THE **Radio Constructor**

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 15 NUMBER 3
A DATA PUBLICATION
PRICE TWO SHILLINGS

October 1961

A Constructor Visits the U.S.A.

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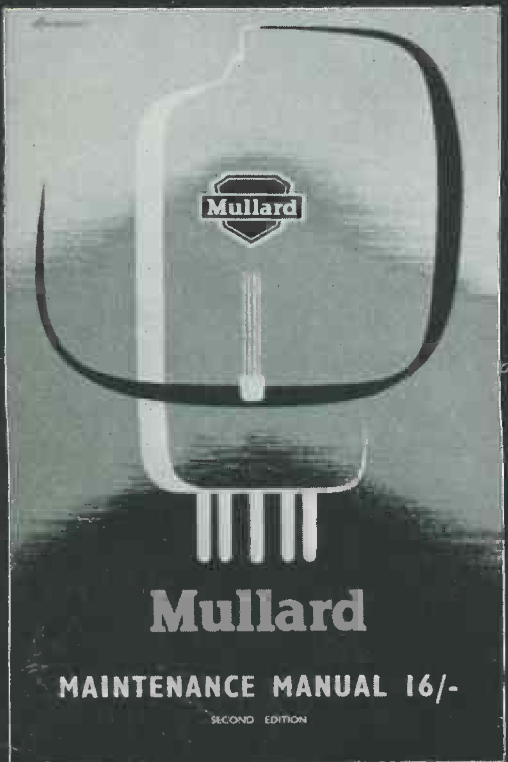

1 This is a completely new and up-to-date edition including all current replacement types. It contains valuable new material and is an essential source of reference for every Service Engineer.

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

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

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

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

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

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PL33	19/3
PL36	12/-
PL38	26/6
PL81	10/6
PL82	7/6
PL83	9/-
PL84	12/8
PL820	18/8
PM84	17/7
PX4	10/6
PY31	16/7
PY32	12/6
PY80	7/6
PY81	8/6
PY82	7/-
PY83	8/6
PY88	13/3
PZ30	19/11
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SP42	12/6
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TH233	33/2
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U16	10/6
U18/20	8/6
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U22	8/-
U24	29/10
U25	17/11
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U31	9/6
U33	26/6
U35	26/6
U37	26/6
U43	9/-
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U52	6/6
U54	19/11
U76	6/-
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U301	23/3
U329	14/-
U339	16/7
U403	16/7
U404	8/6
U801	29/10
U4020	16/7
UABC80	9/-
UAF42	9/6
UB41	12/-
UBC41	8/6
UBC81	11/4
UBF80	9/-
UBF89	9/6
UBL21	23/3
UCC84	14/7
UCC85	9/-
UCF80	16/7
UCH21	23/3
UCH42	9/6
UCH81	9/6
UCL82	11/6
UCL83	19/3
UF41	9/-
UF42	12/6
UF80	10/6
UF85	9/-
UF86	17/11
UF89	9/-
UL41	9/-
UL44	26/6
UL46	14/6
UL84	8/6
UM4	17/3
UM34	17/3
UM80	15/3
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UU6	19/11
UU7	16/7
UU8	26/6
UU9	7/6
UY1N	18/7
UY21	16/7
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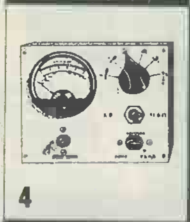
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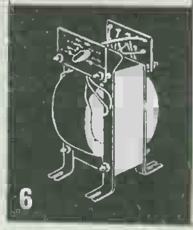
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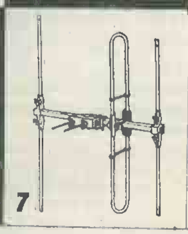
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7 **WOLSEY 3-ELEMENT FOLDED DIPOLE.** I.T.V. Aerial less mounting bracket for external use, complete with 12 yds. of coaxial cable, 15/-. P. & P. 3/6.

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

12 **8-watt PUSH-PULL 5 VALVE AMPLIFIER.** A.C. mains 200-250V Size 10½" x 6½" x 2½". 5 valves. For use with all makes and type of pick-up and mike. Negative feedback. Two inputs, mike and gram. and controls for same. Separate controls for Bass and Treble lift. Response flat from 40 cycles to 15 kc/s, ± 2 dB; 4db down to 20 kc/s. Output 8 watts at 5 per cent total distortion. Noise level 40 db down all hum. Output transformer tapped for 3 and 15 ohms speech coils. For use with Std. or L.P. records, muscial instruments such as guitars, etc. Suitable for small halls, £3.19.6, P. & P. 6/6. Crystal mike to suit 15/-, P. &P. 1/6. 8" P.M. Speaker to suit, 12/6. P. & P. 1/6.

