the transistor and is unalterable. This parameter is then the major limiting factor affecting the input impedance of the stage.

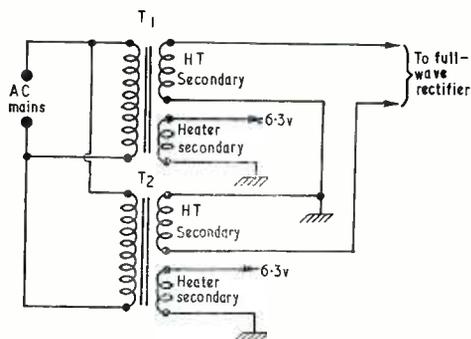
Utilising Single Ended Mains Transformers

C. MORGAN

FREQUENTLY, A CIRCUIT CALLS FOR A POWER supply having a mains transformer with a centre-tapped h.t. secondary. Such a transformer then connects to a full-wave rectifier, whereupon it provides an h.t. potential which requires considerably less smoothing than does that given by a single h.t. secondary feeding a half-wave rectifier.

If two mains transformers with single h.t. windings are available, they may be pressed into service to feed a full-wave rectifier, as shown in the accompanying circuit. It is necessary to ensure that each transformer gives approximately the same voltage across its h.t. secondary winding. If the secondary windings are connected correctly, the a.c. voltage applied to the full-wave rectifier will be the sum of the individual voltages. If this does not occur, the connections to one secondary should be reversed. The necessary voltage reading may, of course, be taken with the aid of an a.c. voltmeter

It is preferable for the 6.3 volt windings from each transformer to feed separate heaters in the associated equipment, although one side of each winding can be connected to chassis, as shown. Transformers of identical make and type could, nevertheless, have the heater secondaries connected in parallel to provide a single heater supply if this was felt to be particularly desirable. However, it is generally advisable to avoid parallel connection of heater windings because of the possibility of



differing turns ratios in individual transformers. Such differences may, if large, cause wasteful circulatory currents between the two transformers and could result in one transformer providing more than its fair share of heater current. Care should be taken to ensure that paralleled heater windings are connected in phase, or the transformers will suffer damage when the power supply is applied.

Utilising transformers with single h.t. windings in the manner described here has the advantage that it enables components which may already be on hand to be used for full-wave h.t. supplies. Also, one large transformer is replaced by two smaller transformers which may be positioned more conveniently in compact or crowded layouts.

HENRY'S RADIO LTD.

Henry's Radio Ltd., the well-known radio component specialists, recently moved from their old address at 5 Harrow Road, W.2, to new and larger premises at 303 Edgware Road, London, W.2. At the new address, a more extensive display of the many items offered to the home constructor has become possible, and a welcome is extended to all readers who care to visit the new showrooms. Henry's Radio Ltd. are specialists in the supply of transistors and miniature components in addition to standard components and other electronic equipment.

News and Comment

Stereo Transmissions

The B.B.C. has been subjected to some criticism of late that it is not interested in promoting stereo broadcasting. The following information supplied by the B.B.C. may, or may not, satisfy the critics.

No decision has been made on whether regular stereophonic broadcasting will be introduced in the future. A number of problems have yet to be solved before such a decision can be taken and it is desirable that international agreement should be reached in Europe about the technical standards to be used. At the International Radio Consultative Committee Plenary Assembly held in Geneva in January/February this year the Zenith-G.E. and other stereophonic systems were considered but no agreement was reached on the adoption of any of the systems as an international standard. The B.B.C., together with several broadcasting authorities in the European Broadcasting Union, is continuing its work on stereophonic systems.

The B.B.C. has now concluded the second series of field trials of the Zenith-G.E. pilot-tone stereophonic system, using the Wrotham Third Programme transmitter on its normal frequency of 91.3 Mc/s, but to assist manufacturers in the design of tuner units for export, the test transmissions are being continued each Wednesday until further notice as follows:

11-11.30 a.m. Stereophonic programme transmission
12-12.30 p.m. Tone test transmission

The stereophonic programme will be preceded by four minutes of tuning signal consisting of two tones of different pitch—the one of lower pitch being on the A (left-hand) channel—followed by one minute with no modulation. At the beginning of the programme period there will be a stereophonic announcement for setting-up purposes and the tone transmission will be preceded by an explanatory announcement.

The fortnightly experimental stereophonic transmissions on alternate Saturday mornings using the television sound channel and the VHF and medium-waveband Network Three frequencies will continue for the time being. Details of these transmissions are published in the *Radio Times*.

Teaching by TV and Radio

As mentioned last month we give some news of educational broadcasting in other countries. This information is merely indicative of what is happening elsewhere.

In the United States educational TV for adults began about 1950, in isolated areas, as a natural evolution from educational radio. In 1953 America's first non-commercial TV station went on the air and there are now 68 such non-commercial stations broadcasting to an audience often exceeding 20 million people; children's programmes are used by 7,500 schools.

Instructional television is provided by ETV (educational TV) stations operated by schools, universities, non-profit corporations, etc.: closed circuit systems at educational institutions; rented or donated time and facilities by commercial stations.

The vast areas and isolated communities in the U.S.A. have undoubtedly been a considerable incentive to the provision of lessons by TV and radio. An indication of this is given by the "flying classroom". Since the Autumn of 1961 thousands of children in the Middle West have been receiving lessons telecast from a specially equipped plane flying at 25,000 feet over the area.

In Czechoslovakia the emphasis appears to be on educational-athletic broadcasts. The Czechoslovak Radio has recently started a series of broadcasts entitled "The Small School of Poetry". The purpose of this series is not to give instruction in the technicalities of poetry, but to answer such questions as "is it poetry when there are no rhymes?" "how should you read poetry?", etc.

Another communist country which has only had television for five or six years, Hungary, programmes appear under the title of "Educational television broadcasts for young people". These programmes started in a small way soon after television began there and often take the form of practical demonstrations as distinct from filmed items. Whether new subjects should be taught or only knowledge obtained at school expanded is one of the considerations programme planners have to take into account. As with all such planners, irrespective of nationality,

limited time available is a difficulty.

There appears to be dissatisfaction in Australia because educational broadcasting seems to come up against various legal snags. For example the N.S.W. University is limited in its ability to present drama over the air because it must not broadcast music. It appears that university authorities in Australia would like a planned coverage of curriculum subjects for the benefit of specific groups, with the public looking and listening if they wanted to.

The provision of educational broadcasts for adults in particular, is obviously no simple matter.

London as World's Electronic Centre?

A group of British industrialists have started a month-long 5,000-mile tour of Europe with the object of making London the major international centre for electronics.

The group is to operate as the spearhead of one of the greatest technical exhibitions in the world, the multi-million pound International Instruments, Electronics & Automation Exhibition (I.E.A.), to be held in London in 1964.

The tour includes Stockholm, Frankfurt, Dusseldorf, Paris, Brussels and Amsterdam. At most of the cities, conferences will be called at which the value of Britain as an international electronics centre will be stressed and details given of the greatly enlarged I.E.A. Exhibition. These conferences will be attended by heads of government departments, chambers of commerce and trading organisations, professional institutions and industrialists. During the tour the British party will have the opportunity of meeting many hundred potential overseas exhibitors face-to-face.

"The object of this spearhead drive is to stress the value of London as the world's hub of the electronic and instrument industries," said one of the organisers.

The International I.E.A., of which H.R.H. The Duke of Edinburgh is the patron, will for the first time occupy all of the Olympia, London, exhibition halls, providing a floor area of half a million square feet. It will be held from 25th May to 30th May, 1964.

Mating Habits of Grouse

In an attempt to follow the mating habits of grouse in Montana a number of them are to be fitted with tiny radio transmitters by the Montana Fish and Game Department. (Reported in *The Daily Telegraph*).

Printed Circuits for the Constructor

By F. BURGESS

This article describes an extremely inexpensive method of home-constructing printing circuits. All the materials required are readily available, and they may all be obtained at relatively low cost

ALTHOUGH THE CLAIM "PRINTED CIRCUITS FOR reliability" is becoming increasingly common in advertisements for electronic apparatus, there seems little doubt that, obvious as its advantages are, the printed circuit is still something of a mystery to the average constructor. This is due to the fact that printed circuit board is not generally easily obtainable, except when associated with kits. This article is an attempt to help clear the way for constructors by describing how a simple yet quite satisfactory substitute for commercial board may be made at no great expense, using everyday materials.

The Board

Commercial printed circuit board consists of thin copper foil bonded on to a sheet of insulator, such as Paxolin. The foil, when suitably shaped by etching, takes the place of wires in a conventional circuit and, being rigidly fixed to the Paxolin, forms a reliable and permanent means of connection. For home construction, the base of the printed circuit may be Paxolin, as with the commercial article, or, if preferred, even wood. The author has used both these materials in his experiments and, provided care is taken to prevent the absorption of moisture in the case of wood, there is in fact little to choose between them under normal working conditions. If wood is to be used, it should be very thin; 3-ply from tea chest panels is ideal.

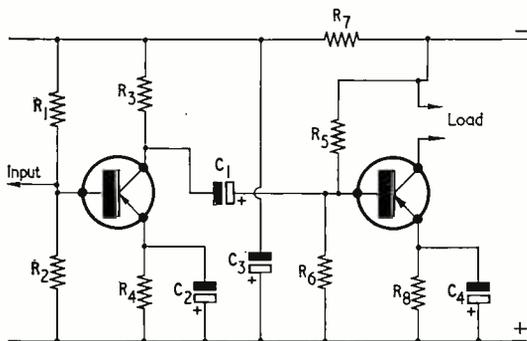


Fig. 1. A 2-stage transistor amplifier

Having decided on the base to be used and the size it is to be, the next consideration is the foil. Ideally this should be copper, but as this is expensive and not too easy to come by, copper plated aluminium foil may be used as a substitute. The aluminium for this purpose may be either "silver paper" wrapping from chocolate bars or, much more preferably, aluminium foil purchased in the form of a roll, such as is used in the kitchen for wrapping cooking poultry. This may be obtained very cheaply at most large general stores. The foil should be unrolled carefully and cut to a size about $\frac{1}{2}$ to 1 in larger than the base all round. It is important during this operation not to crease the foil since this will lead to poor bonding at the crease. For this reason it is not recommended to use "silver paper" unless absolutely necessary.

The adhesive used to bond the foil to the base should be waterproof since aqueous solutions are used in the plating and printing processes later on—Durofix or Clear Bostik are both suitable for the job. Coat the foil on one side with a thin film of the adhesive and allow this film to dry completely. Meanwhile, clean the surface of the base with a fine emery paper, then roughen it with a coarser sandpaper (if wood is used this roughening is unnecessary). When the foil is dry, coat the base with a film of the adhesive and press the foil, coated side down, on to this film. Fold the excess foil around the edges and back behind the base to ensure a good bond at the edges, then press the combined board between two blocks of wood in a vice in order to remove all the air between the base and the foil. Failing a vice, a pile of heavy books may be used. Leave the board clamped or pressed for at least 12 hours (if a wooden base is to be used, the drying period may be considerably less, but in any event should not be less than 6 hours). When the board has dried, remove it from the press and trim the foil edges except for a narrow tag in one corner, large enough to fix a crocodile clip.

At this stage we have a blank printed circuit board made from aluminium foil, which is quite useless unless some means of soldering on to aluminium is available. In order to make the board

suitable for ordinary solder, it is necessary to give it a light coating of copper metal. This can be done quick simply as follows: Dissolve 2oz of copper sulphate (price 2oz for 4d. or 5d.) in a pint of tap water. If to hand, a little battery acid may also be added—this will improve the quality of the deposit of copper, but is not absolutely essential. This solution does not deteriorate and may be used for dozens of plating operations before renewal becomes desirable.

Before the actual plating process is carried out, it is necessary to render the base board impervious to water. Paxolin needs no treatment, but wood must be given a good coat of varnish, clear enamel, or enamel paint before proceeding. Make quite sure that all the exposed wood is covered, and that all the foil is quite clear of paint, etc. The actual plating process is very simple—just attach the foil by means of a crocodile clip connection to the negative side of a d.c. supply of 3 to 6 volts (rectified a.c. is quite good enough for this purpose). Place the board, foil uppermost, in a shallow dish or bowl, this being preferably one made of plastic. Galvanised iron containers must not be used with this solution. Next pour in the plating solution until it covers the foil to a depth of an inch or so. Finally, connect the positive end of the supply to a loop of thick bare copper wire (18–20 s.w.g.) about 2in in diameter, and suspend this loop in the surface of the liquid, over the centre of the foil. Ensure, of course, that the two do not touch. In this way the deposit obtained is reasonably even over the whole surface of the foil. As soon as the loop touches the solution, bubbles of gas should rise from it, and also to a lesser extent, from the foil. If no bubbles are seen, check the crocodile clip connection. Leave the foil in the plating solution for five minutes, then withdraw the loop and take out the board itself. The foil should be covered with a layer of reddish-brown copper. Wash off the excess plating solution under a gently running tap and allow the foil to dry slowly in a warm room. Do not deliberately heat the foil in order to speed the drying process as this will have a detrimental effect on the plating. When perfectly dry, it should be possible to rub the foil with a finger without causing the copper to come away from the aluminium. If this is not possible, i.e. the plating comes off easily, the foil should be cleaned with emery paper and the plating process repeated with a lower voltage supply, since “sponginess” of the deposit is almost always due to a high plating current. Normally, however, the coating of copper is very resistant to rubbing. After a light polishing with a metal polish, the board is ready for etching.

Planning the Circuit

Before the actual etching or printing process can take place, the “conducting” parts of the circuit must be painted with a varnish to protect them from the printing solution. It is difficult to lay down a set of hard and fast rules covering the shape of a printed circuit, and so a typical example of a

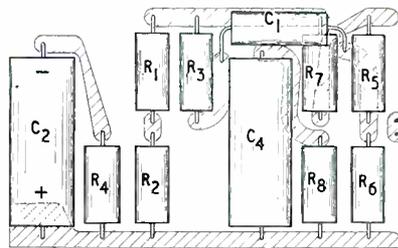


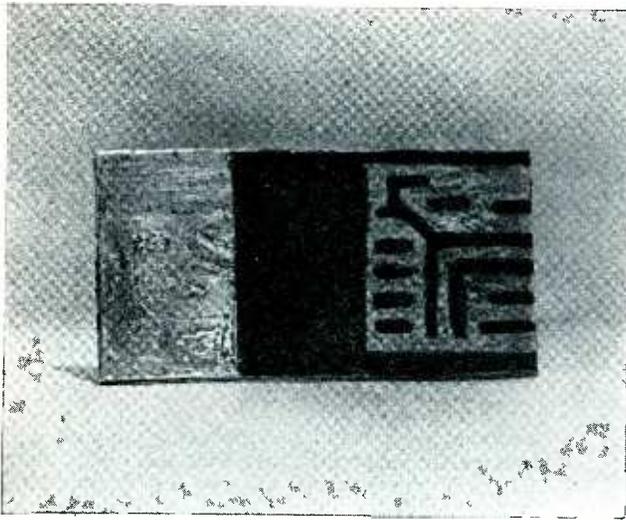
Fig. 2. A printed circuit pattern suitable for the amplifier. For reasons of clarity, C_3 is not shown here. It connects between the upper central conductor and the lower conductor

conventional circuit and its printed equivalent are given in the accompanying diagrams. It is very often quite good enough to draw the conventional circuit “full-scale” and paint the inter-component conductors on to the printed circuit board in the same positions as they are on the full-scale conventional circuit diagram. This method fails with such circuits as multivibrators, which involve crossing of conductors. Crossing cannot be achieved in the printed board, although a short external jumper wire might overcome this.

Transistors are used in the example shown, since it is visualised that most constructors will be using the printed circuit technique for transistors rather than valves. On the whole, the design of a printed circuit is very much a question of personal preference although, of course, one's choice is necessarily limited by the board used. It is advisable to plan the board thoroughly before the making of the initial base-board. If the final printed board is too small, there is little that can be done to enlarge it!

Etching

Having decided the design of the circuit, paint over the parts of the foil which are to be used in the final circuit as conductors, using nail varnish or a thick solution of shellac in methylated spirit. Set the board aside to dry. Meanwhile, prepare the etching solution by dissolving 3–4oz of ferric chloride in a pint of water. This solution may be obtained, ready made, from most chemists. (Ferric chloride itself absorbs moisture from the air and is consequently rather unpleasant to handle.) Place this solution in the dish that was used for the plating process (remove the plating solution first!) and lower the board into it. It should be possible to watch the progress of the etching solution as it eats through first the copper, then the aluminium. When it has eaten right through the foil, remove the board and wash it thoroughly under a tap. Throughout the etching process, agitate the dish gently to obtain even etching. When the board is dry, remove the protective varnish with either nail varnish remover or acetone, or, if shellac was used, methylated spirit.



A board which has been specially treated to exhibit the process. At the left is the aluminium foil bonded to the base. In the centre, the foil is plated with copper. The area on the right shows the foil partly etched

Notes on Assembly

At this stage any effects of poor initial bonding between the foil and the base become evident, and slight amounts of touching up with glue may be necessary. However, if care was taken earlier such action will usually not be called for. The board is now ready for drilling. Use a $\frac{1}{32}$ in drill bit and drill from the foil side so as not to strain the bonding unduly. Each hole should be finished by slightly countersinking on the base side. When this is done, all that is required is to fit the components through the holes and solder them in. Try to aim for a neat round blob of solder on the end of the component wire. Take particular care when soldering heat sensitive components such as diodes, transistors and miniature electrolytics. A heat sink is absolutely essential here, since lead-out wires will normally have been cut short to allow the component to rest near the board. When soldering, try to make each joint as quickly as possible, since undue heating of the glue may cause the foil to come adrift.

Conclusion

Despite the numerous warnings in the text, the

average careful constructor should find this method of making printed circuits both easy and economical. The only commodity which is used up at any speed at all is the glue; even so, a small tube of Durofix should be sufficient for 60 square inches of board, whereas the same amount of board which can be bought in kit form would cost a pound or so. If the assembled board is given a coating of shellac, the circuit should be good for as long as the components it contains.

Editor's Note

Commercially produced printed circuit boards employ high grade synthetic resin bonded paper ("Paxolin" or s.r.b.p.), the copper foil being usually bonded to it by resin adhesives which are fully cured before processing. Such boards have to meet rigid specifications for insulation resistance, ingress of moisture, mechanical strength, and similar requirements. It is doubtful if home-constructed boards such as are described in this article would meet these specifications. Nevertheless, the versions with "Paxolin" bases should very probably give quite satisfactory results for applications where very high resistance between conductors is not required. We would class wood-based printed circuit boards as being experimental only although, again, useful results are feasible if it is remembered that the insulation resistance of untreated wood may vary considerably according to humidity, age, and other factors.

When s.r.b.p. is used for the base, it is advisable to paint the edges with shellac or an equivalent synthetic resin insulating varnish before embarking on the processes described here. Such varnish will then help to prevent the ingress of water into the laminations of the material via its edges during plating and etching.

B.B.C. ORDERS EMI AERIALS FOR FORFAR

To improve reception of its television and radio programmes in East Scotland, the British Broadcasting Corporation has placed a contract with EMI Electronics Ltd. for the supply and erection of new television and v.h.f./f.m. sound transmitting aerials at Forfar.

Operating on Channel 5 in Band I, the television aerial will have a 60ft aperture with four vertical dipoles. It will be corner-mounted on the mast, facing north-west to give maximum coverage of the populated areas.

Below the television aerial will be mounted the v.h.f./f.m. aerial, which will transmit the Home, Light, Third and Network Three programmes in Band II. Horizontally polarised, this array will include eight stacks of unipoles mounted on the north-west and south-west corners of the mast.



understanding radio



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

part 23

By W. G. MORLEY

IN LAST MONTH'S ARTICLE IN THIS SERIES WE continued our consideration of iron-cored transformers and dealt, amongst other things, with the auto-transformer, eddy currents, permeability and hysteresis. We shall now carry on to consider another factor of the transformer which, like eddy currents and hysteresis, can also contribute towards reduction of efficiency.

Leakage Inductances

When an alternating current is caused to flow through the primary of a transformer whose secondary is connected to a load, a magnetic field is set up which varies in magnitude and direction according to the magnitude and polarity of the primary current. The current in the secondary sets up a field which is in opposition to that given by the primary.

In a "perfect" transformer, all the lines of force in the primary field link with the secondary winding, and all the lines of force in the secondary field link with the primary winding. This "perfect" state of affairs does not exist in practice, and some of the lines of force in both primary and secondary fields leave the core and pass out into the surrounding air. Such lines of force offer no contribution to the operation of the transformer and they result in a loss of efficiency. They may be described as the *leakage flux* of the transformer; and can be subdivided into the *primary leakage flux* and the *secondary leakage flux*.

Due to leakage flux, a proportion of the primary current is employed in producing a magnetic field which serves no useful purpose. A similar effect would be given if we were to connect an inductor in series with the primary of a "perfect" transformer, as in Fig. 139. In this instance, the unwanted magnetic field would be produced by the series inductor. The same applies to the leakage flux

about the secondary, and we can similarly add an inductor in series with the secondary of a "perfect" transformer to reproduce the same effect. Because of leakage flux, the primary and secondary windings of a practical transformer behave in the same manner as would the primary and secondary windings of a "perfect" transformer having external inductors connected in series. Such inductors may then be referred to as offering the *leakage inductances* of the transformer.

Efficiency

The efficiency of a transformer is given, as a percentage, by:

$$\frac{\text{Power delivered by secondary}}{\text{Power delivered to primary}} \times 100.$$

A "perfect" transformer would have an efficiency of 100%, which means that all the power delivered to the primary would be delivered by the secondary.

Electrical power is equal to the product of voltage and current and, for equal power in primary and secondary, it follows that a step-up in voltage corresponds to a step-down in current, and that a step-down in voltage corresponds to a step-up in current. If we apply, to a 1:10 "perfect" trans-

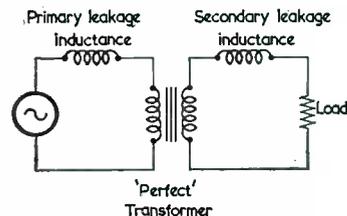


Fig. 139. The primary and secondary leakage inductances of a transformer may be represented as external inductors in series with the windings

former having the requisite secondary load, a voltage of 10 volts at 10 amps, we will obtain, from the secondary, 100 volts at 1 amp. If the "perfect" transformer had a ratio of 10:1, our 10 volts at 10 amps would have resulted in an output of 1 volt at 100 amps from the secondary.

Although we tend to look upon transformers as voltage-converting devices it must not be forgotten that they are similarly useful as current-converting devices. A high current can, for instance, be obtained from a source capable of providing only a low current by the use of a step-down transformer.

There is no such thing in practice as a "perfect" transformer, and the efficiency of practical transformers falls short of 100% because of "losses". These "losses" are given mainly by *iron loss*, *copper loss* and leakage inductances. Iron loss is the result of eddy currents and hysteresis loss, which we have already dealt with. Copper loss is due to the inevitable resistance in the winding wire employed for the primary and secondary, and may be represented in the form of physical resistors in series with the corresponding windings of a "perfect" transformer. Well-designed iron-cored transformers are, in practice, capable of offering efficiencies of 90% or more.

Another source of "losses" which should be mentioned is given by the self-capacitances of the windings, the stray capacitances between them, and the stray capacitances to the core. These capacitances are troublesome in transformers handling audio frequencies in high-grade equipment, and a number of precautions are taken in design and production to keep them at a low level. In such applications the capacitances can cause unwanted couplings between primary and secondary, as well as offering undesirably low reactances across windings. Stray and self-capacitances are not normally very troublesome in transformers intended for operation at power frequencies, or in transformers operating at audio frequencies in inexpensive conventional equipment.

Magnetising Current

If an alternating voltage is applied to the primary of a practical transformer whose secondary is open-circuit (i.e. with no load connected), a current will flow. Such a current is inevitable because, in the first case, the primary behaves as an inductor having a finite value of inductance. The primary current resulting from its inductive reactance is then further modified by the resistance of the winding (copper loss) and by iron loss. The currents resulting from copper loss and iron loss are in phase with the applied voltage, whilst the current flowing as a result of the inductive reactance lags on the applied voltage by 90°. The vector sum of these currents is known as the *magnetising current* of the transformer. Magnetising current is the primary current which flows when the secondary (or secondaries) is open-circuit.

A test for magnetising current is frequently carried out in the production of transformers intended for operation at power frequencies, and

it has the advantage of revealing transformers which may be reject for a number of reasons. Magnetising current will increase beyond the average level if iron losses are excessive (because of, say, incorrect laminations, or laminations with faulty insulation), if primary inductance is too low (because of incorrectly assembled, or insufficient, laminations), or if two turns are short-circuited together in any of the windings. In the last instance, the current drawn by the short-circuited turns will result in a proportionately increased primary current. The magnetising current test is valuable because it causes all windings to have their full working voltage induced in them. Its usefulness is enhanced if the voltage applied to the primary during the test is greater than that which will be applied in subsequent usage, because all inter-turn insulation is then subjected to a higher voltage than normal.

The magnetising current of a transformer designed for power frequencies is considerably lower than the primary current which flows under normal operating conditions.

Turns Per Volt

Transformers intended for power frequencies are connected into circuit such that a relatively constant voltage appears across each turn in the primary and secondary (or secondaries). In consequence, it is occasionally necessary to refer to this voltage, since it represents an important part of the overall design figures for the transformer. It may, however, be more conveniently expressed in terms of *turns per volt*, since the voltage per turn is almost always less than 1. If a transformer intended to work from 200 volt a.c. mains had 2,000 turns in the primary winding, it would be described as having 10 turns per volt. Most conventional power transformers have a turns per volt figure lying between 5 and 12.

Lamination Materials

We have already¹ referred to laminations and lamination shapes, but we have not yet discussed the lamination materials which are employed for iron-cored transformers.

The most commonly encountered lamination materials are alloys of iron and silicon. Adding silicon to iron reduces hysteresis loss and increases resistance (thereby reducing eddy current loss). *Silicon iron* alloys for lamination applications have a silicon content ranging from about 0.04% to 4.5%. Losses decrease as the percentage of silicon in the alloy increases, but there is a counteracting increase in brittleness and cost. Approximately seven different grades of silicon iron sheet suitable for transformer laminations are manufactured in this country, most of these being available in thicknesses of 0.014 and 0.020in. The lower grades are normally made in 0.020in only, because there are few applications requiring 0.014in laminations with these higher loss materials.

Lamination material losses are evaluated on the sheet material at the rolling mill before the laminations are punched out. A core, made up from pieces

¹ In last month's article.

of the material under test, is fitted to a test transformer, whereupon iron loss is evaluated, at a specific flux density, by electrical measurements. Loss is expressed in terms of "watts loss per pound" (or "watts loss per kilogram"). Silicon-iron of 0.020in thickness and a silicon content of 0.04% has a watts loss per pound of about 2.5. The watts loss per pound of 0.020in silicon iron with a silicon content of 3.6% is about 1.2. The same material, at 0.014in thickness, offers a watts loss per pound of about 1.0.²

Silicon-iron material can be made to offer improved magnetic properties (increased permeability and reduced hysteresis) by special heat treatment and cold-rolling process. These cause the crystal axes of the metal to take up a definite orientation, and the improved properties which result can be put to use provided that the magnetic field travels through the material in the preferred direction. Such material is known as *grain oriented silicon iron*, and is usually made in thicknesses of 0.004 or 0.013in. Typical watts loss per pound figures for 0.013in grain oriented silicon iron (with the magnetic

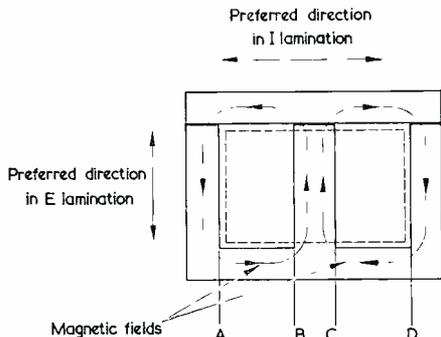


Fig. 140. Grain oriented silicon iron sheet offers an advantage when used for E and I laminations. In this diagram, most of the field travels through the laminations in the preferred direction, the only exceptions occurring between A and B, and between C and D, at the base of the E lamination. The primary and secondary windings are fitted to the centre limb, as shown in dotted outline

field in the preferred direction) are of the order of 0.46 to 0.62 according to grade. Grain oriented silicon iron materials are extremely useful for C-core assemblies, where the preferred direction may be along the strip from which the C-core coils are wound. In consequence, all the magnetic field in the C-core travels in the preferred direction. Grain oriented silicon steel offers a marginal improvement in "scrapless" E and I lamination assemblies also, as illustrated in Fig. 140; the laminations shown here being stamped out of strip having the preferred direction along its length. In this instance, most of the field about the winding travels through the core in the preferred direction, as shown, the only exceptions occurring at the base of the E lamination.

² The figures quoted here, and for grain oriented laminations, are for a flux density of 13,000 gauss.

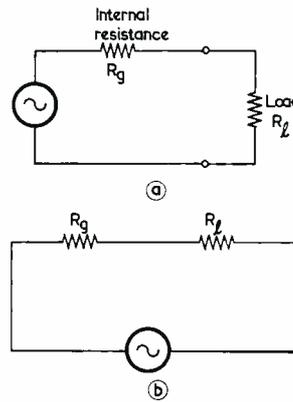


Fig. 141 (a). Investigating the case where it is desired that maximum power be dissipated in the load (b). The circuit of (a) may be re-drawn as here

With interleaved construction, however, the I laminations on either side of the base of the E offer a magnetic path along the preferred direction, and reduce the effect given by the short lengths of material with incorrect orientation.

A special class of lamination materials employs alloys of nickel and iron, and these offer very high permeabilities at low flux densities. *Nickel iron* alloys of this type are also known as *Permalloys*, and they have some 45 to 80% of nickel according to grade. A small amount of molybdenum or chromium is added to some grades. Another high permeability lamination material is *Mumetal*, this incorporating some 75% nickel plus small quantities of chromium and copper. There are other, similar, alloys, which are used for specialised applications. Permalloy and Mumetal laminations are, in general, employed in transformers handling low powers, and they are particularly useful when such transformers are required to combine high primary or secondary inductances with small physical dimensions. These laminations are more expensive than silicon iron laminations and are, in consequence, encountered much less frequently in ordinary radio work. Material thicknesses vary, although a thickness of 0.015in for nickel iron laminations is a fairly representative figure.

Impedance Matching

In our discussion on transformers up to the present, we have looked upon sources of alternating current as being "generators" whose internal resistance or impedance is of no significance. All

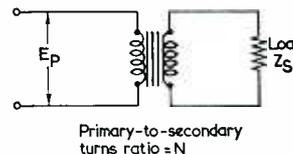


Fig. 142. Demonstrating impedance transformation

that these "generators" have been called upon to do is to cause a current to flow through the primary winding of a transformer.

In many instances in radio work, sources of alternating current have unavoidably high internal impedances, and these internal impedances have to be taken into account if maximum transfer of power to the load is to take place. There are, also, many cases where, for best results, it is desirable for an a.c. "generator" to feed into a load having a particular impedance which does not cause maximum transfer of power. We shall next consider briefly the instance where maximum transfer of energy to the load is required. The case where a "generator" is required to work into a particular impedance for best results cannot be fully explained at the present stage, and the reader is asked to accept the fact that this state of affairs exists in practice, and that it will become clearer later.

Fig. 141 (a) illustrates an a.c. generator having an internal impedance, which we shall assume to be resistive, shown as R_g . This resistive impedance is illustrated as being in series with the generator (which is now assumed to be "perfect") in just the same manner as we represent the internal resistance of a cell by a resistor in series with it.³ Fig. 141 (a) also includes the generator load (again shown as a resistor) and this is designated R_l . We shall now investigate the value of R_l , in terms of R_g , which causes maximum transfer of power to the load.

The circuit of Fig. 141 (a) can be re-drawn as in Fig. 141 (b), in which we have two resistors connected in series across a "perfect" generator. In Fig. 141 (b) we want to know what ratio R_l must have to R_g for maximum power to be transferred to R_l . But, because of the symmetry of the circuit, we could alternatively assume that R_g is the external load and that R_l is the internal impedance, whereupon we would require to know what ratio R_g must have to R_l in order that maximum power be transferred to R_g . Due to the circuit symmetry, the ratio of R_l to R_g for maximum power transfer to R_l must be equal to the ratio of R_g to R_l for maximum power transfer to R_g , and this set of circumstances can only be satisfied when R_g and R_l are equal to each other. In other words, maximum power transfer to R_l (and to R_g) takes place when $R_l = R_g$.

Returning to Fig. 141 (a), we may now say that maximum power transfer to the load occurs when its resistance is equal to the internal resistance of the generator. Half of the total power is then dissipated in the load, and half in the internal resistance of the generator. Under these conditions, the generator is described as being *matched* to the load (or the load as being *matched* to the generator).

Although we commenced this section by referring to impedance matching, it may be noted that we explained the instance illustrated in Figs. 141 (a) and (b) in terms of resistance, or resistive impedance, only. The reason for this is that, if either the

internal impedance of the generator or the impedance of the load has reactive components⁴, the relationship between the two impedances for maximum transfer of energy becomes more complex than needs to be discussed in the present context, and is not satisfied by $R_l = R_g$. In elementary radio work involving calculations concerning matching, it is normally safe to assume that the impedances under discussion are resistive, and we shall follow this practice here. In the explanation of impedance matching with the aid of transformers which follows, it is assumed that all impedances mentioned are resistive.

It frequently happens that an a.c. generator has, for maximum power transfer, to match into a load which is either higher or lower than its own internal impedance. It is possible to effect such matching by employing a transformer. To illustrate this point let us consider Fig. 142, which shows a transformer whose secondary is connected to a load, Z_s . The primary-to-secondary turns ratio of the transformer is N . Let us next apply a voltage, E_p , to the primary. The voltage appearing across the

secondary will be $\frac{E_p}{N}$, whereupon the current flowing

in the load will be $\frac{E_p}{Z_s}$, or $\frac{E_p}{NZ_s}$. Now, the primary

current will be $\frac{1}{N}$ times the secondary current, or

$\frac{1}{N} \times \frac{E_p}{NZ_s} = \frac{E_p}{N^2Z_s}$, this being the current which is

caused to flow in the primary by the voltage E_p .

We have already seen⁵ that, when a resistor is connected across the secondary of a transformer, the primary behaves as though it were a resistor also. As we now know the primary voltage and current, we may easily find the value of this primary "resistor". It is:

$$\begin{aligned} & \frac{E_p}{\frac{E_p}{N^2Z_s}} \\ &= E_p \times \frac{N^2Z_s}{E_p} \\ &= N^2Z_s. \end{aligned}$$

In other words, the impedance presented by the primary is equal to the secondary load impedance multiplied by the square of the primary-to-secondary turns ratio of the transformer.

Several numerical examples may assist in further demonstrating the effect. In Fig. 143 (a) we have a generator with an internal impedance of 100Ω ,

⁴ That is, inductance or capacitance in addition to, or instead of, resistance.

⁵ In "Understanding Radio" part 21, May 1963 issue.

³ "Understanding Radio" part 6, January 1962 issue.

and we wish to couple it via a transformer so that maximum power is transferred to a load, Z_s , of 1Ω . The transformer required here must have a turns ratio of 10:1. Since the primary-to-secondary turns ratio, N , is 10, then the primary will appear to the generator as though it were a resistor of $N^2Z_s = 100\Omega$, and accurate matching for maximum power transfer to the load will be achieved.

In Fig. 143 (b) we have an a.c. generator which, for best results, has to feed into an impedance of 100Ω . However, the load has a value of $2,500\Omega$. What turns ratio is required in the transformer?

We know that $Z_p = N^2Z_s$, where Z_p is the impedance presented by the primary, N is the primary-to-secondary turns ratio, and Z_s is the impedance of the secondary load.

Therefore: $100 = N^2 \times 2,500$

$$\begin{aligned} \text{therefore} \quad N^2 &= \frac{100}{2,500} \\ &= \frac{1}{25} \end{aligned}$$

$$\begin{aligned} \text{therefore} \quad N &= \sqrt{\frac{1}{25}} \\ &= \frac{1}{5}. \end{aligned}$$

Thus, $N = \frac{1}{5}$, and the primary-to-secondary turns ratio is 1:5. It will be seen that in this instance we need a step-up transformer (because the secondary impedance is higher than the primary impedance) whereas in the previous case we needed a step-down transformer (because the secondary impedance was lower than the primary impedance).

When we noted, earlier, that the primary of a transformer behaves as a resistor when a resistor is connected across the secondary, we saw also that the primary behaves as an inductor when an inductor is connected across the secondary, and as a capacitor when a capacitor is connected across the secondary. The *impedance transformation* offered by a transformer to resistive impedances connected across the secondary applies also to inductive or capacitive impedances connected across the secondary. As was stated just now, however, it is most

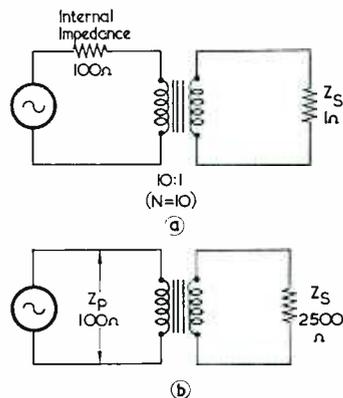


Fig. 143 (a). An instance in which the primary presents an impedance of 100Ω to the generator (b). Another impedance transformation example. What ratio should the transformer have to present a primary impedance of 100Ω ?

helpful, with elementary radio calculations, to work with resistive impedances only.

Before concluding on the subject of impedance matching, several points of terminology need to be mentioned. The transformed impedance offered by a transformer primary is frequently referred to as a *reflected impedance*. We have also referred to the instance where an a.c. "generator" requires a specific load impedance for optimum circuit operation, this impedance being different to that needed for maximum power transfer. As with the maximum power transfer instance, applying the required impedance load to the "generator", either directly or by way of a transformer, is similarly known as *matching*.

Next Month

In next month's article we shall carry on to practical iron-cored transformers and their applications. After this, and if space permits, we shall deal briefly with iron-cored chokes and swinging chokes (a subject we could not previously cover without an understanding of iron cores).

South Shields and District Amateur Radio Club

On Sunday, 7th July this Club will hold its Fifth Mobile Rally. (1) Venue: Bents Parks Recreation Ground, Coast Rd., South Shields. (2) Control Station: G3DDI which will tune over the 160m band from 11 a.m. (3) The Control Station will look for "DX" mobile contacts and a prize will be awarded for the greatest distance contact. A prize will also go to the visitor travelling the greatest distance on the day of the Rally. (4) Rally competitive events, which will commence at 2 p.m., will include the following: Driving Competition (over planned course on site), Odd Sounds Quiz, Transmitter Test. (5) Light refreshments will be available on the site.

THE HALLTRON

J. B. Dance, m.sc.

IN ORDER TO UNDERSTAND THE operation of a new type of semiconductor device known as the Halltron, it is first necessary to understand the basis of the Hall effect from which the Halltron derives its name.

The Hall Effect

If a piece of any conducting substance is placed in a magnetic field and a current is passed through the material in a direction perpendicular to the direction of the magnetic field, a small voltage known as the Hall voltage appears across the specimen in a direction perpendicular to both the direction of the magnetic intensity and the direction of the current passing through the device.

This effect occurs to some extent in all substances, but only in semiconductors is it large enough to have very great practical importance. The effect occurs because the magnetic field causes the moving charges to be deflected to one side or the other of the specimen, depending on the polarity of the charge, the direction of the field and the direction of movement of the charge.

The Hall voltage is proportional to the magnetic field intensity and to the current passing through the specimen. The effect of temperature on the Hall voltage is relatively small—about 0.15% per degree Centigrade.

The greater the mobility of the charge carriers in the semiconductor material, the greater the Hall voltage. This mobility can therefore be used as a figure of merit for the semiconductor material when used in devices which operate by means of the Hall effect. The fairly new semiconductor materials indium antimonide and indium arsenide have the highest charge carrier mobilities yet found in any semiconductor materials and are therefore very suitable for use in Hall effect devices.

The Halltron

Halltrons are semiconductor devices employing the Hall effect, and are manufactured by Ohio Semiconductors. The type HR-31 employs a thin wafer of indium arsenide and the type HS-51 a thin wafer of indium antimonide. A thin slice of the material is used so that the magnetic circuit requirements are simplified.

The high mobility of the charge carriers results in the semiconductor materials used in Halltrons having a high conductivity. The devices have an impedance of little more than an ohm and can therefore be used in high or low impedance circuits.

Uses

1. If the current passing through the device is constant, the voltage across the specimen will be proportional to the magnetic field intensity. A voltmeter connected across the device can thus be used to indicate the magnetic field intensity.

2. The Hall voltage is proportional to the product of the magnetic field intensity and the current passing through the device. If it is desired to measure the amount of power delivered to a load, the current passing through the load can also be passed through the Halltron and the voltage across

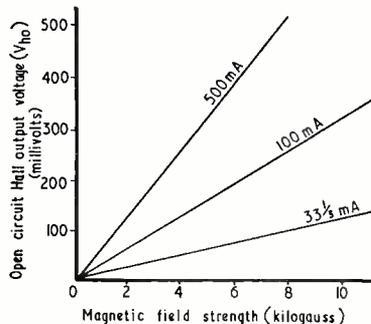
the load can be used to develop the magnetic field in which the Halltron is placed. Care should be taken to ensure that the magnetic field is in phase with and proportional to the voltage developed across the load.