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

14 **TRANSISTOR TESTER.** For both P.N.P. and N.P.N. transistors incorporating moving coil meter. In metal case, size 4½" x 3¼" x 1½". Scale marked in gain and leakage, 19/6, P. & P. 2/6.

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

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


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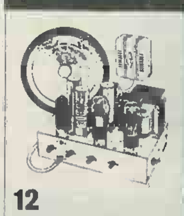
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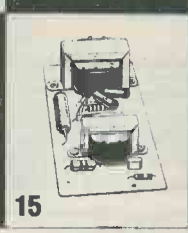
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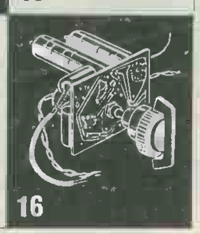
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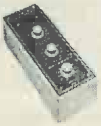
AT MUCH LOWER COST

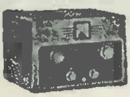
TA-1M

O-12U



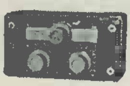
DC-1U

S-33

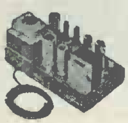


DX-40U

AG-9U



UJR-1



MA-12

TAPE RECORDING/REPLAY AMPLIFIERS, Models TA-1M and TA-1S. Available both monophonic (TA-1M) and stereophonic (TA-1S) and the former can be modified later to stereo with modification kit TA-1C. Special features include bias level control, thermometer type recording level indicators, press-button control. Attractive metal case. TA-1M **£18.2.6** TA-1S **£23.6.0**

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HI-FI SPEAKER SYSTEM: SSU-1. Ideal twin speaker/ducted-reflex cabinet for stereo/mono in average room (left "in the white"). Legs £1.1.0 extra. **£10.17.6**

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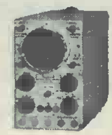
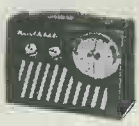


OS-1

V-7A

S-88

SSU-1



UXR-1

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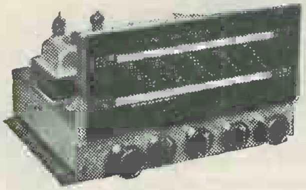

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5U4	7/6	6SN7	6/6	ECC84	9/6	PCC84	9/6
5Y3	7/6	6V6G	6/6	ECF80	9/6	PCF80	9/6
5Z4	9/6	6X4	7/6	ECH42	10/6	PCL82	11/6
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6B8	5/–	12A6	7/6	ECL82	10/6	PL81	12/6
6BE6	7/6	12AT7	8/–	EF39	5/6	PL82	10/6
6BH6	9/6	12AU7	8/–	EF41	9/6	PY80	7/6
6BW6	9/6	12AX7	8/–	EF50	5/6	PY81	9/6
6D6	6/–	12BE6	8/6	EF80	8/–	PY82	7/6
6F6	7/6	12K7	6/6	EF86	12/6	SP61	3/6
6H6	3/6	12Q7	6/6	EF92	5/6	UBC41	9/6
6J5	5/6	35L6	9/6	EL32	5/6	UCH42	9/6
6J6	5/6	35Z4	7/6	EL41	9/6	UF41	9/6
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8/450v.	2/3	500/12v.	3/–	2,500/3v.	4/–
8/500v.	2/9	8+8/450v.	3/6	5,000/6v.	5/–
16/450v.	3/–	8+8/500v.	5/–	32+32/350v.	5/–
16/500v.	4/–	8+16/450v.	3/9	32+32/450v.	6/–
32/450v.	3/9	8+16/500v.	5/6	32+32+32/350v.	7/–
25/25v.	1/9	16+16/450v.	4/3	50+50/350v.	7/–
50/25v.	2/–	16+16/500v.	6/–	64+120/350v.	11/6
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SMALL, 220–0–220 v. 50 mA., 6.3 v. 2 a.	17/6
STANDARD, 250–0–250 65 mA., 6.3 v. 3.5 a.	17/6
HEATER TRANS., 6.3 v. 1½ a. ...	7/6
3 a.	10/6
Ditto 1.4, 2, 3, 4, 5, 6.3 v. 1½ a.	8/6
MULLARD "510" OSRAM "912", 300–0–300, 120 mA, 6.3 v. 4 a. c.t., 6.3 v. 2 a. tapped 5 v.	38/6
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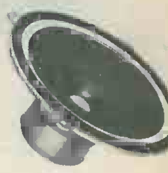