The Hall voltage will then be proportional to the voltage across the load multiplied by the current passing through the load; that is, to the power being delivered to the load. A voltmeter connected to the Halltron can be calibrated in units of power delivered to the load. (The resistance of the Halltron is very low and therefore the current flowing through it produces a very small voltage drop and the power dissipated in the device is low.)

3. The Halltron can be used to measure d.c. or a.c. current flowing in a conductor by measurement of the magnetic field near the conductor, a separate steady current being passed through the device. Current from one milliamp to hundreds of thousands of amps may be measured in this way without shunts, current transformers or any connection between the Halltron and the circuit carrying the current being measured. The devices may be used as "clip-on" ammeters. If the current being measured is small, it is advisable to concentrate the magnetic field into the Halltron by the use of suitably shaped high permeability materials.

4. If the current passing through the Halltron and the current passing through the winding which creates the magnetic field represent two waveforms which are to be multiplied together, the Hall voltage has the form of the required product. This method of multiplication has uses in computers.

5. The Halltron may be used for converting d.c. signals into a.c. signals so that they may be amplified by normal capacitor



Typical characteristic of a Halltron. Open circuit Hall voltage plotted against magnetic field strength for various values of control current

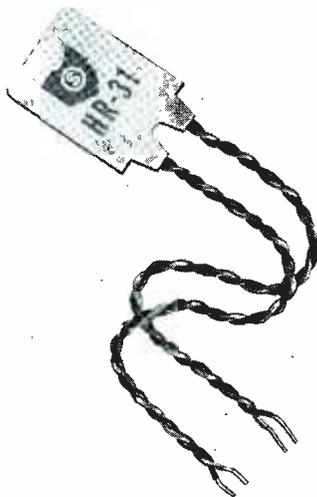
coupled amplifiers. The signal current is passed through the Halltron and a current having the required "chopping" waveform is applied to the winding which generates the magnetic field. The Hall voltage will vary as the chopping waveform and, over a longer period, as the signal current to the Halltron.

If the chopping frequency is in the megacycle range, it is generally preferable to pass a current of this frequency through the Halltron and use the signal to generate the magnetic field.

Halltrons also find applications in gyrators, isolators, accelerometers, transducers, modulators and frequency mixing circuits, etc. Many new circuits employing Halltrons as the control devices are expected to be developed in the near future.

Size

Typical dimensions are length



3/8 in, width 1/2 in and thickness 0.030 in.

Information

Complete magnetic circuits containing Halltrons which are ready for wiring into pieces of apparatus are also available from the manufacturers of the device.

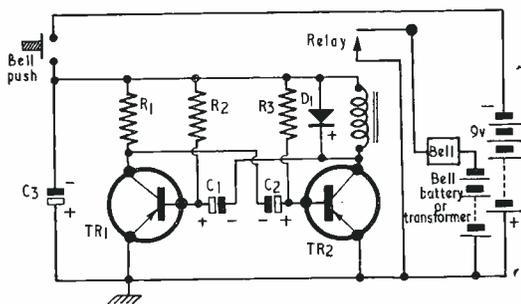
The Ohio Semiconductors HR-31 Halltron. The device has a thin package design which minimises magnetic circuit requirements

Further information about the performance and uses of these new devices may be obtained from the manufacturers, Ohio Semiconductors, 1205 Chesapeake Avenue, Columbus 12, Ohio, U.S.A.

Multivibrator Door Chime Repeater

by M. GEORGE, B.Sc.

LIKE YOUR CONTRIBUTOR K. V. R. BOWERMAN* we, too, have a "Ding-Dong" door bell which we don't hear when the television is switched on, and the slightly warped idea of having a self-repeating circuit appealed to me also. However, my junk box only ran to one relay which energised at about 3mA (an old model control relay, actually) and so the accompanying circuit was devised.



Almost any p.n.p. transistor will work in the circuit. When the button is pressed the 1,000 μ F capacitor, C₃, charges and runs a low frequency multivibrator for 3 to 6 cycles, the relay closing and opening once each cycle. A little juggling with C₁ and C₂ in the 4 to 50 μ F range produces

a period of 0.5 sec. one way and 2 secs. the other giving Ding—0.5 sec.—Dong—2 secs.—Ding—etc.

A separate battery is needed for the multivibrator circuit as the voltage drop caused by the bell is considerable and interferes with the charging

Components List

Resistors

- R₁ 10 to 20k Ω
- R₂ 56k Ω
- R₃ 56k Ω

Capacitors

- C₁, C₂ 4 to 50 μ F, experimental, 12V wkg., electrolytic
- C₃ 1,000 μ F, 12V wkg., electrolytic. (Value may be increased to provide longer running).

Relay

2,000 to 3,000 Ω coil. Capable of energising at 5mA or less

Semiconductors

- TR₁, TR₂ Any p.n.p. a.f. transistor with V_c max. greater than 9 volts
- D₁ Germanium diode

* K. V. R. Bowerman, "Door Chime Repeater", *The Radio Constructor*, February, 1963.

Note: none of the components are critical, and some may need to have their values determined experimentally.

of the 1,000 μ F capacitor unless the button is released very quickly, i.e. before the relay closes. No current is drawn from the multivibrator battery except when the button is pressed and, even then the current drain is only a few mA. In consequence practically any battery will cope. A potential of 9 volts is required.

Since TR₂ draws several mA and TR₁ only

0.5 to 0.75mA, a short "on" part of the cycle for TR₂ conserves the charge in the 1,000 μ F capacitor and more readily allows several cycles to occur. The short "on" period is provided by the cycle times just mentioned.

C₃ should be a good quality capacitor with a low leakage current in order that it may hold its charge for the time required (i.e. 10-15 seconds).

TRADE REVIEW . . .

The "RADIONIC" Radio and Electronic Construction System

The Radionic construction system is new and is designed for radio enthusiasts, for educational purposes and as a research facility.

It consists basically of a transparent panel drilled to standard pitch, components pre-mounted on colour coded bases and perforated brass connecting strip, snipped off to length as required, to effect the connections.

A nut, tightened against the compressibility of the perspex creates a firm and permanent contact. All soldering is done in the production stage.

The panels are of standard size and two or more may be joined together by means of a plastic beading which "grips on" to the edges and serves both to join them and to raise them above table level.

The advantages of the system are many. The circuit can be laid out in close accordance with the circuit diagram. It can easily and quickly be checked through the transparent panel without the need for mental somersaults. This is particularly helpful for beginners. Components can quickly be changed for those of differing values. Universal mounts are available for ordinary non-mounted components.

The system has been marketed initially in the form of radio construction and experimental sets with top quality components and Mullard transistors.

Prices range from £5 18s. 6d. for a No. 1 Set to £14 19s. 6d. for a No. 4. The former builds 14 receivers up to the reaction stage and the latter 26 circuits including 6-transistor superhets with 7 x 4in, 11,000 line loud-speaker reproduction. Any set can be expanded indefinitely by the addition of supplementary parts.

With each set go the *Radionic Handbook* and the appropriate circuit cards. Excellent performances are

achieved and the sets will operate well on the short waves. A *Radionic News Letter* keeps owners in touch with developments.



The characteristics of the Radionic System make it particularly attractive for instructional purposes and a range of very reasonably priced instructional sets is currently being evolved.

In the industrial field the system offers a well engineered and highly flexible breadboard facility for circuit development work.

The system (all patents applied for) has been designed and produced by: Radionic Products Limited, Adastral House, Nutfield, Redhill, Surrey. Tel.: Redhill 5050.

NEW AERIAL RECONNAISSANCE AIDS

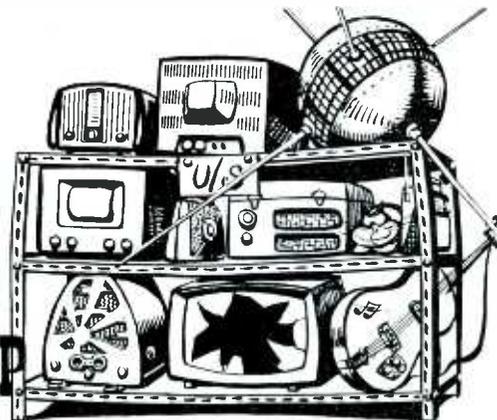
Tests have now been successfully completed on two new forms of electronic aids to aerial reconnaissance developed by EMI Electronics Ltd.

The first, known as Sideways Looking Radar, can provide an accurate map of the territory over which the aircraft is flying. Radar lobes extend out on either side of the aircraft and thus avoid giving advance information, to the enemy's counter measures, of the aircraft's arrival.

The second is known as Line Scan and consists of an optical scanner which provides pictorial information of the ground as viewed from the aircraft. This information can be stored in the aircraft or transmitted to a ground station whilst the aircraft is still in flight, automatically producing a photograph of a strip of the ground along the aircraft's track at the ground station. Thus, reconnaissance information is available even if the aircraft should not return.

Other EMI airborne reconnaissance equipment in current operation includes radar for British V-Bombers and the on range ASV radar fitted in Coastal Command aircraft.

IN YOUR WORKSHOP



This month, Smity the Serviceman, aided as always by his able assistant Dick, looks into the difficulties caused by one of the most infuriating aspects of servicing work: the intermittent fault

"Sound and vision disappear intermittently."

Dick glanced at this message on the label attached to the television chassis he had selected for repair, and he sighed resignedly. Another intermittent! He connected an aerial and the mains supply lead and switched on.

After a few seconds, the heaters began to glow. He waited expectantly and, shortly afterwards, the sound channel of the local transmitter became audible from the speaker. Some moments later the line output transformer started to sing, this being followed, after the e.h.t. rectifier had warmed up, by the appearance of a perfectly acceptable picture on the c.r.t. screen. Dick swung the channel selector knob to the alternative local channel, to find that the same conditions prevailed here as well.

Without warning, both the sound and vision suddenly disappeared.

With a grunt of satisfaction, Dick placed his testmeter in front of him and checked the voltage on the h.t. line of the receiver. The meter needle did not move. He next located the dual 100+300 μ F reservoir and smoothing capacitor unit, and checked the voltage on its tags. The meter needle shot immediately, for both tags, to 300 volts. These capacitors were obviously charging nearly to the peak value of the mains supply and there must be a break in the h.t. circuit immediately after the smoothing capacitor. Dick looked

suspiciously at the solder joint on the tag of the smoothing capacitor section itself. It appeared to be very dry.

The Perils of Servicing

Dick disconnected the mains lead and picked up his soldering iron. Steadying the chassis with his left hand, he applied the bit to the suspected solder joint. The joint was difficult to reach and, in his concentration, he allowed his finger to touch the barrel of the iron.

The peace of the Workshop was at once shattered by a stentorian roar of anguish as the smoothing capacitor commenced to discharge some of its 300 volts by way of Dick's body. Involuntarily, Dick jerked at the soldering iron whereupon the bit came in contact with the mounting lug of the capacitor; and his initial bellow was followed by the pistol-like crack which results when a fully charged 300 μ F electrolytic receives a direct short-circuit. Shattered by the noise Dick pulled back the iron, with the result that its lead, trailing across the bench, neatly hooked off his testmeter. Dick lunged forward frantically, and caught the meter just before it hit the floor. Burdened with the meter in his left hand and the soldering iron in his right, he next straightened up. However, due to the fact that he had inadvertently trodden on one of its test leads during his frenzied dive to save the meter, his left hand came to an abrupt halt after it had moved six

inches only. Surprised by this unexpected impediment, Dick swung round and looked down, not noticing that this movement caused the soldering iron barrel to pass between the picture tube support struts on the television chassis. With a presence of mind which, under any other circumstances, would have been worthy of the utmost praise, Dick lifted his left foot to release the trapped test lead.

Now that the testmeter was freed, and whilst he was on the point of replacing his left foot on the floor, Dick stood up abruptly, only to find that, whereas he had previously been holding a soldering iron in his right hand, this hand had now mysteriously acquired a television chassis as well. His state of uncertain equilibrium reverted to wild unbalance at this unexpected weight and he fell heavily backwards, to perceive with horror that the television chassis had become dislodged from the soldering iron and was now describing a graceful parabola above him. As the chassis travelled through the air the aerial lead connected to it tightened, and there were three separate popping noises as three insulated staples securing the aerial lead to the wall pulled out under the strain. The fourth staple held and, like a weight on the end of a rope, the chassis swung crazily round in a circle, its ultimate direction being towards Dick's upturned face. Desperately, Dick held his already fully encumbered hands up in front of

him and, miraculously, caught the chassis in a grip which, though uncertain, at least brought its descent to a halt. But the weight of the falling chassis jerked the now-tautened soldering iron lead beyond its natural length, whereupon its connections were forcibly pulled out from the plug terminals, short-circuiting together as they did so. A sharp crack from the fuse-box proclaimed that one of the long-suffering Workshop fuses had, as usual, met an early demise, and all the lights went out.

Smithy, whose attention had been attracted to Dick's extempore performance by the first yell of pain, deftly dodged a flying staple and gazed down detachedly at his prone assistant. There was silence for a long moment. Then a valve in the television chassis, loosened by the treatment to which it had been subjected, fell neatly into Dick's mouth. Dick spat it out disgustedly, and found his voice.

"For the love of mike," he snorted, "don't just stand there!"

"What," asked Smithy carelessly, "do you want me to do?"

"Take this blistering chassis off me, of course," snarled Dick. "If I relax my grip for a moment, it'll fall straight on to my face."

With an air of condescension, Smithy took the offending chassis from Dick's insecure clasp and, disconnecting its aerial lead, placed it safely on his bench. Dick sighed with relief and allowed his arms to relax, after which he handed over the testmeter and soldering iron also. With much grumbling and checking for broken bones, he eventually got up and, shakingly, sat down on the stool at his bench.

Safety First

"Well," said Smith eventually, "I've seen some things in my time but never anything quite like that."

"It's all right for you to talk," responded Dick bitterly. "If you'd gone through what I have just now you wouldn't be feeling so good yourself. Blimey, I can *still* see that TV chassis swinging down towards me!"

"It was certainly an impressive sight," agreed Smithy. "Fortunately, the chassis wasn't damaged too much."

"Blow the chassis," said Dick indignantly, "it was *me* I was thinking of. Anyway, I'm not doing any more work for a bit. I'm all shook up!"

"As you like," said Smithy equably. "I'll put the kettle on. It's near enough time for tea-break anyway."

Leaving his stricken assistant to recuperate, Smithy wandered over to the Workshop sink and occupied himself with filling the kettle.

"Incidentally," he added, over his shoulder, "what *was* wrong with that TV?"

"It had an intermittent," replied Dick. "When the fault came on, there was h.t. on the reservoir and smoothing capacitors, but not a sausage anywhere else in the set."

"There must have been a break somewhere after the smoothing capacitor," commented the Serviceman.

"That's what I thought," said Dick. "I found what looked like a poor joint on the reservoir capacitor tag and I popped the iron on to it. Whereupon I got the father and mother of all the belts which ever existed! This was despite the fact that I'd disconnected the mains, too."

"Did you discharge the capacitor before you started playing around with it?"

of a resistance bridge, or something."

"I'm putting it that way," said Smithy, "to show you how very dangerous these capacitors can be when they're fully charged. Let's assume that you get your hands across one of these capacitors and, for some reason or another, you can't let go. In your case, you would have started off with a voltage of 300 or so. Even after 80 seconds this would still be 111 volts, because the time constant defines the time taken for the voltage to fall to 37% of its original value."

"I'm beginning to see your point," said Dick, impressed. "When you've got capacitances as large as these, it's almost like putting your hands across a bank of accumulators adding up to the same voltage. I'm beginning to think I was lucky, just now, in being able to break the circuit as quickly as I did."

"I'll say you were," agreed Smithy. "You must always remember to discharge those capacitors if there's any risk of shock. And I don't mean slap a screwdriver across them, either! It's a good idea to knock up a simple gubbins consisting of two flexible leads connected to a 1 watt resistor of about 100Ω or so. (Fig. 1.) One lead can be terminated in a crocodile clip which you connect to chassis, whilst the other lead can end in an insulated test prod which you apply to the tag of the capacitor you want to discharge. With a gadget like this, you get a quick discharge without any fireworks."

"That seems a neat idea," said Dick. "I'll knock one up when I've got back to normal."

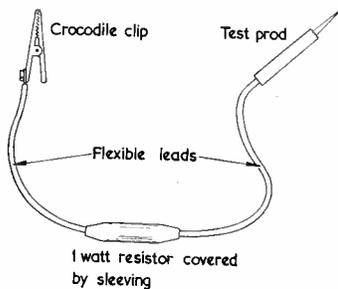


Fig. 1. A simple device which may be used for discharging h.t. electrolytic capacitors without excessive currents. The resistor may have a value around 100Ω

Intermittent Faults

"What you need," commented Smithy, "is some occupational therapy. The kettle's nearly boiling, and I would suggest that you have a stab at making the tea."

Dick was already beginning to return to his normal self and, as he busied himself at the sink, his usual cheerful outlook started to appear once more. Smithy watched him, thoughtfully.

"It's funny that you should have had an intermittent snag on that set of yours," he remarked, after a while, "we've had quite a rush of them recently."

"For my money," called out Dick, as he filled the teapot, "intermittents are the biggest bugbear we have to contend with in this servicing lark."

"I wouldn't argue," replied Smithy. "One snag with intermittents is that, quite often, you're not entirely certain whether you've cleared them or not. You may, in carrying out the

"I'm afraid not," admitted Dick ruefully. "One tends to forget these things, you know."

"Then you shouldn't," commented Smithy severely. "Most TV sets these days have reservoir capacitors around 100μF and smoothing capacitors around 300μF, as you probably had in that model there. And those figures, my boy, represent the dickens of a lot of capacitance. A representative resistance for the human body is about 200kΩ between opposite hands and this means that, if you're mug enough to put your fingers across a total of 400μF, you set up an RC circuit with a time constant of 80 seconds!"

"Talk about being cold-blooded," said Dick, horrified. "You sound as though the human body is one arm

routine tidying up which you do when you're looking for the fault, have accidentally cleared it up temporarily only. The set works O.K. in the customer's house for a week or so, then—bingo!—on comes the intermittent again. Another difficulty is that you may have the set in the shop for quite a few days before you find the trouble, after which it is cured by merely applying the soldering iron to a dicey joint. Whereupon you have a repair bill which carries a fantastic charge for labour together with a material charge of a farthing for solder."

"Intermittents are certainly a cause of trouble," said Dick, handing Smithy his tea.

"They're a menace," replied Smithy, a note of bitterness creeping into his voice, "and I speak from many years of unhappy experience. Another nuisance factor with them is that customers never seem to understand that you can't find what's causing the intermittent until the intermittent comes on. Then, as soon as it *does* come on, you've got to work frantically with the testmeter trying to locate the snag, keeping your fingers crossed all the time that your efforts won't cause it to clear again. Sometimes, the small current caused by applying a testmeter to a circuit may result in the intermittent clearing. In this instance, all you can do is to leave the testmeter permanently connected so that it will, if you're lucky, show up the fault condition when it next appears. The result is that you've got a testmeter tied up all the time on a job which may not go faulty for ages. Yes," concluded Smithy flatly, "intermittents are the big bind in our job. They take up a disproportionate amount of time, they sour relations with the customer, and they tie up test equipment which you cannot always afford to spare."

A Logical Approach

"Is it possible," asked Dick, "to have a logical approach towards intermittents?"

"Not to any great extent," replied Smithy. "There's too much guesswork involved. Still, there *are* a few facts which may simplify the process of locating them."

Smithy sipped his tea.

"What you need," he said, "is a two-stage attack. The first stage is to try and guess the section of the receiver in which the fault appears. Thus, if you have a TV set in which the picture disappears every now and again whilst the sound remains on, you can pretty safely eliminate the tuner unit and, obviously, the sound i.f. and a.f. amplifiers. If, when the

picture disappears, you still have a blank raster you can also eliminate the line and vertical timebases. In this instance you would carry on to suspecting the vision i.f. stages and the video amplifier. In other words, you guess at the faulty stage by a standard process of elimination. I should add, incidentally, that customers' descriptions of the fault can sometimes be very helpful here. They may not always be technically accurate, but they often give you a vital clue.

"The second stage in your attack," continued Smithy, "is to start guessing at the connection or other fault in the guilty part of the receiver which is causing the trouble."

"Connection?" interrupted Dick.

may be causing the fault. If you look at components in that way you are more liable to suspect the component which is actually causing the fault."

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

"It'll become clearer as we go along," said Smithy. "Having introduced the idea that many intermittents are caused by faulty connections, the next thing to do, if we are going to use a logical approach, is to grade those connections in terms of reliability. Whereupon I would suggest that the connections which are mostly to be suspected are those which are not soldered."

"You don't get many connections like that these days," commented Dick.