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6 p. 4-way 2 wafer, long spindle	6/6
2 p. 6-way, 4 p. 2-way, 4 p. 3-way, long spindle	3/6
3 p. 4-way, 1 p. 2-way, long spindle	3/6

Wavechange **"MAKITS".** Wafers available: 1 p. 12 wafer, 2 p. 6 wafer, 3 p. 4 wafer, 4 p. 3 wafer, 6 p. 2 wafer. 1 wafer, 8/6; 2 wafer, 12/6; 3 wafer, 16/–. Additional wafers up to 14, 3/6 each extra.

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

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Long spindles. Midget 5K ohms to 2 Meg.

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

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80 ohm CABLE Coax

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

Fringe Quality, Air Spaced 1/- yd.

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

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12.5K to 50K 10 w 3/–

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

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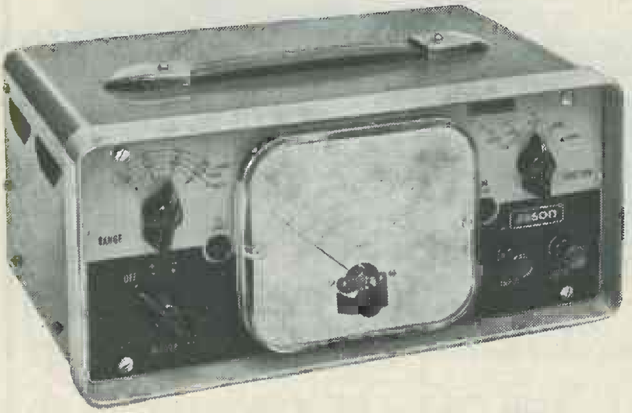

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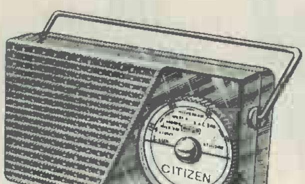

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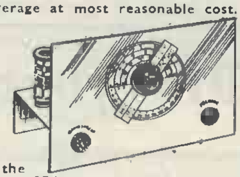

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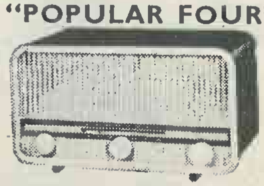

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Incorporating **THE RADIO AMATEUR**

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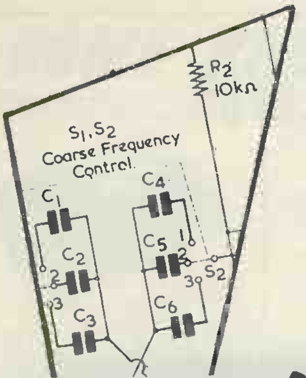

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suggested circuits

No. 131 AN EXPERIMENTAL REMOTE CONTROL SYSTEM

A DESIRABLE FUNCTION IN ANY remote control system is that the interconnecting medium be inexpensive. When the remote and local positions are connected together by wires, it is normally preferable that the minimum number of interconnecting leads be employed.

The device described this month takes advantage of a rather novel technique to enable four separate circuits to be controlled over a single pair of lines. The principle under which the circuit operates is such that the number of controlled circuits could be readily increased to ten without undue complication, control of these being still effected over a single pair of remote leads. An additional feature with the present circuit is that the current flowing through the remote leads is very small. These leads may, in consequence, have appreciable resistance without upsetting circuit operation. Low-cost wire can accordingly be employed.

The circuit illustrated is experimental in character and may need to be modified to suit particular requirements or components.

The Circuit

The circuit of the remote control system accompanies this article. As may be seen it employs four triodes, each being one-half of a 12AT7. A relay having an energising current of 10mA has its coil connected in each anode circuit, a series resistor, R_1, R_3, R_5 or R_7, limiting coil current so that it falls within the maximum cathode current for the triode. Relay 1 has a single set of changeover contacts, whilst the remaining relays have two sets of changeover contacts each.

The cathodes of the four triodes connect to a fixed potentiometer, R_9 to R_{12}, offering voltages which are 5, 10, 15, and 20 volts positive of chassis. The h.t. supply is specified as 200 volts at 30mA. A separate supply of 20 volts at 200mA is required for the fixed potentiometer.

A 1MΩ resistor is inserted in series with each grid to limit grid current to a safe value.