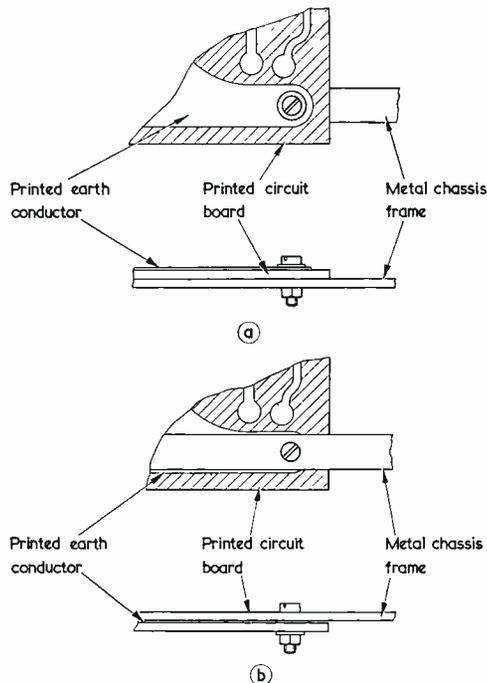


Fig. 2. Frequently, the earth conductor on a printed circuit board is connected to a metal chassis frame with the aid of a nut and bolt. In (a) the connection to the earth conductor is made via a washer and the bolt head. In (b) the earth conductor is in direct contact with the metal frame

"Won't components give you intermittents just as frequently as connections?"

"Of course they will," replied Smithy. "But what I'm trying to put over here is that most intermittents are caused by faulty connections, including faulty connections *inside* components. I try to visualise components not as little black boxes with wires poking out of them, but as a network incorporating two or more connections, any one of which

"Don't you?" chuckled Smithy. "Modern radio and TV sets are crawling with them!"

"Hey?"

"It's perfectly true," grinned Smithy. "These unsoldered connections may not be obvious at first sight, but there are plenty of them. To start off with, there are nut and bolt connections to printed circuit boards."

"Come off it, Smithy," protested Dick. "You're joking now!"

"No, I'm not," replied Smithy. "For instance, many printed circuit boards receive their earth connections by way of chassis frame mounting bolts. Either the bolt head screws down on to the earth conductor on the board (Fig. 2 (a)) or the earth conductor is brought into contact with a metal chassis member (Fig. 2 (b)). This is quite a common technique and a connection of this nature is one of the first things to suspect if, should it become intermittent, it could cause the fault."

Smithy paused for a moment. "The next type of unsoldered connection," he continued, "is the riveted or eyeletted type. You will very frequently find, with receivers having aluminium chassis, that the earthing solder tags are secured by eyelets. (Fig. 3 (a).) In my opinion this is a bad practice, because the tightness of the eyelet depends

entirely upon the setting of the eye-letting machine when the tag is fitted. Also, the tightness of the eyelet is bound to ease off slightly as the years go by. Again, oxide forms on the surface of aluminium very readily, and this may cause a film of oxide to appear between the aluminium and the earth tag, thereby making a very doubtful connection. All of these factors can lead to intermittent breakdowns."

"You don't get many aluminium chassis these days," put in Dick. "Receivers use printed circuits now."

"I know they do," replied Smithy, "but you may still find sub-assemblies built up on aluminium brackets with eyeletted earth tags. However, you've raised another point here. One of the difficulties with printed circuit design consists of carrying over the earth conductor from one section of the board to another.

The simplest method of doing this is to employ a jumper wire. (Fig. 3 (b).) The jumper wire is soldered at both ends and is not very likely to lead to an intermittent fault. Very often, though, the earth connection is carried over by the mounting lugs of an aluminium coil can (Fig. 3 (c)), whereupon you have a very definite potential cause of intermittents. This is because the two mounting lugs may be riveted to the can, giving you the same dicey conditions as you have with earthing tags on an aluminium chassis."

"Sometimes," commented Dick, "you have earthing tags eyeletted to steel chassis as well."

"True enough," confirmed Smithy. "And these are similarly liable to give trouble. Steel chassis are cadmium plated but, even so, they still tend to become oxydised now and again. This tendency is less pronounced if the chassis is passivated, of course."

"A passivated chassis," queried Dick, "is one of those having a yellow appearance, isn't it?"

"That's right," said Smithy. "The passivation affects the outside molecules of the cadmium plating and offers additional protection. It is perfectly in order, by the way, to solder on to a passivated surface despite its unusual appearance. Indeed, the earth tags on a well-designed steel chassis are integral with the chassis itself, being punched and bent out when the chassis is formed. Earth tags of this nature are, of course, much more reliable than eyeletted tags."

"Are there any other unsoldered connections?"

"Stacks," replied Smithy cheerfully. "You will almost inevitably find unsoldered connections inside resistors, tubular capacitors, mica capacitors and electrolytic capacitors. With the resistors, it is frequent practice to have brass end caps which are force-fitted to the rod of composition material. Tubular capacitors, whether they be paper, polystyrene or polyester, also use solderless connections. Mica capacitors employ rivets or eyelets for the lead-out connections. And electrolytic capacitors similarly have eyelets or other methods of pressure connection. So you have a whole host of unsoldered connections, any one of which could conceivably give rise to an intermittent!"

"Blimey," said Dick, dismally. "I hadn't looked at things in that light before!"

"Don't be too depressed about it," grinned Smithy. "Most of the internal unsoldered connections inside components give rise to very

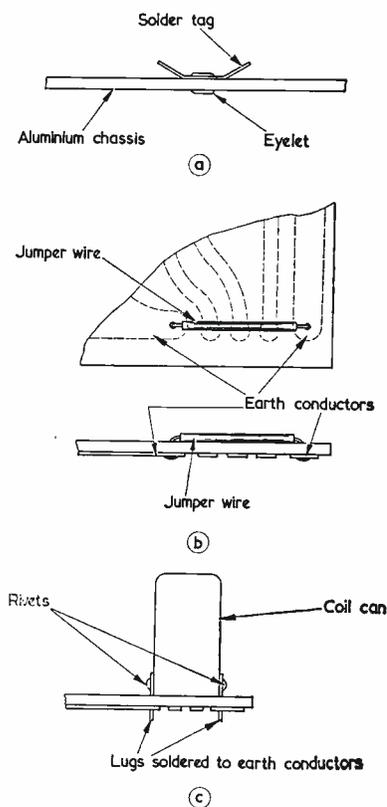


Fig. 3 (a). A possible cause of intermittent faults is given by solder tags eyeletted to aluminium chassis

(b). Employing a jumper wire to couple two earth conductors together on a printed circuit board. In the upper view the conductors are below the board, their outline being shown in dotted line

(c). An alternative method of coupling together two earth conductors consists of using the mounting lugs of a coil can instead of a jumper wire

little trouble in practice. From my own experience I would place the reliability of these connections in the following order. The connections inside polystyrene and polyester capacitors appear to be most reliable, these being closely followed by composition resistors and mica capacitors. Paper capacitors come next, and are much more liable to give rise to intermittent faults than the other components I've mentioned. And, finally, there are electrolytic capacitors, which I consider to be the worst of the lot. Indeed, if you have an intermittent in which the fault condition could be caused by an electrolytic going open-circuit, I would suggest that you replace the electrolytic almost as a matter of course."

"Why," asked Dick, "are paper and electrolytic capacitors more liable to give rise to trouble so far as intermittent connections are concerned?"

"Because of their construction," said Smyth. "Although I must confess that I am probably being a little unfair to paper capacitors, as the modern versions of these components seem to be a lot more reliable than the old ones used to be. With electrolytic capacitors, however, it's a different story. The plates of electrolytic capacitors are of oxidized aluminium, and it is frequently difficult to obtain a perfectly reliable mechanical connection to these. Because of this they seem to be much more liable to give rise to intermittent faults than other components."

"Wetting" Voltages

Smyth stopped talking and silently held up his cup in a manner reminiscent of the Statue of Liberty. Without a word Dick rose, took the cup from him and carried it over to the Workshop sink, where he set about replenishing it. He returned with his cargo of precious fluid and placed it carefully on Smyth's bench. Silently, he resumed his own seat. It was a ritual which had become automatic through long custom.

"There is an interesting point about intermittent connections in capacitors," Smyth carried on, "which may help you to locate a fault of this nature. It has to do with 'wetting' voltages."

"With what?"

"With 'wetting' voltages," continued Smyth. "When you have two contacts which aren't soldered together, you may sometimes find that they tend to become open-circuit or high-resistance because of the appearance of an oxide film between them. If, however, a size-

able potential difference—say thirty volts or more—is applied to the two contacts, the oxide film may break down and you get a good connection again. This potential difference is known as a 'wetting' voltage. When a receiver is switched off for a period all its capacitors discharge with the result that, when the set is switched on again, it is quite possible for a 'wetting' voltage to appear across any intermittent internal capacitor connections which may exist. Since the capacitor takes a short time to charge up, the wetting voltage does not disappear immediately. It *does* disappear, however, when the capacitor is fully charged. If ever you get an intermittent fault which disappears when you switch off the set and switch it on again afterwards, it is a good plan to suspect the capacitors and any unsoldered connections in the capacitor charging circuits. The re-application of the 'wetting' voltage when you switch on again may be the cause of a faulty capacitor connection becoming good again. Unsoldered connections to other components could also respond to the switching off-switching on treatment, but it isn't a bad plan to suspect the capacitors first. Particularly if these are of the electrolytic or paper variety."

"Are there any other unsoldered connections to look out for?"

"Quite a few," replied Smyth. "But they are all the obvious ones. They include the connections between valve pins and valveholder sockets, the connections to potentiometer tracks and so on. These are normally pretty easy to locate when they go intermittent."

Soldered Connections

"What about soldered connections?" asked Dick.

"Well," replied Smyth, "a properly soldered connection doesn't, of course, give rise to intermittent faults. So what you have to look for here are connections of this type which *aren't* properly soldered, and these can usually be located by visual examination. Incidentally, some of the early printed circuit sets were pretty bad in this respect because, at that stage of development, both the copper foil and the component lead-outs didn't take the solder as readily as they should during the soldering process at the factory. Later boards are very much better so far as solder connections are concerned. It is, once again, a wise plan to look upon individual components as a network of soldered connections, where applicable, rather than little black boxes on their own. This gives you, once more, a field

for fault-finding which may well be profitable."

"Which are the components," asked Dick, "that are most liable to give rise to intermittent faults because of poor solder connections?"

"Wound components," replied Smyth promptly. "Any wound component, whether it be a choke, coil or transformer, is very liable to give trouble on this score. The fault occurs because of bad soldering at the lead-out points. A typical example which you often encounter is with video chokes. These little chokes frequently have a badly soldered connection between the coil wire and the lead-out termination. The same applies, of course, to pretty well any other coil as well, and particularly to TV and f.m. i.f. coils and turret tuner coils. These are single-layer coils which usually employ wire with insulation which melts at soldering temperatures. The coil ends are merely inserted in their tags without stripping back the insulation, whereupon the subsequent soldering operation first melts the insulation before soldering the conductor, itself, to the tag. The insulation on wires of this nature

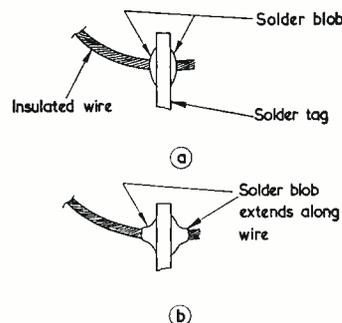


Fig. 4 (a). Wires with insulation which melts at soldering temperatures may take up this appearance at a solder joint. The insulation extends right up to the solder blob. A joint of this nature should be suspected (b). In this joint the solder extends out from the blob along the wire. Such a joint may be considered reliable

may be enamel, or nylon and acetate fibre. If you get a solder joint of this nature in which the insulation extends right up to the solder blob (Fig. 4 (a)), it may be giving you trouble because the insulation might not have been fully melted during soldering. If, on the other hand, the solder blob extends along the wire

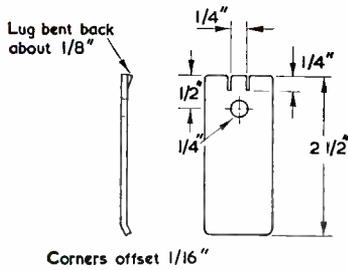


Fig. 3. Clamp slider

of the corner brace. This piece is used later to make the slider.

The remaining piece is now slotted down its long side with a small hacksaw. This slot is 2 in long, $\frac{1}{4}$ in wide, and is central down the strip (see Fig. 2).

A new hole, $\frac{3}{8}$ in in diameter, is drilled $\frac{3}{4}$ in below this slot, and is countersunk so that the rivet (fitted later) will be flush with the surface.

The other leg, which is now $1\frac{1}{2}$ in long, is cut down its length to $\frac{3}{8}$ in wide, as shown in Fig. 2. This is narrow enough to go between most components on the top of the chassis. This narrow leg is covered with a piece of thin foam rubber or plastic foam draught-excluder, which grips the chassis and also prevents damage.

The Clamp Slider

The $2\frac{1}{2}$ in strip of metal cut from the third corner brace is now used for the clamp slider. Drill a $\frac{1}{4}$ in hole centrally, $\frac{1}{2}$ in from the top. The two bottom corners are bent slightly so that they will grip the inside of the chassis (see Fig. 3).

At the top $\frac{1}{4}$ in above the hole, two slots $\frac{1}{4}$ in deep and $\frac{1}{4}$ in apart are cut. The resulting lug, when bent backwards by about $\frac{1}{4}$ in will locate in the slot in the clamp body and prevent the slider twisting when it is being tightened down.

The Base

The base consists of a $\frac{3}{4}$ in wardrobe rod socket and a series of washers which, when assembled, give a very strong but movable base (see Fig. 4).

The only work involved here is filing down washer No. 2 to fit tightly inside the rod socket under washer No. 1.

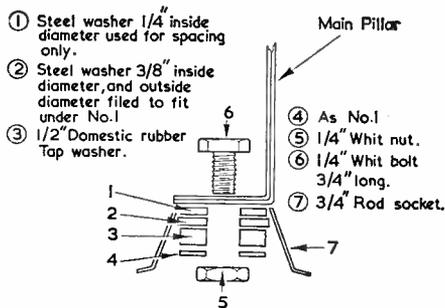


Fig. 4. Base with friction stay

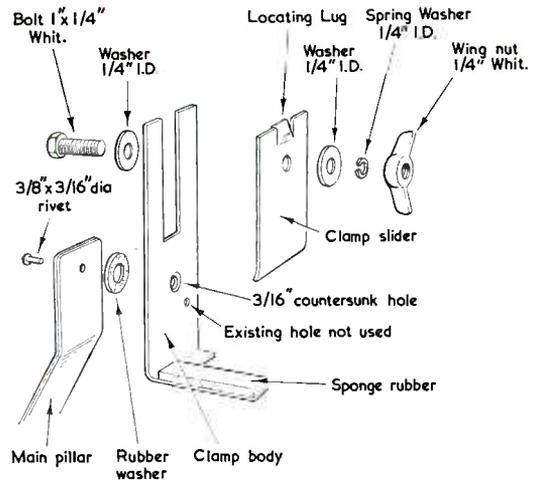


Fig. 5. Assembly of the clamp

Once this has been done the base can be joined to the main pillar, and assembly proceeds in the following manner.

Pass the $\frac{3}{4} \times \frac{1}{4}$ in Whitworth bolt through the bottom of the main pillar; place on spacing washer No. 1, and then the rod socket with washer No. 2 tapped firmly in place.

Next fit the rubber tap washer (with the centre hole enlarged), washer No. 4, and the nut.

Tighten the nut until the base can only be turned by gripping very firmly.

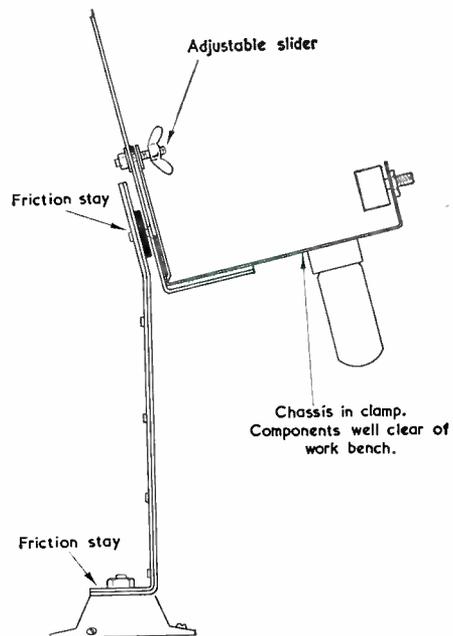


Fig. 6. The clamp in use

The projecting end of the bolt is now tapped with a hammer to prevent it working loose.

Final Assembly

It is next necessary to rivet the clamp body to the main pillar, spacing the two parts with the rubber hot water bottle washer to form a friction stay (see Fig. 5). The rivet used here needs to be hammered very firmly, as a surprising amount of strain is exerted on this stay and, of course, it must not slip during use.

The slider can finally be put into position as in Fig. 5, whereupon the clamp is ready for use.

Fig. 6 shows the clamp in operation, illustrating how it holds a typical radio chassis.

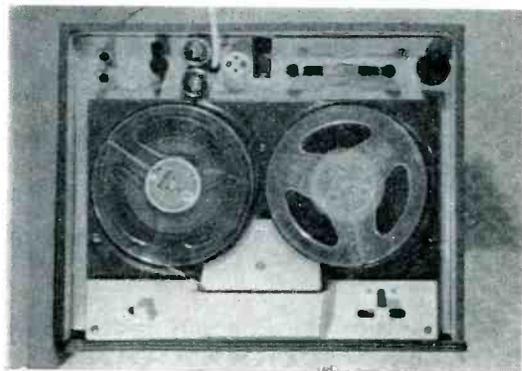
Components List

- 3 4 × 4in steel corner braces
- 1 3/4in metal wardrobe rod socket (see text and Fig. 4)
- 1 1 × 1/4in Whitworth bolt with wing nut
- 5 3/8 × 3/16in diameter aluminium rivets
- 1 1/2in rubber tap washer
- 1 Washer for rubber hot water bottle
- 4 Steel washers 1/4in inside hole
- 1 3/8in steel washer (see text)
- 1 3/4 × 1/4in Whitworth bolt and nut
- 1 Spring washer 1/4in inside diameter
- Sponge rubber, as required.

Cover Feature

Economy Tape Recorder

R. MURRAY-SHELLEY



ALTHOUGH THE ACCENT OF THIS RECORDER is on economy of construction and ease of operation, the results obtained from it are, nevertheless, at least equal to those obtained from many more expensive commercial recorders.

This instrument is based on the B.S.R. two-track "Monardeck" type TD2, which is obtainable from several advertisers in this magazine. The mechanical difficulties involved tend to preclude really satisfactory results being obtained from a home-built tape deck. The B.S.R. deck has proved to be most reliable. It gives a single speed of 3 3/4 in/sec and will take 5 3/4 in tape reels. With double play tape, therefore, an overall playing time of 3 hours is possible. The B.S.R. deck was chosen primarily because of its relatively low price. Other decks should prove equally suitable, but it must be pointed out that, whatever model is chosen, it should be fitted with a high impedance record/playback head and a low impedance erase head.¹

The Circuit

The amplifier circuit is shown in Fig. 1. This circuit uses B9A valves throughout, and is a varia-

tion on a tried and tested circuit which is used commercially. The first stage—the pre-amplifier—employs an EF86 working as a voltage amplifier at high gain. The output from this valve is taken to one half, V_{2(a)}, of an ECC83 double-triode. The amplified output from this stage is then fed to V_{2(b)} for further amplification. A frequency selective negative feedback loop via C₅ provides the necessary equalisation on both Record and Playback. This simplifies to a large extent switching operations. The required constant current recording characteristic is provided simply by R₁₃. The EL84 valve shown in Fig. 1 doubles as the bias oscillator in the Record position, and as the output stage on Playback.

In the Record position, therefore, the EL84 generates a bias current at a frequency of about 60 kc/s, this being applied to the record head via C₁₄, and to the erase head via C₁₈. Switch S₂ is used to short-circuit the erase head, thus providing a means of superimposition. This facility is useful in certain instances—introducing pieces of music, for example. S₂ is intended to be used intermittently only, and for short periods; normally it is left open as shown in Fig. 1, whereupon normal erasure takes place.

The oscillator coil is home-made, this being quite a simple operation. The bias frequency is

¹ However, a high impedance erase head could also be used, the erase feed being taken from point "c" on the oscillator coil (Fig. 1) via a 0.05μF capacitor. The secondary of the oscillator coil could then be eliminated.

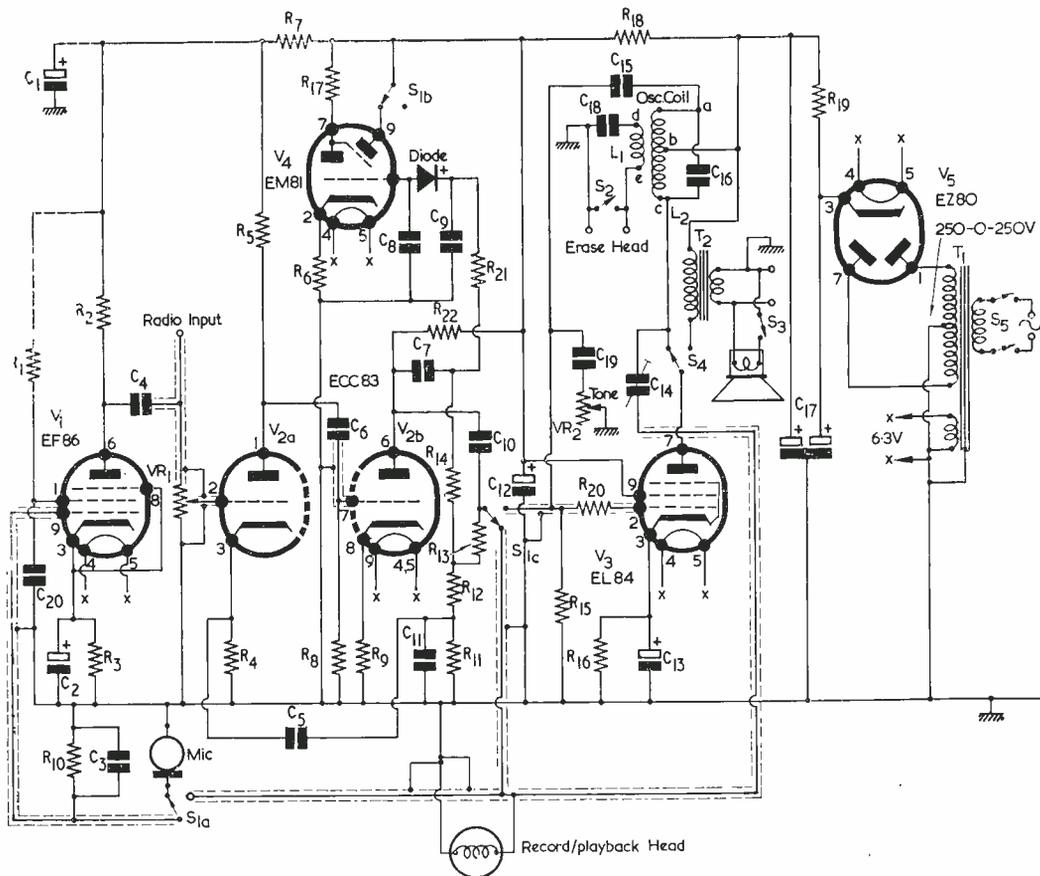


Fig. 1. Circuit diagram of the recorder

Components List

Resistors (all fixed values $\frac{1}{2}$ watt 10% except where otherwise stated)

- R1 1M Ω
- R2 220k Ω
- R3 2.2k Ω
- R4 2.2k Ω
- R5 100k Ω
- R6 680 Ω
- R7 47k Ω
- R8 220k Ω
- R9 2.2k Ω
- R10 2.2M Ω
- R11 2.2k Ω
- R12 47k Ω
- R13 100k Ω
- R14 47k Ω
- R15 470k Ω
- R16 150 Ω 2 watt
- R17 470k Ω
- R18 10k Ω

- R19 500 Ω 5 watt
- R20 2.2k Ω
- R21 470k Ω
- R22 100k Ω
- VR1 500k Ω log, with d.p. switch (S5)
- VR2 500k Ω log

Capacitors (all 350V wkg except where otherwise stated)

- C1 8 μ F electrolytic
- C2 25 μ F electrolytic 12V wkg
- C3 200pF ceramic
- C4 0.01 μ F paper
- C5 0.04 μ F paper
- C6 0.01 μ F paper
- C7 0.1 μ F paper
- C8 0.002 μ F paper
- C9 200pF ceramic
- C10 50pF ceramic
- C11 0.04 μ F paper

- C₁₂ 16 μ F electrolytic
- C₁₃ 50 μ F electrolytic, 25V wkg
- C₁₄ 100pF trimmer
- C₁₅ 180pF ceramic
- C₁₆ 0.003 μ F paper
- C₁₇ 32+32 μ F electrolytic
- C₁₈ 0.05 μ F paper
- C₁₉ 0.005 μ F paper
- C₂₀ 0.5 μ F paper

Valves

- V₁ EF86
- V₂ ECC83
- V₃ EL84
- V₄ EM81
- V₅ EZ80

Diode

GEX34, or similar

Tape Deck

"Monardeck" two-track type TD2. (Birmingham Sound Reproducers Ltd.)

not at all critical, any value between about 40 kc/s and 90 kc/s being suitable.

Recording Level

The recording level is monitored by a so-called "magic eye"—V₄ in Fig. 1. This is fed from V₂(b) via R₂₁. The capacitors C₈ and C₉ form a delay circuit which damps the response of the EM81, thus giving a clearer indication of the recording level. The circuit values specified ensure that optimum recording level corresponds to the "wings" of the valve display just closing.

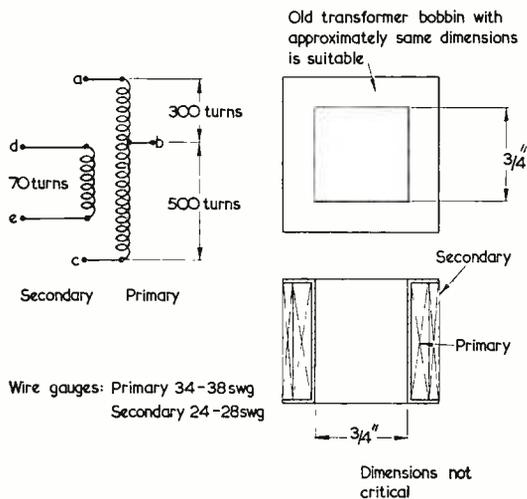


Fig. 2. Details of the oscillator coil

Microphone

Crystal microphone (or other sensitive high impedance type)

Inductors

- T₁ Mains transformer. Primary to suit mains supply voltage. Secondaries: 250-0-250V 70mA, 6.3V 2.2A minimum
- T₂ Output transformer. Ratio 40:1, primary current 50mA
- L_{1, 2} Oscillator coil (see text)

Switches

- S₁(a), (b), (c) Part of tape deck
- S_{2, 3} Low-voltage surface mounting switches (see text)
- S₄ Ganged with S₁ (see text)
- S₅ D.P. switch, part of VR₁

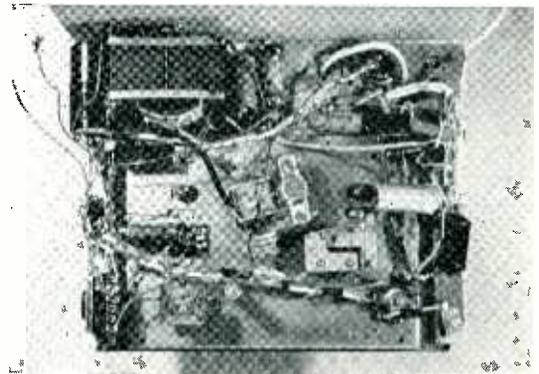
Miscellaneous

- 5 B9A valveholders, moulded, nylon loaded (with screening cans for V₁ and V₂)
- Loudspeaker
- Loudspeaker socket
- Coaxial sockets
- Groupboard
- Knobs, etc.

The power supply circuit is fairly conventional, a mains transformer being used in the interests of safety. The smoothing arrangements are quite thorough, this being necessary to avoid undue hum in the complete amplifier. It has been found that the overall hum and noise levels in the amplifier are satisfactorily low.

In the Playback position the EL84 acts as the output valve and will deliver up to 4.5 watts output. The output may be monitored on an internal speaker and provision is also made for the connection of an external speaker. In this case the monitored speaker can be switched out using S_{3,2}

² S₃ should not be opened unless an external speaker is connected. Otherwise, high a.f. voltages may appear across the primary of T₂ and result in damage.—EDITOR.



Showing the component layout on the motorboard — compare with Fig. 3

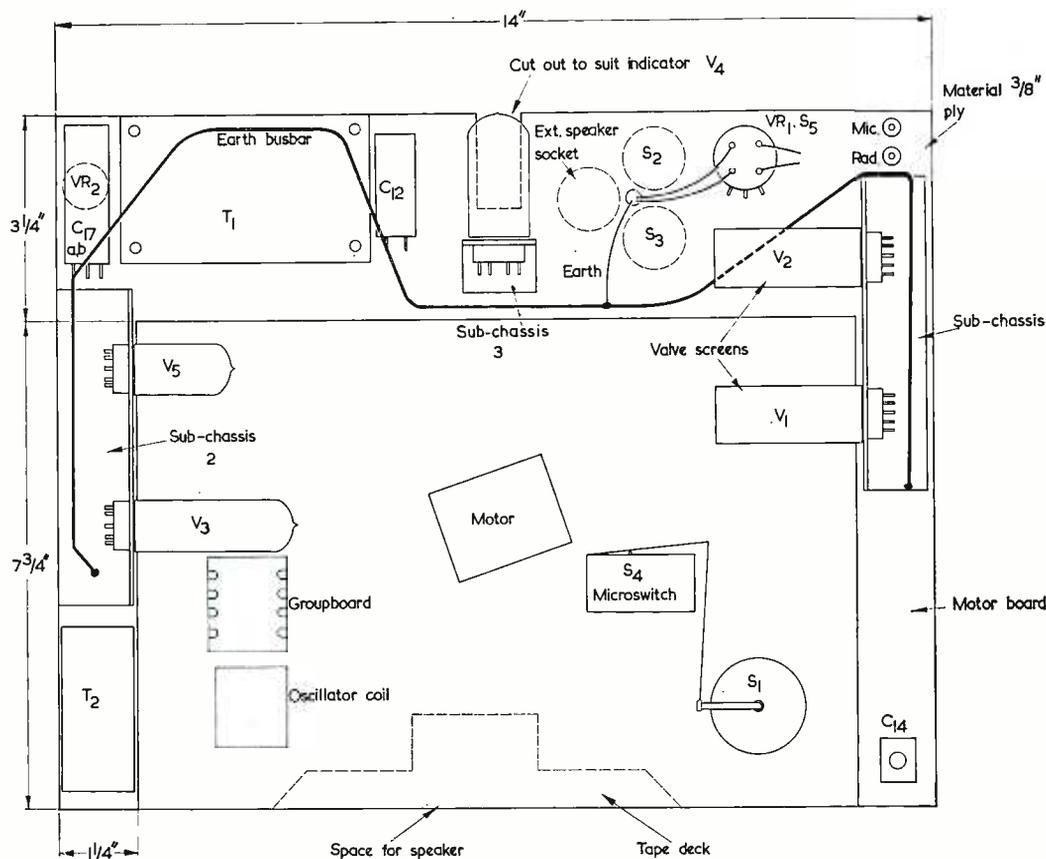


Fig. 3. The general component layout on the motorboard

The switching arrangements have been kept as simple as possible consistent with good results. A tone control of the simple treble-cut type is provided on playback by VR₂ and C₁₉.³ A low sensitivity socket for recording from a radio feeder unit is provided as shown in Fig. 1. This socket also enables the circuit (in the Playback position) to be used as an ordinary "straight through" amplifier.

Construction

The method of construction is rather novel. It is normal practice to construct the complete amplifier on a single chassis. In this case, however, it was decided to construct the amplifier on three separate sub-chassis. This method of construction facilitates the accurate positioning of components and valve stages in order to reduce hum levels to very low proportions. It is necessary for example to separate the small-signal, high-gain, side of the amplifier from strong sources of hum such as the mains transformer and the drive motor, and also from the

³ From an examination of the circuit, it might appear that the setting of VR₂ would affect oscillator output amplitude. However, the author has carried out tests on the finished circuit which show that this variation is not sufficient to affect either the bias level or the erase efficiency to any discernable level. He therefore considers it in order to include this control.—EDITOR.

oscillator. Again, the layout enables the output valve, output transformer, oscillator coil, mains transformer and rectifier valve to be situated in close proximity to each other.

The general component layout is shown in Fig. 3. It will be seen that the tape deck is mounted on motor board (dimensions given in Fig. 3) and that the sub-chassis are themselves all mounted on this board. Thus, the mechanical and electronic parts of the recorder form a complete self-contained unit which is easily removable from the case should servicing become necessary.

The Oscillator Coil

The oscillator coil can be home-made quite easily, though a commercial coil could, no doubt, be used satisfactorily. Fig. 2 gives details. The dimensions and numbers of turns are not particularly critical, though they should be adhered to if possible. An old transformer bobbin makes an excellent former for this coil. The primary can be random wound and should be interleaved with paper at 300 and 600 turns. The secondary should be layer wound with an interleaving paper between each complete layer. The finished coil can be protected with wax.

To avoid a loss of oscillator power, the oscillator

coil must not be mounted close to any earthed metal objects. It should therefore be kept at least 1½ in away from the tape deck. A piece of wood or plastic can be used to support the coil.

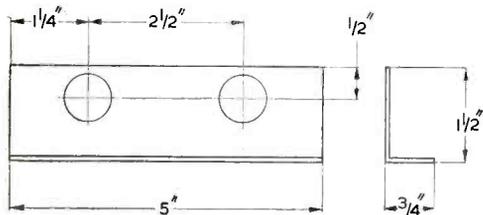


Fig. 4. Drilling details for Sub-Chassis 1 and 2. The material is 16 s.w.g. aluminium

Sub-Chassis

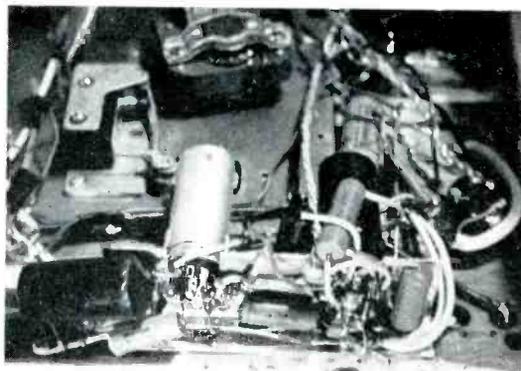
Fig. 4 gives the drilling details for Sub-Chassis 1 and 2. These are identical. Fig. 5 then shows the wiring of Sub-Chassis 1. The major difficulty in the construction of this type of apparatus involves keeping the hum and noise levels to a very low level. Hence, certain precautions must be taken when wiring this amplifier. In the first place it can be seen from Fig. 3 that use is made of an earth busbar. This is connected to earth at one point only, and is used to avoid the possibility of earth "loops" being made unintentionally in the wiring, into which hum currents could be induced. It is essential to keep all connections, particularly to valves V_1 and V_2 , as short and direct as possible. Screened leads must be used where shown in the diagrams.

Care should be taken to ensure that all solder joints are sound. A thermal shunt should be used when soldering the diode associated with V_4 .

The components for the initial amplifier stages should be of high quality, the resistors being 10% tolerance, and the capacitors, if possible, new components. In the prototype, normal carbon composition resistors were used quite satisfactorily

for the circuitry associated with V_1 . High stability cracked carbon resistors could, however, be used to advantage.

The schematic wiring diagram of Sub-Chassis 2, the groupboard 3, the oscillator coil and the output transformer, is shown in Fig. 6. The groupboard can be fixed to the tape deck, using a self-tapping steel screw in one of the many small holes which will be found drilled in it. It should, of course, be insulated from the deck with a piece of Paxolin. The tape deck itself should be earthed at one point only. The actual earthing point was not, with the prototype, particularly critical, and one of the motor holding-down bolts was employed for the connection. The output transformer should be rated at at least 4½ watts. The valveholders for this stage and, in fact, throughout the amplifier, should be of the nylon loaded type. The grid stopper resistor, R_{20} , should be mounted as close to the grid pin of V_3 as possible.



From the circuit diagram, Fig. 1, it will be seen that it is necessary to switch the anode connections of V_3 by means of S_4 . The switch wafer supplied with the B.S.R. deck is of the 4-pole 2-way variety. Three of these poles are taken up with $S_{1(a)}$, (b), and (c). Attempts to use the remaining pole, $S_{1(d)}$

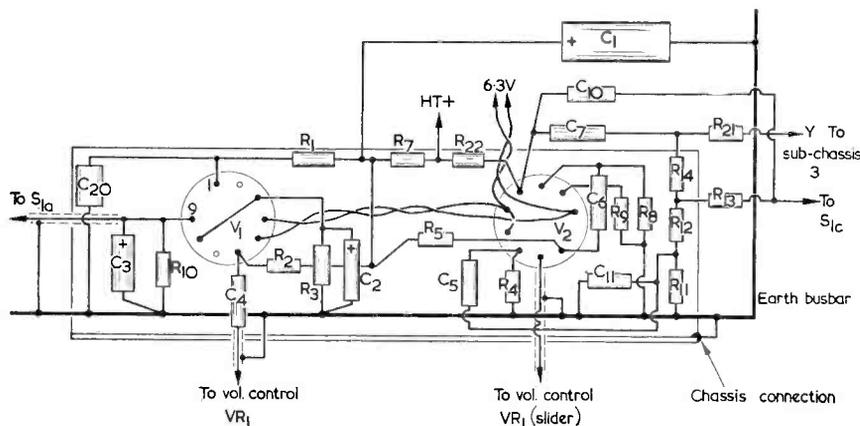


Fig. 5. The wiring on Sub-Chassis 1

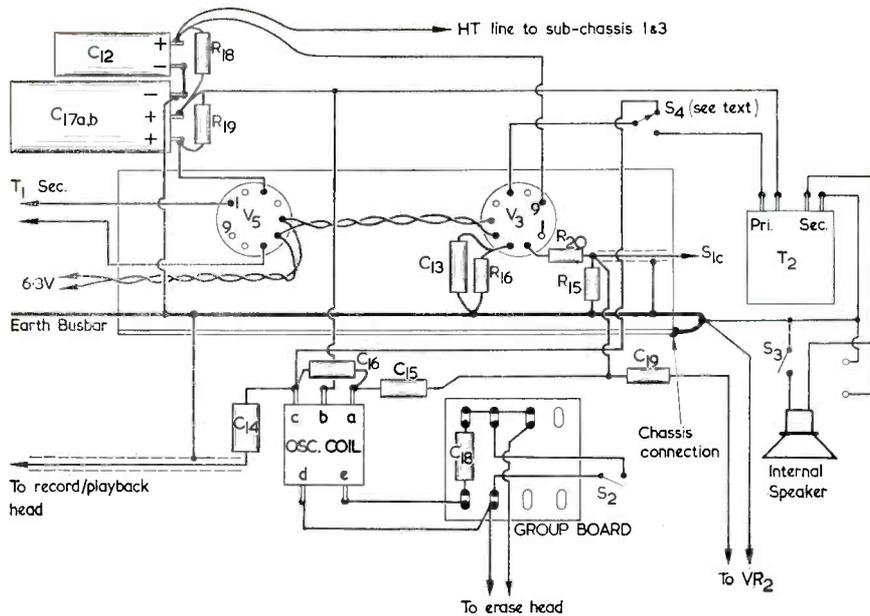


Fig. 6. Schematic wiring diagram for T_2 , Sub-Chassis 2, the group board, and the oscillator coil

to perform the anode switching operation were unsuccessful, due to inevitable feedback between $S_{1(d)}$ and $S_{1(a)}$. Accordingly, a separate switch is required. This could either take the form of another wafer on the operating switch, screened from it by an aluminium screen, or, as in the prototype, it can take the form of a microswitch, actuated by S_1 as shown in Fig. 7. This arrangement has proved to be very satisfactory in practice. The microswitch, S_4 , is of the single-pole 2-way type, and is obtainable from ex-government sources and from advertisers in this magazine. This switch is also fixed to the tape deck using self-tapping screws. The actuating mechanism of S_1 consists of a small bush (in the prototype this came from part of an old tuning mechanism) and a suitable 1in or $1\frac{1}{4}$ in bolt. The whole is screwed to the extension of S_1 operating shaft, which will be found on the deck. The relative positions of $S_{1(a)}$, (b) and (c) should be those shown in Fig. 7.

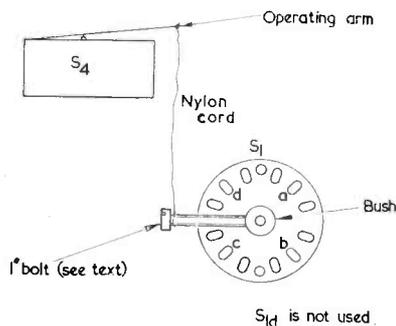


Fig. 7. Method of actuating switch S_4 from S_1

Fig. 8 shows the wiring of Sub-Chassis 3, this being the recording level indicator circuit. A cut-out in the motor board enables the valve display to be seen.