Two leads connect to the remote control unit. The latter has a battery and a fixed potentiometer (R_{13} to R_{17}) which enables positive potentials of 5, 10, 15 and 20 volts to be tapped off by S_1. Values for R_{13} to R_{17} are not specified in the diagram, and these are discussed later.

Circuit Operation

To understand the circuit operation it is first of all necessary to remember that each 12AT7 triode has a short grid base. When, at an h.t. voltage of 200, each triode is negative of its cathode by 5 volts the valve passes very little anode current, this current being much lower than that needed to energise the relay in its anode circuit. Negative voltages on the grid in excess of 5 volts can cause the valve to cut off completely. When the grid of each 12AT7 triode has a potential equal to that on its cathode the valve passes a relatively high current. In this case the current it passes is sufficiently high to energise the relay in its anode circuit.

Let us now consider the circuit when switch S_2 is open. Under this condition the upper remote lead has the same potential as chassis. This potential is passed to each valve grid, either direct or via one or more of the lower de-energised contacts of relays 2, 3 and 4. Since their grids are at chassis potential all the valves are cathode biased by the voltages given at the taps in the fixed potentiometer R_9 to R_{12}. In consequence, none of the valves passes sufficient current to energise its relay, and the relays remain in the de-energised position.

Let us now close S_2 and set S_1 to the "+5V" position. This causes a voltage which is 5 volts positive of chassis to be applied to the valve grids, with the result that $V_{1(a)}$ grid takes up the same potential as its cathode. $V_{1(a)}$ conducts and relay 1 energises. The remaining relays remain de-energised.

When S_1 is set to the "+10V" position the grid of $V_{1(b)}$ assumes the same potential as its cathode, whereupon this valve conducts and causes the relay in its anode circuit to energise. The lower set of changeover contacts for relay 2 now operates, and this disconnects the grid of $V_{1(a)}$ from the new control voltage and connects it to chassis. In consequence, $V_{1(a)}$ is now biased by the 5 volts developed across R_{12} and its anode current drops sufficiently to allow relay 1 to de-energise.

Next, let us set S_1 to the "+15V" position. In this instance the grid of $V_{2(a)}$ assumes the same potential as its cathode, whereupon it conducts and relay 3 energises. The lower changeover contact of relay 3 disconnects the grid of $V_{1(b)}$ from the new control voltage and connects it to chassis. $V_{1(b)}$ becomes cut off, relay 2 de-energises, and the lower changeover contact of relay 2 moves to the de-energised position. Previously it connected the grid of $V_{1(a)}$ direct to chassis; it now connects the grid of $V_{1(a)}$ to chassis via the energised contacts of relay 3. Thus, the relay in the anode circuit of $V_{1(a)}$ remains de-energised, as before.

When S_1 is set to the "+20V" position, zero grid voltage with respect to cathode is applied to $V_{2(b)}$. This valve now conducts, causing relay 4 to energise. The lower changeover contact of relay 4 transfers the grid of $V_{2(a)}$ from the new control voltage to chassis potential, and relay 3 de-energises.

The lower changeover contact of relay 3 moves to the de-energised position, whereupon the chassis connection to the grids of $V_{1(a)}$ and $V_{1(b)}$ is now obtained via the lower changeover contact of relay 4.

It is interesting to note how the circuit operates when S_1 is moved in the reverse direction. Let us first of all return it to the "+15V" position. The grid of $V_{2(b)}$ now takes up a potential which is 5 volts negative of its cathode, with the result that relay 4 de-energises. Its lower set of changeover contacts moves to the de-energised position, transferring the grid of $V_{2(a)}$ from chassis to the new control voltage. The grid of $V_{2(a)}$ now assumes the same potential as its cathode and this valve conducts, energising relay 3. The lower changeover contact of relay 3 moves to the energised position, transferring the grids of $V_{1(a)}$ and $V_{1(b)}$ from the momentarily applied new control voltage to chassis potential. The relays in the anode circuits of $V_{1(a)}$ and $_{(b)}$ remain, therefore, de-energised.

When S_1 is set to the "+10V" position relay 3 de-energises, causing the new control voltage to be applied to the grid of $V_{1(b)}$. $V_{1(b)}$ conducts, energising relay 2, and causing the grid of $V_{1(a)}$ to connect once more to chassis. Relay 1 continues in the de-energised position.