The switches S_2 and S_3 were, in the prototype, two small low-voltage surface mounted types. The external speaker socket can be of any convenient type. The input sockets for microphone and radio were ordinary coaxial sockets.

The transformers T_1 and T_2 are fitted in the positions shown in Fig. 3. They are attached to the motor board using small wood screws, as are Sub-Chassis 1, 2, and 3.

The smoothing capacitors C_{17} and C_{12} are attached to T_1 or to the motor board with suitable capacitor clips and screws.

Setting Up and Testing

Upon completion of the wiring, the circuit should be checked, both against the circuit diagram, Fig. 1, and against the wiring diagrams, Figs. 5, 6 and 8.

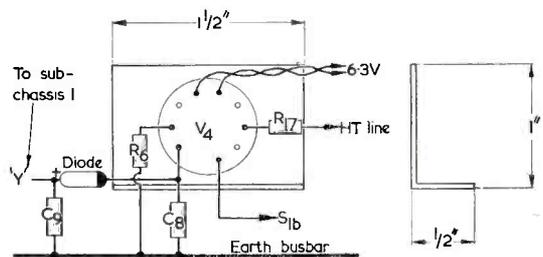


Fig. 8. The construction and wiring of Sub-Chassis 3. The material is 16 s.w.g. aluminium

The only adjustment necessary is that of the recording bias, and it is made by adjusting trimmer C₁₄. The method of adjustment is quite straightforward, and involves making a recording and adjusting C₁₄ in stages. The correct position is that which gives best results on playback. Too little bias results in distortion, and too much in a loss of sensitivity on playback. It will be found that the adjustment is not very critical but it should, nevertheless, be made with care. The microphone should be a high impedance type, a sensitive crystal model being suitable. The length of the microphone lead should not, in this case, be altered, since this would adversely affect the microphone's performance.

Wherever possible, the recorder should be used in conjunction with an extension speaker. The small monitor speaker in the recorder is not really suitable for developing the capabilities of the unit to their greatest extent.

The design of the case is left to the imagination of the individual constructor. A ready-made recorder cabinet could probably be pressed into service if required. Some points, however, are worthy of note. The case dimensions are governed to a great extent by the size of the monitor speaker

used. In the prototype this was a 7 x 4in elliptical model, which was mounted on a baffle forming the front of the recorder case. A good effect can be produced by making the recorder case of $\frac{1}{2}$ in plywood, which is then covered by plastic imitation "wood" material. Whatever design is adopted, however, adequate ventilation should be provided. In the prototype this took the form of a number of holes drilled in the bottom and side of the case.

There is sufficient room on top of the motor board to accommodate a tape splicer, as shown in the photographs of the unit.

Recording from the radio, or from record players, etc., should be made using the radio input socket (i.e. not through the microphone, in which case a loss of quality would occur). Notice that the input impedance presented by the radio socket is high, and therefore it is not practicable to record from the radio simply by connecting the radio extension speaker sockets to the radio input of the recorder.

In conclusion, it may be stated that this recorder will be found to be suitable for all types of recording, whereupon it will produce excellent results.

An introduction to . . .

COLOUR TELEVISION

By J. R. DAVIES

PART 2

IN THE FIRST ARTICLE IN THIS SERIES WE EXAMINED the three primary colours, red, blue and green, and saw how, by additive mixing, they could produce a wide range of colours and, thereby, enable a practicable colour television system to be set up. We also discussed the C.I.E. Chromaticity Diagram and defined the terms *hue* (which is the basic colour regardless of how much white is added), *luminance* (the brightness of a colour) and *saturation* or *purity* (which is the freedom from dilution by white of a colour). The term *chrominance*, which covers hue and saturation, was also introduced.

Frequency Interlacing

A colour television picture may be presented by additive mixing at the receiver, whereupon it follows that a simple method of broadcasting such a picture would consist of transmitting three separate signals, each corresponding to a primary colour. However, if each signal were to have

the same resolution (i.e. ability to present detail) the bandwidth required for the transmissions would be three times as great as for a similar monochrome (black and white) picture. Whilst this bandwidth could be slightly reduced by debasing the resolution for one of the colours (preferably blue, which the eye does not resolve as readily in small areas as green and red) the total bandwidth would still be very large by monochrome standards. The radio frequency spectrum available for television transmissions is limited, and it would be an extremely wasteful policy to employ a colour television signal of this type. A second objection to a colour transmission of this nature is that it would not be *compatible*.¹ The signal could not be picked up and presented in black and white by existing monochrome receivers.

¹ A compatible system is one which allows existing monochrome receivers to reproduce a colour transmission. The N.T.S.C. system also allows colour receivers to pick up monochrome transmissions, these being reproduced in black and white.

In the American N.T.S.C. system,² an ingenious and complex method of handling the three primary colours results in the transmission of a luminance signal and a chrominance signal in the same bandwidth as is occupied by a normal monochrome signal. The luminance signal is equivalent to a monochrome signal (and it may be described as such) and it occupies the full video bandwidth. This signal may be picked up and reproduced by a monochrome receiver. The chrominance signal carries colour information but, as less resolution is required here, it occupies a lower bandwidth.

The colour information is transmitted on a subcarrier located within the luminance signal bandwidth, and it consists of a suppressed carrier which is amplitude modulated in quadrature (i.e. at 90° phase difference) by two signals. One of these signals is known as the *I* signal, and it has a maximum frequency of 1.5 Mc/s, whilst the other is known as the *Q* signal, whose maximum frequency is 500 kc/s.³ For the time being we need do no more than accept the existence of the modulating *I* and *Q* signals; and the manner in which they are formed will be described later. The chrominance signal is transmitted inside the luminance signal by a technique known as *frequency interlacing*, or *frequency interleaving*, which we shall next consider.

As was mentioned in last month's article, we shall refer to the American 525 line standard whenever it is necessary to give numerical details or examples. Such references now become necessary, and the major characteristics of the 525 line standard are listed, for convenience, in Table I.

Table I

Main characteristics of the American 525 Line System

Lines per picture	525
Fields per second	60
Pictures per second	30
Line frequency (c/s)	15,750
Nominal video bandwidth (Mc/s)	4.2
Video modulation	Negative
Sound modulation	F.M.
Sound carrier relative to vision carrier (Mc/s)	+4.5

If the output of a monochrome television camera which is scanning a stationary scene is analysed in terms of frequency, it will be found that almost all the information appears in clusters situated around harmonics of line frequency. This is to be expected, since each element of the picture is scanned at line frequency. When the camera output modulates the associated transmitter, we find that the energy in the transmitter sidebands similarly appears in clusters, these being spaced at harmonics of the line frequency away from the carrier. A typical example is illustrated in Fig. 4 (a), wherein we see the clusters around the 100th

harmonic of line frequency. With the 525 line standard, the 100th line frequency harmonic is spaced away from the carrier by 1.575 Mc/s (i.e. the line frequency of 15,750 c/s multiplied by 100).

The sideband spaces between the clusters are unused, and could readily accommodate further information. In the N.T.S.C. system, they accom-

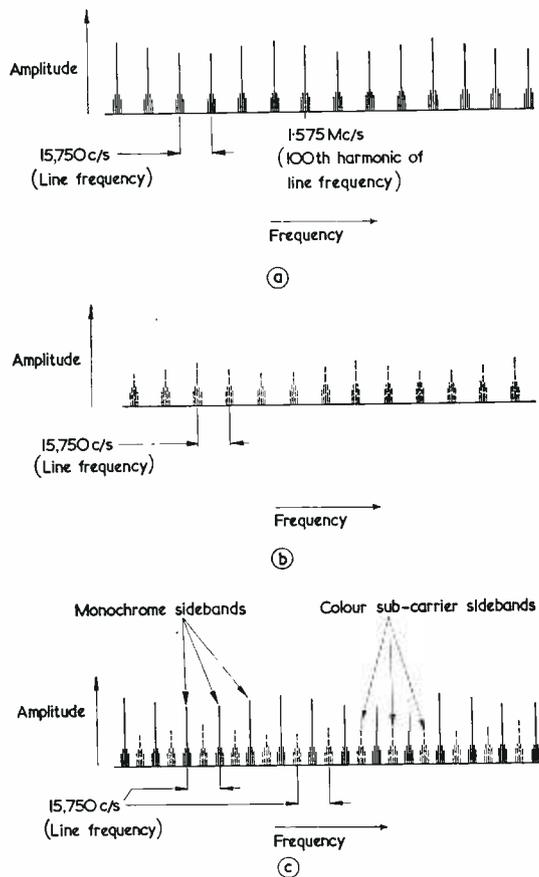


Fig. 4 (a). The information in the sidebands of a monochrome transmission appears in clusters around the harmonics of line frequency
 (b). The information in the colour subcarrier similarly appears in clusters around the line frequency harmonics
 (c). By using frequency interlacing, the colour subcarrier sidebands may be interleaved with the monochrome sidebands, thereby allowing two signals to appear in the same bandwidth

modate the colour subcarrier which is modulated by its *I* and *Q* signals. The *I* and *Q* signals are obtained from the camera signals and, like the monochrome picture, contain information which appears in clusters around the harmonics of line frequency. Again, sidebands are formed and these appear, in relation to the subcarrier, in the manner shown in Fig. 4 (b). All that is next required is to

² The N.T.S.C. system is that accepted by the National Television Systems Committee in America in 1953, and it was pioneered by Radio Corporation of America.

³ The letters *I* and *Q* may be assumed as standing for In-phase and Quadrature respectively.

interleave the colour subcarrier sidebands with the sidebands of the main transmission, whereupon the two sets of sidebands become perfectly interlaced with each other. See Fig. 4 (c). The result is that we now have two quite separate sets of sidebands, these being contained within the same bandwidth as was previously employed by the monochrome signal on its own.

In order to achieve perfect interlacing between the two sets of sidebands, the chrominance subcarrier must have a frequency which lies midway between two of the information clusters given by the monochrome signal. In other words, it must lie midway between two of the line frequency harmonics. This requirement will be met if the subcarrier is spaced away from the monochrome carrier by a figure which is equal to half the line frequency multiplied by an odd number.⁴

In the N.T.S.C. system the colour subcarrier frequency is 3.58 Mc/s (corrected to three significant figures) and it lies between the 227th and 228th harmonics of line frequency.

The Luminance Signal

A typical colour television camera may employ three camera tubes, each of which corresponds to one of the primary colours. By means of a system of lenses and mirrors, the scene to be transmitted is presented to one tube by way of a red filter, to the second tube by way of a blue filter, and to the third tube by way of a green filter. The camera is set up such that all the tubes are in registration with each other, and all scan the same part of the scene at any given instant. At the same time, the output of the "red" tube corresponds to the red component of the scene, the output of the "blue" tube corresponds to the blue component of the scene, and the output of the "green" tube corresponds to the green component of the scene.

A monochrome signal may now be obtained by adding, in the correct proportions, the outputs of these three camera tubes, and this signal will be similar to the black and white signal offered in a monochrome system.

To estimate the proportions required, let us assume that we are able to look into the television camera when a completely white scene is presented to it, and that we are able to see, after the filters, the red light which falls on to the image plate of the "red" tube, the blue light which falls on to the image plate of the "blue" tube, and the green light which falls on to the image plate of the "green" tube. Also, let us assume that each tube offers the same voltage output for equal luminance, regardless of colour. Now, white light consists of an equal proportion of all colours of the spectrum⁵ and, assuming no losses in the filters, will cause an equal amount of red, blue and green light to appear on the image plates of the tubes. Each tube will, therefore, give an equal voltage output. However,

if we *look* at the tubes, we will find that the green image plate appears nearly twice as bright as the red plate and nearly six times as bright as the blue plate. This is because the eye is nearly twice as sensitive to green as it is to red, and nearly six times as sensitive to green as it is to blue.

We require our camera to give a monochrome signal output which follows the same response as that of the human eye and so, to obtain our luminance signal, we add the three outputs from the tubes accordingly.

This gives us:

$$Y = 0.59G + 0.30R + 0.11B,$$

where Y represents the voltage amplitude of the luminance signal, G the voltage amplitude of the "green" tube signal, R the voltage amplitude of the "red" tube signal, and B the voltage amplitude of the "blue" tube signal. The figures given in this equation correspond accurately to the response of the eye at the three primary colours employed in the N.T.S.C. system, and they ensure that the monochrome signal corresponds with similar accuracy.

It will be noted that each letter in the equation corresponds to a voltage. Because we are dealing with voltages, it is a very easy manner to add them, as is required by the equation.

The luminance signal offered by the combination of 59% green signal, 30% red signal and 11% blue signal is transmitted at the full video bandwidth offered by the system (4.2 Mc/s in the American 525 line system) and, if picked up on a standard monochrome receiver, is reproduced as a standard black and white signal. When picked up on a colour receiver it gives the luminance information and, because of its wide bandwidth, provides all the fine detail which the system is capable of handling. The chrominance information, which does not require by any means as high a degree of resolution, is then transmitted on the colour subcarrier.

The use of the ratios 0.59, 0.30 and 0.11, for green, red and blue respectively, leads us to a further important point. If a white scene is presented to the colour camera, the outputs of the three tubes will, as we have just seen, be equal. Let us assume that each output is equal to 1 volt. Then

$$\begin{aligned} Y &= (0.59 \times 1) + (0.30 \times 1) + (0.11 \times 1) \\ &= 0.59 + 0.30 + 0.11 \\ &= 1. \end{aligned}$$

Therefore, the luminance amplitude under these conditions is also 1 volt.

The R-Y and B-Y Signals

In the N.T.S.C. system, the three colour signals from the camera are not transmitted in the form in which they appear immediately after the camera tubes. Instead, they are first converted into two signals, these being the R-Y and the B-Y signals (which are referred to as the *colour-difference signals*). As we shall see next month these signals, after further manipulation at the transmitter, modulate the colour subcarrier.

⁴ Giving, thereby, the series 1.5, 2.5, 3.5, . . . times line frequency.

⁵ Nearly equal, in the case of Illuminant C.

In a system which employs three primary colours it may seem, at first sight, a little perplexing to find that only two of these colours find their way into the colour information channel. The further fact that the luminance signal is subtracted from each of the two colours chosen presents an additional source of query. However, there are two important reasons for employing two colour-difference signals, and we shall now consider these.

At the receiver, the reproducing device consists of a cathode ray tube with three guns, one of which causes a green display to be given, one of which causes a red display to be given, and one of which causes a blue display to be given (or there may be three separate cathode ray tubes whose presentations are projected, via the appropriate primary colour filters, on to a single screen). It is necessary to feed each of the three guns with the signal which corresponds to its own colour, and these signals have to be extracted from the information broadcast by the transmitter. This information consists of the luminance signal, Y, and the colour-difference signals, R-Y and B-Y, which we have just mentioned.

To reclaim the red signal at the receiver, all we need to do is to add the luminance signal to it. This gives us:

$$(R-Y)+Y \\ =R.$$

We may similarly reclaim the blue signal by adding the luminance signal to it:

$$(B-Y)+Y \\ =B.$$

The process of reclaiming the green signal is nearly as simple, but we have, first, to carry out a calculation to find its relationship to the other signals transmitted. We know that

$$Y=0.59G+0.30R+0.11B, \\ \text{therefore } 0.59G=-0.30R-0.11B+Y.$$

$$\text{But } R=(R-Y)+Y \\ \text{and } B=(B-Y)+Y.$$

$$\text{So, } 0.59G=-0.30[(R-Y)+Y]-0.11[(B-Y)+Y]+Y \\ =-0.30(R-Y)-0.30Y-0.11(B-Y)-0.11Y+Y \\ =-0.30(R-Y)-0.11(B-Y)+0.59Y$$

$$\text{therefore } 0.59G-0.59Y=-0.30(R-Y)-0.11(B-Y)$$

$$\text{therefore } G-Y=-\frac{0.30}{0.59}(R-Y)-\frac{0.11}{0.59}(B-Y).$$

In consequence, we have only to add the R-Y and B-Y signals in the proportions shown in the equation to obtain the missing G-Y signal. Incidentally, the fact that both the R-Y and B-Y signals appear as negative quantities merely infers a reversal of phase.

Having obtained the G-Y signal, we then add

the Y signal, as with the other two colour-difference signals:

$$(G-Y)+Y \\ =G.$$

Fig. 5 (a) illustrates how the three colours may be separated from the Y, R-Y and B-Y signals, and then fed to the three guns of the receiver display

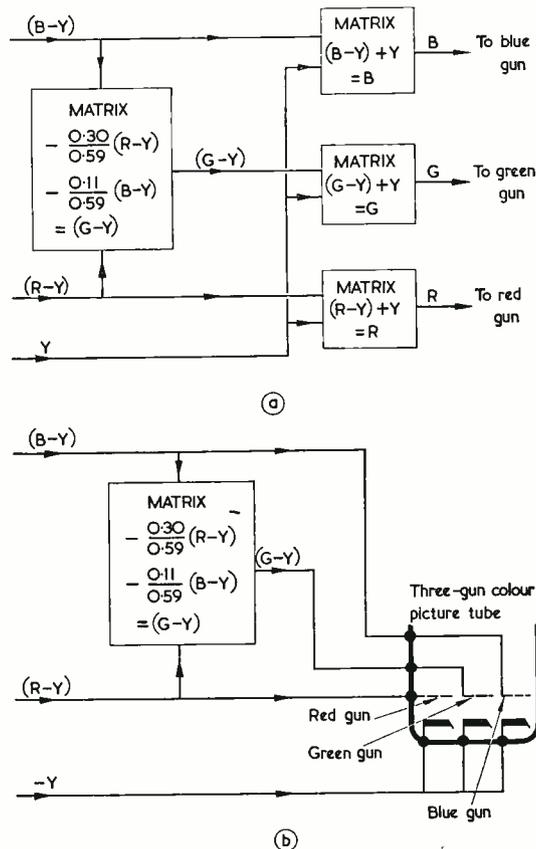


Fig. 5 (a). Block diagram showing how, in the receiver, the blue, green and red signals may be extracted from the B-Y, R-Y and Y signals

(b). In practice the three right hand matrixes of (a) may be dispensed with, adding taking place between the grids and cathodes of the colour picture tube. Since the cathode and grid of each gun require voltages of opposing phase to give correct addition, the Y signal is shown with reversed phase

tube. Each gun is fed by an adding matrix which adds the Y signal to the appropriate colour difference signal. A further adding matrix adds the combinations of the requisite portions of the R-Y and B-Y signal to provide the G-Y signal. All the matrixes shown may consist of simple resistive networks, since all they have to do is to add voltages. In practice, however, there is no need for the three adding matrixes which immediately precede the tube guns, because the guns can carry out this

function themselves. This is done as shown in Fig. 5 (b), wherein the luminance information is applied to all three cathodes of the guns, and the colour-difference signals are applied, separately, to the three grids.

We may see that one of our two points of query, namely the use of two colour signals instead of three, has now been cleared up. There is no necessity for a third colour signal because it can be reclaimed from the other two and the luminance signal.

The other point which requires explanation is the choice of colour-difference signals instead of signals which correspond directly to colour. This can next be considered.

If we present a purely white scene to the camera we obtain an equal amplitude in the red, green and blue camera channels. Let us assume that this amplitude is 1 volt. Then:

$$R = G = B = 1.$$

The luminance signal is also equal to 1 volt because

$$Y = 0.59G + 0.30R + 0.11B = 1.$$

We can now say that, under these conditions,

$$Y = R = G = B = 1.$$

Our colour-difference signals are $R - Y$ and $B - Y$. However, since $Y = R$ the $R - Y$ signal drops to zero. Similarly, because $Y = B$, the $B - Y$ signal drops to zero.

If we substitute our white scene for one of half the luminance, (i.e. a greyish scene) then,

$$R = \frac{1}{2}$$

$$G = \frac{1}{2}$$

$$\text{and } B = \frac{1}{2}.$$

Therefore $R = G = B = \frac{1}{2}$.

At the same time,

$$Y = 0.59G + 0.30R + 0.11B \\ = 0.59(\frac{1}{2}) + 0.30(\frac{1}{2}) + 0.11(\frac{1}{2}) \\ = \frac{1}{2}.$$

Therefore, under these conditions,

$$Y = R = G = B = \frac{1}{2}.$$

Once more, the $R - Y$ and the $B - Y$ signals drop to zero.

The same will apply for any other monochrome scene varying, through the greys, from white to black. Because of this, it follows that, when a black and white scene is being scanned, the colour difference signals *disappear completely*. Since these signals are employed to modulate a suppressed subcarrier, the sidebands on the latter *also disappear completely*. The colour subcarrier can be considered, in consequence, as carrying colour information only, and scenes having colours of low saturation require only a small amount of information to be carried by its sidebands. The system therefore more closely resembles a monochrome system, and this improves its compatibility so far as reception by monochrome receivers is concerned.

(To be continued)

Radio Topics . . .

By RECORDER

THE B.B.C. HAS MANY VIRTUES, and it also has a few shortcomings. The most infuriating of the latter is, I feel, the patronising assumption that, so far as anything to do with space flight is concerned, the British public has an intelligence which is some four points south of sub-moronic.

Interruptions

There have been no manned space flights yet whose reporting, via B.B.C. sound radio, has not been at least partly marred by continual interruptions on the part of the Corporation's commentators which are supposed to be informative, but which have, in practice, proved to be wholly fatuous. A typical instance occurred recently when astronaut Gordon Cooper returned to earth again after his day and a half's journey around the world. The B.B.C. kept the Light Programme open after midnight to carry the N.B.C. broadcast on this event, and this is a decision which is worthy of

commendation. *Not* worthy of commendation, however, is the fact that the B.B.C. also had on duty a commentator at London and another in America who kept continually breaking into the N.B.C. transmission. Neither of these well-intentioned gentlemen had any more clues (if as many) than the rest of us, but every now and again the completely fascinating N.B.C. broadcast was faded out whilst they indulged in a hesitant little natter, full of "ers" and "ahs" and with strict avoidance of anything mildly technical, which would have raised yawns at even the most tepid of vicar's tea parties. The fact-packed N.B.C. broadcast continued whilst these boring conversations were in progress, but it went unheard on this side of the Atlantic.

What the B.B.C. forgets is that the American radio commentators at these space flights are not only past-masters at their job, but that they are also unashamedly enthusias-

tic over the American achievements on which they report. What is more, they have done their homework, and they are completely *au fait* with the general technicalities and problems of space flight. All these facts come over superlatively well in their broadcasts. Again, American radio coverage of space flight events has an informality and apparent opportunism that is quite enthralling. Commentators interrupt each other with late items of information, official announcements cut into reports in mid-sentence, and the whole transmission proceeds at the break-neck pace which the subject deserves. I'm not saying, incidentally, that we do not have B.B.C. commentators who are equally able. We have, but they never seem to be present when space flight board-casts from America are on the air. These are the times when the plummier voices of the B.B.C. Establishment are wheeled out.

The American flights into space

represent an American initiative and an American accomplishment, and it would be silly to take any view other than this. What is of equal importance is that the Americans draw no veil whatsoever over the reporting of their attempts into space, and the broadcasting authorities are able to give full coverage on what is happening at the moment if happens, regardless of whether it be success or failure. In consequence, when the B.B.C. re-transmits American reports it should do so in full, and not interrupt them with inane discussions between ill-informed members of its own staff. To do so is not only a discourtesy to the American broadcasters; it is also a discourtesy to British listeners.

Two More Service Jobs

Despite my attempts to keep out of trouble, I still find myself being talked into volunteering to carry out the odd bit of servicing every now and again. Professional service engineers who feel that, by reason of these jobs, I'm doing them out of their honest earnings may be comforted by the fact that the sets which eventually come to me are ones which nobody else will look at anyway!

A typical instance was a valve battery portable which had seen better days, and which now suffered from heavy distortion. In the past someone had changed the speaker (which is, I suppose, *one* way of trying to get rid of distortion) but there had been no improvement. Since valve portables are now rendered obsolescent by transistor receivers, with their much lower battery consumption, it was put to me to see whether the set should be fixed or whether it should be discarded in favour of something more modern.

The receiver employed a standard low-consumption valve line-up, this comprising a DK96, DF96, DAF96 and DL96. These valve portables employ automatic bias for the output valve, this being provided by the voltage dropped across a resistor of about 560Ω or so in series with the h.t. negative line. Such a resistor drops about 5 volts for an h.t. potential of 90 volts, and one of the first things to do with a set of this nature is to check the value of the bias resistor and the voltage across it when the set is switched on. These measurements can be taken very conveniently, with the chassis in the cabinet, by measuring between chassis and the h.t. negative terminal. Both readings were satisfactory, whereupon I assumed that the receiver was drawing correct h.t. current and that the output valve had the correct bias.

However, my assumption was wrong. After I'd got the chassis out I found that there was zero voltage on the grid valveholder tag of the output valve and that this grid tag went slightly positive of chassis when the valve was pulled out. A leaky coupling capacitor from the previous anode seemed to be indicated and this was, indeed, the faulty component. With a new capacitor, the set worked very nicely, and its performance became exceptionally good when I replaced the existing output valve by a new one. The previous valve had obviously grown old before its time as a result of the grid current it had passed.

The fault I had found was, of course, a simple one. But the story points the moral of showing how easily one can be misled by making too many assumptions during servicing!

A second repair fell into the heavy engineering category, and it was concerned with an early a.m./f.m. receiver manufactured by that company which puts excellent electronics into its chassis and then couples the controls to the front panel by way of levers, cog-wheels, Bowden cables and clock springs. This receiver was working satisfactorily, but the somewhat flimsy wavechange spindle, which was concentric with the tuning drive shaft, had completely worn away due to the apparent stiffness of the switch. On looking inside, I found that the spindle was coupled to the switch by way of two levers, an actuating bar and a 90° gear train. Despite all this, it was the switch itself which was stiff, and no attempts on my part could clear it. I should imagine that, over the years, the inner Paxolin discs of the Yaxley sections had swollen slightly, a fault which would be impossible to clear. The switch was quite capable of being operated, but its stiffness was such that it would be pointless to fit a new spindle, as the latter would become worn again within a few weeks of use. So I fitted a new and very robust shaft at the other end of the chassis, with a large and equally robust knob sticking out of the back of the set!

After having completed the mechanics of the job, I checked out the receiver, which worked quite nicely. The only thing that puzzled me was a succession of "pinging" noises as I tuned through a station on the f.m. band. I traced these to the f.m. cord tuning drive. F.M. tuning was achieved by raising or lowering a set of cores in and

out of a set of corresponding coils. Due to the passage of time the carriage to which the cores were secured tended to travel along its guide in a succession of little jumps instead of evenly and smoothly, as its designer had intended. Each little jump then shifted the oscillator frequency accordingly, and caused the sudden generation of a frequency modulated signal. The result was the "pinging" noise from the speaker.

You live and learn!

Apt Description

An apt description of a beatnik's beard, as heard recently from Frank Muir and Denis Norden: "He has a beard which looked as though he'd magnetised his chin and dipped it in iron filings".

New Exide Battery

Chloride Batteries Ltd. announce a new addition to their range of Exide batteries, this being the type 3-MFB7. The 3-MFB7 offers a potential of 6 volts, and it will be fitted as initial equipment on future battery/mains television receivers manufactured by Perdio Electronics Ltd. Two batteries are used in series to form a 12 volt assembly, and they are kept fully charged by a built-in trickle charger unit in the receiver. When used away from a power point, the batteries will allow a full evening's viewing before a recharge is necessary.

Completely unspillable, each 3-MFB7 battery consists of three cells in a container of high-impact polystyrene fitted with a one-piece lid. The translucency of this container material makes the level of the electrolyte clearly visible and facilitates topping up. The new battery incorporates a number of novel features. For instance, the old-fashioned vent plug has been eliminated and the cells are simply provided with solid filling plugs. The battery embodies in its construction a gas-collecting chamber which causes any spray to be returned to the cells and enables the gases to be exhausted outside the equipment, thus avoiding the possibility of internal corrosion. Terminal assembly employs cadmium-plated mild steel and brass screws with coin slots for easy manipulation, and the terminals are anchored directly to the lid mouldings and not to any of the internal battery parts. This method of construction allows any strain imposed through the connecting leads to be borne directly by the battery container and not transferred to the internal assembly of the cells.

The 3-MFB7 battery will operate at any angle and is rugged enough to stand rough handling. It has

a capacity of 6 amp-hours at the 20 hour rate of discharge. The dimensions are $3\frac{3}{16}$ in long by $3\frac{1}{16}$ in

wide by 4 in high, and the weight is 3 lb when filled. It is available from any Exide Service Agent.

EXPERIMENTS with NEGATIVE and POSITIVE FEEDBACK

By J. A. ROBERTS

THERE ARE MANY METHODS of introducing negative feedback in a.f. amplifiers, and one of the easiest consists of omitting the cathode bypass capacitors. This

good reproduction is required. It is not generally known, however, that the gain can be restored (with a corresponding loss of linearity) to a point equivalent to that given

when the bypass capacitors are in use by adding just one resistor.

This resistor, R, is connected between the cathodes of a two-stage amplifier as shown in Fig 1, where-upon it provides a degree of positive feedback. The net result for one particular value of R is that the negative feedback due to the cathode resistors is balanced by the positive feedback via R. It is therefore possible to replace the bypass capacitors with this resistor.

Further reduction of the value of R will result in an increase of positive feedback which will increase gain until a point is reached when the amplifier oscillates. It is thus possible, with a variable resistor, to introduce feedback which can be varied from negative to positive. An amplifier using this system can be really versatile, as it can provide either high gain or high quality. The idea can be easily incorporated into existing two-stage circuits as it only entails the removal of the bypass capacitors

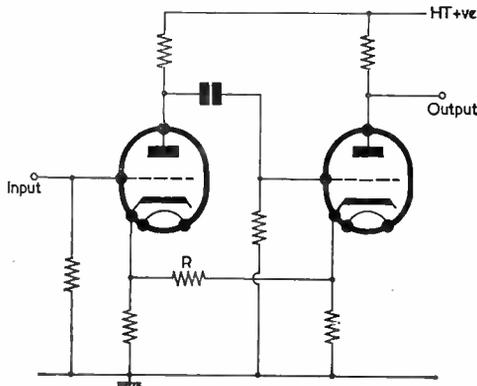


Fig. 1. In this circuit, resistor R counteracts the effect given by omitting the cathode bypass capacitors

of course results in an improvement in the linearity of the amplifier but there is a loss of gain. Such an amplifier would therefore be used when the input signal is high and

Components List (Fig. 2)

Resistors (all $\frac{1}{4}$ watt)

- R₁ 1M Ω
- R₂ 1k Ω
- R₃ 270k Ω
- R₄ 1M Ω
- R₅ 100 Ω
- VR₁ 500k Ω
- VR₂* 50k Ω pre-set

Capacitors

- C₁ 100pF mica
- C₂ 0.01 μ F

Valves

- V₁ EF91
- V₂ 6CH6

*Or 20k Ω variable in series with 30 k Ω pre-set, as in Fig. 3.

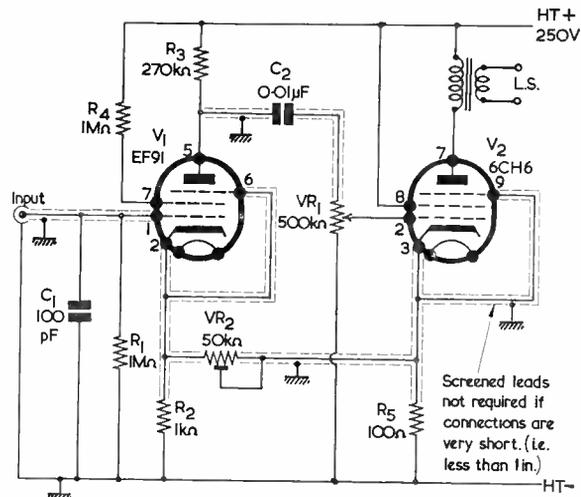


Fig. 2. A practical circuit with adjustable feedback from negative to positive. The value of VR₂ may require alteration with other component values or valves

and the addition of a small pre-set potentiometer or even a fixed value $\frac{1}{4}$ watt resistor. The value of the latter would need to be determined by experiment as it will vary from amplifier to amplifier.

A Practical Circuit

A typical practical circuit is shown in Fig. 2 but, as was just mentioned, the scheme can be used with almost any two-stage amplifier. If it is necessary to set the pre-set potentiometer to provide maximum gain this must be done with the volume control at its maximum setting. The feedback control can be fully variable (see Fig. 3) rather than pre-set, whereupon the amplifier may be externally controlled to provide full negative feedback or maximum positive feedback without oscillation taking place. This is achieved by initially setting the 500k Ω volume control (Fig. 2) for maximum volume and the 20k Ω variable resistor (Fig. 3) for minimum resistance (maximum volume). The 30k Ω internal pre-set resistor (Fig. 3)

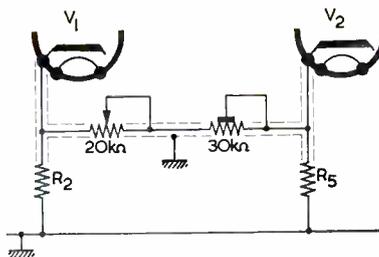


Fig. 3. If desired, VR₂ of Fig. 2 may be split into a 20k Ω variable resistor and a 30k Ω pre-set resistor

is then set to a point just prior to oscillation, whereupon control of feedback is provided by the 20k Ω variable resistor.

It should be noted that the screened leads shown in Figs. 2 and 3 are essential if hum is to be avoided, as the gain of the amplifier can be very high at maximum settings.

The circuit employing the 20k Ω variable resistor and the 30k Ω

pre-set component is a very useful and versatile arrangement for the experimenter as it can be used as an audio oscillator, high gain amplifier, high quality amplifier, morse practice oscillator (by keying the feedback path), as well as providing an audio test signal when servicing amplifiers and the audio stages of receivers. In the last instance, the signal may be taken from the anode of V₂ via a 0.01 μ F capacitor.

Simple Telephone Pick-Up Coil

By C. Morgan

THE ABILITY TO EXTEND THE RANGE OF A CONVERSATION heard over the telephone has several advantages, one of these being that the whole family can listen in if the call is of general interest, and another being that the conversation can be fed to a tape recorder.

A suitable pick-up coil is given by a G.P.O.-type

3,000 relay having a resistance of the order of 200 to 300 Ω . The armature and contacts should be removed and the coil connected to the input terminals of an a.f. amplifier or tape recorder. The coil can then be orientated for maximum coupling whilst a call is in progress.

BRENTFORD AND CHISWICK EVENING INSTITUTES

During the next session, on Wednesday evenings, the Institute will be running a Radio Amateur's course for the City and Guilds Radio Amateur's Certificate and the Morse class on Thursday evenings for the P.M.G.'s Certificate at the Brentford Evening Institute, Clifden Road, Brentford, Middlesex. Enrolment week starts on Monday, 16 September. The Radio Amateur's course lasts for the Session (three terms) and the Institute is a centre for the City and Guilds Examination. Fee for the course is 30/-.

The Morse class is now, at the request of students, lengthened from one term to two and the fee is £1 or, for the two classes together, the fee is 35/- (Fees are at half rate for those under 18 years of age.)

Requests for further information, or application by post, which can be sent now, should be addressed to the Evening Institute Department, Education Offices, Town Hall, Chiswick, London, W.4.

Should enough applications be received, the Radio and Electronics Mathematics class will also be formed for this Session. This class is specially run for those who have difficulty in reaching the required mathematical standard in the City and Guilds Examination and in amateur radio generally find the need of a fuller understanding of this branch of mathematics.

The Radio and Television Servicing class will be meeting on Tuesday evenings at the same Institute during the coming Session.

The Private War of Me

By Sylvia Margolis

WE LIKE YOUR STYLE, SAID THE EVER-SO-NICE man from *The Radio Constructor*, so how about writing something for us?

Flattering, no doubt, but a fat lot of use that was. This *Radio Constructor* thing, now, is all very H.F. stuff—circuits and diagrams and whatnot. And even the bluest-eyed enthusiast has never been able to explain to me the difference between ohm's, watts, amps, puffs, henries and all that jazz. I don't believe Ohm's Law and think it should be repealed. Besides, I detest the whole abominable, messy, frustrating business of radio construction. So where do I come in? What the hell to write about?

Yet the sad tale of how I lost my private war against radio construction might make a story. The first diplomatic growlings were made some years ago, when we saw a film called "Race for Life", all about amateur radio and how you can save lives and cure botulism with it. Or so it seemed on that unlucky night. All starry-eyed, my husband arranged for us both—BOTH, mind you—to study at evening classes for the Radio Amateurs' Examination. Firmly I changed my course to Elementary Italian, so that, whilst he was absorbing enough radio theory to be let loose on the air, I was sucking up enough Italian to be let loose on the pasta and to cope with the bottom-pinchers. He got his amateur licence and I got a black-and-blue bottom.

Things were never the same after that. Our circle of friends changed drastically. Relatives spoke of us sadly in the past tense. House and car were invaded by masses of equipment, all commercial and handsome and expensive.

But my husband wanted to do what all the other big boys did. He dreamed of experiment and building. So he built a sideband transmitter that was quite marvellous, except that it looked like a gas cooker. I scraped the solder off the carpet and made strong ambassadorial representations.

A complete change of social routine I could tolerate. When my prospective mink coat turned out to have a V.F.O. and I.F. gain and the duckiest A.T.U. imaginable—well, some women are landed with gamblers or drunks or sadists for husbands. Who was I to grumble? But this mess and solder and piles of electronic rubbish—this was too much. My ultimatum was backed by threats of unmentionable reprisals.

We had perforce to keep the radio gear in the living room. Now I admit that "KW" and Collins and Hammarlund are no mean addition to the

decor, quite status symbols in fact. But not the "G3NMR SPECIAL". Out went the gas cooker. First skirmish to me. Maurice fell for the myth that he had so little spare time that it was a question of choice between building or operating. I saw to it that he chose operating. Contacts with furrin parts really "send" me, whereas I can whip up no lasting passion for the precise relationship between the 6146, the 811A and those 813s in parallel.

Meanwhile I had made a few sneaky moves of my own. An article called "CQ-34-26-38" was accepted, in a misguided moment, by a leading British amateur radio magazine, who have regretted it bitterly ever since. Then I described the hobby in the B.B.C. programme, "Woman's Hour". There followed a series of articles in the American radio magazines. In these I tried to draw on amateur radio for themes for comic, tragic and even love stories. Why not? All life is there. Amateur Radio knows no bounds of race, religion, belief, colour, class or occupation. Surely these people must sometimes laugh, cry and love!

Insidiously the hobby took hold of me. Some bright spark in the Amateur Radio Mobile Society suggested that a monthly bulletin be issued. So *Mobile News* was born. This boisterous, rumbustious and incorrigible journal will have a go at anybody, without fear or favour. Yet the first scatty single news-sheet has developed into a regular 14-page magazine with a readership of nearly 2,000. *Mobile News* is received with welcome, respect and affection by our members and with a kind of wary, grudging, sour regard by some surprising people in surprising places.

Mobile News was the enemy's real break-through. We featured a superb little sideband transceiver named the "Courier". All generals can produce spiteful apologia for their defeats and mine is that the H.F. bands had gone dead. There was nothing to be worked on the air, so my husband built a "Courier". Not only is this honey elegant—she works. My defences finally cracked when "Courier" did a mobile-to-mobile contact from London to Malaya.

Worse was to come. My 12-year-old son is marking time until he is old enough to hold his own transmitting licence. At 9 he had become the youngest-ever member of the Radio Society of Great Britain, but so far his activities had been limited to short wave listening and accumulating an encyclopaedic knowledge of DX details. Then some Fifth Columnist gave him the components to build a crystal receiver. There followed long secret consultations with Maurice and then I heard the dread words: "Mummy, Daddy let me solder my first joint today".

I knew I was beaten. I scraped more solder off the carpet but remembered that the hand that holds the soldering iron will never hold a flick-knife. I asked for an armistice.

Yet I am bitter and unforgiving in defeat. It was all that darned little "Courier". Why did it have to be so efficient and inexpensive.

There is such a thing as guerilla warfare, though . . .

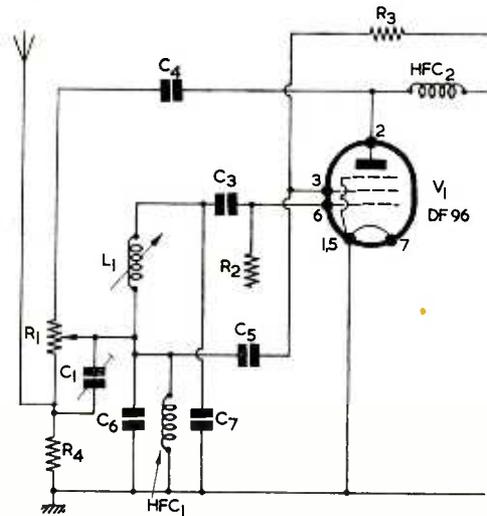


Fig. 2. The circuit adapted for medium waves

the grid end of the variometer and earth.

H.F.C.1 is a normal choke of the kind which is effective between 19 and 550 metres and its function is to prevent unwanted coupling at audio frequencies between anode and grid. H.F.C.2 is similar and serves as a reaction choke. V1 is a DF96 which consumes only 25mA at 1.4 volts for its filament and, in the circuit shown, about 1.3mA at 69 volts high tension. C1 is a pre-set trimmer which is adjusted to suit the aerial-earth system used so that there are no blind spots where reaction cannot be obtained, and so that selectivity is in suitable relationship to sensitivity.

Medium Wave Circuit

Fig. 2 shows the arrangements for medium waves. The only new components are C6, C7 and R4, though a two-pole wavechange switch will also be required, as is mentioned later. C6 and C7 in series with each other produce the necessary 600pF across the variometer and, at the same time, form a central capacitive tap for reaction purposes. At the high frequency end of the medium waveband there will be a very poor L/C ratio, and at wavelengths below about 210 metres it was at first found difficult to obtain oscillation, though this was very readily available from 210 to 550 metres. For this reason C5 is taken to the live end of C6 instead of direct to earth, and this results in the screen-grid of the valve assisting the anode to produce reaction. On short wave

bands C5 is effectively at earth potential, which is desirable as the assistance of the screen-grid is not required with the good L/C ratios on these wavelengths.

A suitable value for C1 on short waves gives far too little coupling from the aerial on medium waves. Because of this, the aerial is taken to the bottom end of R1. As already stated, for nearly all the medium waveband reaction is very readily available. It takes place at a low setting of R1 so that only a small

part of R1 appears between the aerial and L1—just the right amount to provide suitable coupling. Without R4 it was found that, for much of the medium waveband, oscillation could not be stopped even at a minimum setting of R1. The value of R4 is chosen to overcome this difficulty without, at the same time, reducing the aerial coupling appreciably. This arrangement for aerial coupling has a further advantage in preventing break-through, on short waves of powerful local medium wave transmissions. It will be found on the short wavebands that although oscillation can be readily obtained, a setting of R1 fairly near the maximum is required. At this setting there is a large proportion of R1 between the aerial and L1 which, in combination with the small capacitance of C1, provides only very loose coupling for any medium wave signal which may be attempting to break through.

Low Frequency Circuit

The low frequency part of the circuit is shown in Fig. 3. If headphones are connected directly in the anode circuit of a pentode only a fraction of the signal, and only the higher audio frequencies at that, becomes available. By using the secondary of an intervalve transformer with a 5:1 ratio as the load, an a.c. resistance 25 times that of the phones will be reflected into the anode circuit, and the increase in the signal has to be heard to be believed. Admittedly, power is low, but it is quite adequate for headphone recep-

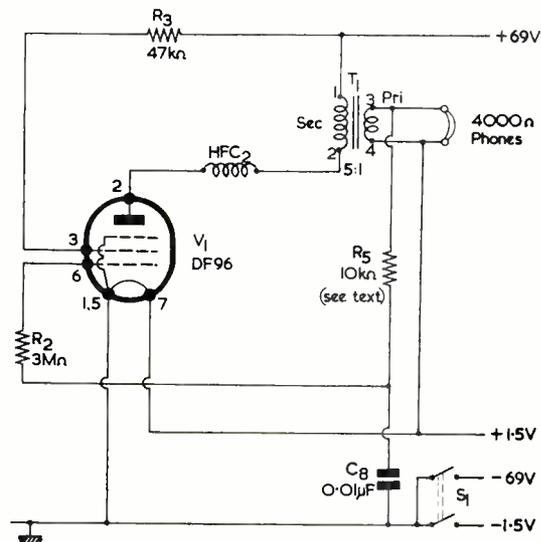


Fig. 3. The a.f. section

Components List (Figs 1, 2, 3 and 5)

Resistors

- All fixed resistors $\frac{1}{4}$ watt
 R₁ 10k Ω potentiometer, linear
 R₂ 3M Ω
 R₃ 47k Ω
 R₄ 2.2k Ω
 R₅ 10k Ω (see text)

Capacitors

- C₁ 50pF pre-set
 C₂ See text
 C₃ 100pF
 C₄ 100pF
 C₅ 0.01 μ F
 C₆ 1,200pF
 C₇ 1,200pF
 C₈ 0.01 μ F

Inductors

- L₁ Variometer (see text)
 H.F.C.1 } Chokes. Denco, Ref.
 H.F.C.2 } No. R.F.C.5
 T₁ 5:1 intervalve transformer.
 RadioSpares "Standard"
 or equivalent

Switches

- S₁ d.p.s.t., on-off
 S₂ d.p.s.t., wavechange

Valve

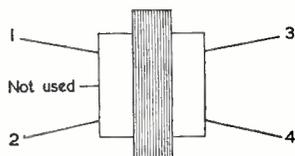
- V₁ DF96

Miscellaneous

- Headphones—4,000 Ω
 Spindle couplers, etc.

tion where good amplification is more important than high power output. As about 1mA of d.c. will be flowing through the secondary of T₁ a reasonably large component should be used to avoid core magnetisation.

Even with a transformer in use and a reflected load of 100k Ω , there is still a loss of the lower audio frequencies. A modicum of positive feedback, favouring the lower frequencies is, therefore, introduced by taking the grid leak, R₂, to the junction of a resistor and capacitor across the primary of T₁. A Radio Spares "Standard" (not "Midget") 5:1 transformer is used in the proto-



T₁ Connections

Fig. 4. Connection layout for the transformer employed in the prototype

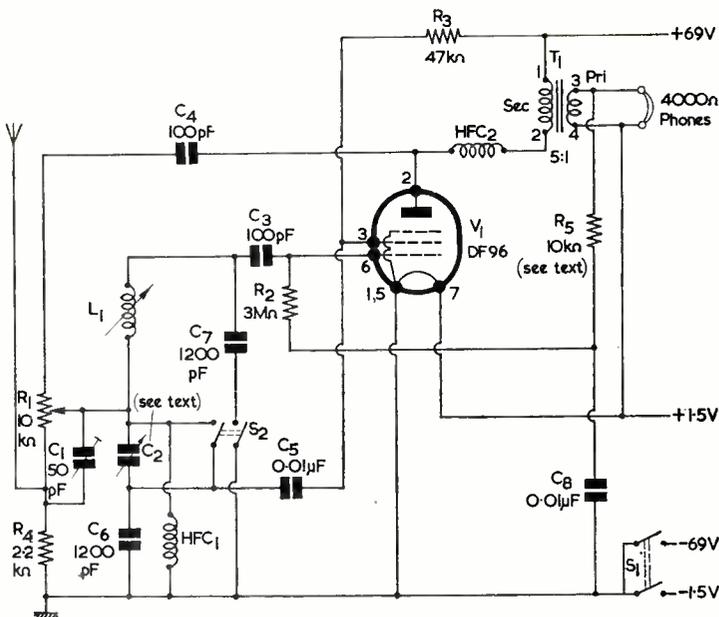


Fig. 5. The complete receiver

type, and the values of R₅ and C₈ are chosen for this component. The windings of T₁ must be correctly in phase and, for the Radio Spares transformer, should be connected as shown in Fig. 4. If a different transformer is used some experimenting will be needed to ascertain the right connections, and some modification may be needed to the values of C₈ and R₅, though C₈ may probably be left at 0.01 μ F.

Fig. 5 shows the complete circuit and the only new component, the wavechange switch S₂, needs no explanation. It can be seen to change the circuit, effectively, from that shown in Fig. 1 to that in Fig. 2, and vice versa.

Dismantling the Variometer

When the variometer is obtained it will be found to be contained in a large metal cylinder, and some dismantling is necessary.

First, remove the eight screws holding the "lid" on the cylinder, under the dial. Pull on the circular metal end now exposed, until the assembly starts to leave the cylinder. Cut through the wire to the terminal on the cylinder and remove the collar on the spindle by unfastening the two grub screws. The unit can then be withdrawn further and the bare wire passing through the white insulator at the far end should be cut, as also should the wire connecting the bottom end of a 0.001 μ F capacitor to a tag on the variometer.

The tags to which these last two wires are soldered are the terminal connections for the variometer. Next remove the circular front to which are attached the 0.001 μ F capacitor and a pre-set potentiometer, neither of which are needed. The back of the unit, with the white insulator passing through it, should also be removed. The dial can be extracted from the lid by removing the four screws which pass through it. It can well be used in the receiver, being coupled to the variometer through an insulated extension rod.

The dial will be found to be graduated from 0 to 200. Two short red lines indicate the blind spots, already mentioned, which appear while the internal switch is being operated. As assembled, the dial reads from 0 to 100 with the coils in parallel and inductance increasing with the numbers, and from 200 to 100 with the coils in series and inductance increasing as the numbers reduce. On short waves it will be found that from 0 to 100 will cover from about 19 to 51 metres, and from 200 to 100 will tune from about 47 to 95 metres. On medium waves reaction will not be operative until about 20 is reached on the scale, which indicates about 180 metres. 100 degrees on the scale indicates about 290 metres. With the coils in series it may be found that there is no oscillation for the first few degrees from 200, when the coils are fully in opposition, but the coverage

with reaction will be from about 280 to 550 metres.

Results with the Prototype

The prototype receives a very large number of stations on the short wave bands at excellent headphone strength. Many of these stations provide full loading for an amplifier employing a single "red

spot" transistor coupled to a loudspeaker. Local medium wave stations will similarly load a single transistor amplifier, and many others can be received at good headphone volume on the receiver alone. Sensitivity on the short wavebands is quite unusual. No high claims are made for sensitivity on the medium waveband but there is surprisingly

little spread from a very powerful transmitter just "round the corner".

Layout is not critical, although extension rods on the three controls (variometer, reaction control and panel trimmer) are advisable. In the prototype the wavechange switch, S_2 , is operated by C_2 when at its maximum position, as C_2 is not in use on the medium waveband.

The 1963 . . .

Radio and Electronic Component Show

THE 1963 RADIO AND ELECTRONIC Component Show forcibly demonstrated the wisdom of two decisions which have been made by the R.E.C.M.F. The first of these is to present the Exhibition at Olympia and the second is to stage it every two years instead of annually. The change of venue has enabled the Exhibition to be visited in comfort without having to undergo the fantastic crushes which occurred in the past, whilst the two-year period between shows allows a more ready appraisal of development to be achieved.

New Products

A number of new products were to be seen, notable amongst these being a range of variable tuning capacitors introduced by Plessey. In these capacitors small plastic "pips" are inserted in both the rotor and stator vanes to ensure correct meshing and centring. As a result, it is possible to provide reduced spacing between vanes since the pips obviate the risk of short circuits. A further advantage is that the vanes, being held more rigidly than in the conventional assembly, are less subject to microphony. The Plessey capacitors have two pips on each rotor vane and three pips on each stator vane.

Jackson Brothers (London) Ltd. have introduced a reverse vernier epicyclic ball drive, this being a dual ratio version of their well-known standard ball drive. The new component was inspired by the need for a small and simple drive for u.h.f.

television tuners, and it offers ratios of 6 to 1 and 30 to 1. Jackson Brothers have also introduced a new miniature air dielectric trimmer, which offers capacitance swings of 5, 8.5 and 11.5pF (according to type) and which has the very small temperature coefficient of 50 parts per million per degree Centigrade.

A completely new semiconductor device, the "Quantrol", was shown by Electronic Machine Control Ltd. The Quantrols on display resembled metal-cased transistors and had a body length of about 0.6in and a diameter of about 0.25in. A Quantrol is a two terminal device and it apparently incorporates a double junction of lightly doped semiconductor material. A typical application was demonstrated to the writer, and in this a Quantrol was connected between a Variac transformer and a resistive load. For a.c. voltages below about 30, the Quantrol is effectively an open circuit, and it has a resistance of 10 to 50M Ω . When the a.c. potential exceeds 30 volts the Quantrol suddenly becomes conductive, offering a resistance of 20 to 50 Ω . Furthermore, it stays in this state even when the a.c. potential is reduced to zero volts. Provided that the applied a.c. potential is not above the triggering level around 30 volts, the Quantrol may be switched to the non-conductive state by applying a d.c. pulse to it, a suitable pulse being given by a battery or a charged capacitor. The Quantrol then remains in the non-conductive state until the potential of the applied a.c. reaches triggering level again.

The fact that the Quantrol remains in the state last assigned to it was strikingly demonstrated to the writer. A Quantrol was first of all switched to the conducting condition and was then completely removed from its associated equipment and checked by a standard ohmmeter which indicated the low resistance state. The device was then returned to the equipment and pulsed to the non-conducting state. It was again removed, and this time the ohmmeter indicated the high resistance condition.

The applications for a device of this nature are, of course, considerable, and one suggestion put up by Electronic Machine Control Ltd. is that it be employed for overvoltage protection, wherein it could be triggered on by an excessive a.c. voltage. After the overvoltage had ceased, the Quantrol could then be switched off by applying a pulse. Although it offers rather the same facilities as the silicon controlled rectifier, the Quantrol employs different operating principles. It is, at present, still under active development and maximum currents for the on condition have been limited to around 100mA.

Teledictor Limited announced a portable equipment for thawing frozen water pipes. This consists basically of a 2kVA transformer offering outputs at 6, 9 and 13 volts. When in use, a current of about 200 amps through the pipe should be aimed for, and this can be monitored by an ammeter in the primary side of the transformer. Three versions of the unit are at present in produc-

tion, and the design of a fourth model which takes advantage of the technique is in progress. The fourth model differs from the other three in that it is intended to be installed permanently. It may then be switched on when frosts are forecast, whereupon it protects the water supply at much less cost than would be needed for lagging.

Photoconductive Relay

Mullard Ltd. showed, amongst other innovations, their new four-element photoconductive relay type RPY13. This is the equivalent of an electro-mechanical relay with four make contacts, but it has no moving parts and it can operate in dusty or corrosive atmospheres. It consists of a filament lamp surrounded by four cells of photoconductive cadmium sulphide, all these being sealed in a glass envelope. When the lamp is energised, the resistance of each cadmium sulphide cell falls from many megohms to a few ohms, giving a condition analogous to the closing of a relay contact. Since four cells are used, the device is equivalent to a conventional electro-magnetic relay having four make contacts. The RPY13 has a height of 49.2mm, a diameter of 22.2mm, and a standard B9A base.

Another item shown for the first time by Mullard Ltd. was "Piezo-

oxide". This is a piezo-electric ceramic which has advantages over quartz and rochelle salts in that it can be made in a number of different compositions to offer a wide range of piezo-electric properties, and that it can be pressed in a variety of shapes to give the most efficient transfer of energy. A demonstration showed a slab of Piezoxide firing a conventional sparking plug when subjected to pressure by a rotary cam. In consequence, the material could be employed to generate the spark in a petrol engine and thereby eliminate the magneto.

Connollys (Blackley) Ltd. are the first to introduce into this country a range of ultra-fine insulated copper wires. These new wires have diameters of 0.0009, 0.0008, 0.0007 and 0.0006in, and are insulated with the standard "Conyisol" enamel. "Conyisol" is a solder-through polyurethane coating which is equivalent in all other respects to standard synthetic enamels. The tiny diameter of these wires may be appreciated when it is realised that 0.0008in corresponds to 52 s.w.g.

A convincing demonstration of the capabilities of p.t.f.e. insulation was staged by Wandleside Warren Wire Co. Ltd. In this demonstration a pair of p.t.f.e. covered wires was subjected to a gas flame for three minutes. Despite the intense heat

resulting, the p.t.f.e. insulation did not break down.

Television

U.H.F. tuner units attracted the most interest, and typical models were exhibited by A.B. Metal Products Ltd., Sidney S. Bird and Sons Ltd., and Plessey. Judging by exhibits, it would seem that u.h.f. tuner design in this country is beginning to stabilise at circuits built around four tuned circuits, these comprising aerial tuning, bandpass tuning and oscillator tuning. All tuned circuits employ lecher lines and variable capacitors. At present, u.h.f. tuners are based on the PC88 and PC86 frame grid triodes, but considerable thought is being given to the use of transistors instead of these valves. Transistorised tuners would still employ the basic four tuned circuits, but it is anticipated that they would offer improved noise performances. One of the headaches that afflict the u.h.f. tuner designer is that the allocation of B.B.C. channels in Bands IV and V causes two channels from each transmitter to be spaced apart by a figure which is close to twice the standard television intermediate frequency. In consequence, u.h.f. tuners for use in this country have to offer a very high image rejection, and this may need to be as much as 55dB or more.

BERTHING BY TV

Trials have recently been carried out on the *Borodino*, 3,206 gross tons, owned by Ellerman's Wilson Line, Limited, to assess the help that closed-circuit television can give during berthing and un-berthing. The *Borodino* and other vessels of the fleet sailing from Hull on the Scandinavian service make round trips of short duration involving calls at several ports where any turn-round delay must be avoided. The round trip chosen for the *Borodino* trial, for instance, was of ten days from Hull to Hull, calling at Copenhagen (36 hours), Aarhus, and Aalborg (12 hours).

The problem that faces the captain of the *Borodino* is that, from the wheelhouse, the stern view is partially obscured by superstructure, and the progress of the after mooring party can be followed only from reports telephoned by the second officer who must leave his post to do so.

Captain R. Tanton, O.B.E., marine superintendent of Ellerman's Wilson Line, believed that C.C.T.V. could provide the continuous observation required in the wheelhouse of the progress on the after mooring lines; and following discussions with The Marconi International Marine Co., Ltd., a system was installed on a trial basis.

On 26th April, the *Borodino* left Hull for Copenhagen equipped with a basic installation of one fixed aspect camera, for mounting aft, and a monitor and camera controls in the wheelhouse. Because the camera would be required only during the period when the vessel was coming alongside a quay or leaving, it was of the dismantlable type: in consequence no heavy-duty housing or other protection was required, which in return reduced weight, simplified rigging and unrigging, and made a light-duty mounting possible. At sea the camera was stowed and on arrival was clamped to the after guard rail (on the docking bridge) facing to port—the normal berthing side—although it could be clamped to view to starboard with equal ease.

Captain Tanton and Captain A. T. Jardine, the master of the *Borodino*, were of the opinion that the use of the Marconi Marine installation at the ports visited on this occasion was of considerable assistance, particularly in relating engine movements to the working of mooring lines.

EMI Tape Recorders for Aero Engine Tests

Residents living near large military and civil airfields frequently complain about the deafening roar of powerful aircraft engines during running up, taking off and landing. Noise, its generation and suppression, is today the subject of much research, for as more powerful aero engines are produced the noise abatement problem becomes more and more acute.

Even Rolls-Royce aero engineers have their noise problems and, to help solve these during installation stages, professional tape recorders have been supplied by EMI Electronics Ltd. Using these tape recorders, a research programme is in progress at the Rolls-Royce Flight Research and Development Establishment at Hucknall, near Nottingham.

Noise intensities are recorded on two-channel EMI TR90 professional tape recorders in a control room near the test beds and subsequently played back for frequency spectrum analysis. Data obtained by positioning microphones at varying distances and angles from the noise source enable a polar diagram of noise energy to be produced.

Without using tape recorders, Rolls-Royce engineers would find it both costly and unpractical to carry out analyses. Engines would need to be run up for several hours and large quantities of expensive fuel used. But tape recordings can be taken over a few minutes of engine running time.

Besides the more obvious advantages of speed, economy, and simplified procedures of recording noise levels on magnetic tape, large masses of data can be stored and subsequently replayed for analysis, as often as necessary. During most studies, rapid variations of noise levels occur and it is not possible to note accurately the fluctuations from meter readings when using conventional testing methods.

Many types of analysis make it necessary to determine the sound pressure levels not only as a function of frequency but also as a function of time. The only satisfactory method of examining transient noise is by first recording it on magnetic tape.

It is equally important, when dealing with noise abatement problems, for analysis graphs to be interpreted to indicate annoyance factors. As a result of these analyses, engine modifications can be made, to reduce noise levels.

Rolls-Royce will be able to make similar recordings for analysis of noise levels from aircraft in flight by using a portable professional tape recorder also supplied by EMI Electronics.

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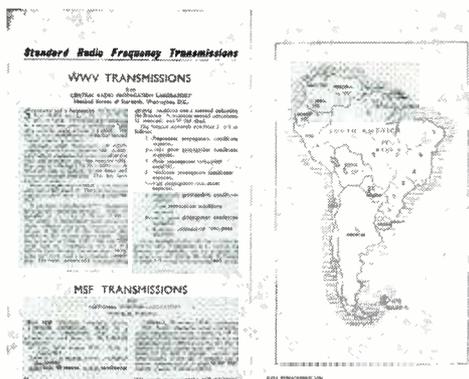


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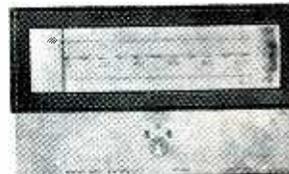
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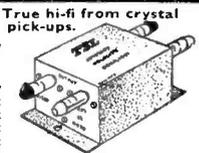
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continued from page 917

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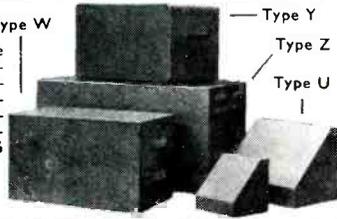
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