Setting S_1 to the "+5V" position causes the grid of $V_{1(b)}$ to go 5 volts negative of its cathode. whereupon relay 2 de-energises. The grid of $V_{1(a)}$ now connects to the new control potential, whereupon the valve conducts and relay 1 energises. If S_2 is now opened $V_{1(a)}$ is also biased back, and relay 1 de-energises. We have just considered circuit operation when changing from one control voltage to the next. If an individual control voltage is selected and suddenly applied to the circuit, the resultant operation is somewhat simpler. To take an example, let us assume that, with S_2 open, we set S_1 to the "+15V" position, and then close S_2. The control voltage selected is capable of causing $V_{1(a)}$, $V_{1(b)}$ and $V_{2(a)}$ to conduct. However, as soon as relay 3 energises its lower changeover contact transfers the grids of $V_{1(a)}$ and $V_{1(b)}$ to chassis, and relays 1 and 2 stay de-energised.

Summing up, it may be stated that relay 1, 2, 3 or 4 may be made to energise at will by setting S_1 to the appropriate position. When switch S_2 is open none of the relays operate. In consequence, it becomes possible to control four remote circuits via a single pair of remote leads.

Further Points

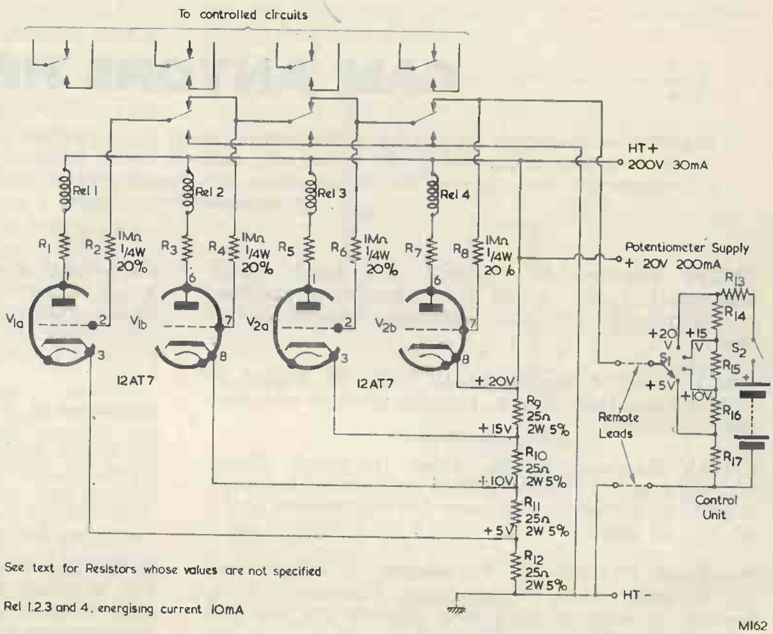
With an experimental device of this nature it is inadvisable to specify all components closely. In the circuit given it is assumed that an h.t. supply of 200 volts at 30mA is available, together with relays capable of energising at 10mA. The values given for R_9 to R_{12} allow a standing current of 200mA through this potentiometer. Valves type 12AT7 are quoted because they have a short grid base. However, any other triodes (or triode-strapped pentodes) having similar characteristics could be employed in their place.

Resistors R_1, R_3, R_5 and R_7 should have values which limit cathode current to a safe figure when the appropriate valve is conducting. (The limiting cathode current for a 12AT7 is 15mA.) If relay coil resistance is sufficiently high these resistors may not, of course, be needed.

It is possible to use relays having energising currents higher than 10mA. If this is done, it will be necessary to employ valves capable of passing the additional cathode current or to parallel two (or more) 12AT7 triodes at each position. It would be advisable, in addition, to re-value the components in the fixed potentiometer R_9 to R_{12}, so that the standing current is increased in proportion. There will also, of course, be an increase in h.t. current requirements.

The series grid resistors R_2, R_4, R_6 and R_8 limit grid current to a safe value, particularly when positive voltages are momentarily applied when changing from one control condition to the next.

A simple voltage selector circuit employing a battery is illustrated for the remote position, but this may be changed to any alternative form favoured by the constructor. The circuit into which the selected voltage is fed has a high resistance and there is no necessity to employ very low value resistors in the potentiometer given by R_{14} to R_{18}.



A total resistance in this potentiometer of some 50kΩ should prove to be quite satisfactory in practice. Due to the fact that relay current flowing through potentiometer R_9 to R_{12} will cause cathode voltages to be slightly higher than occurs when all the relays are de-energised, the control voltages tapped off at the remote unit may need to be some 0.5 volts positive of the corresponding voltages given at the taps in R_9 to R_{12} with all relays de-energised. If desired, switch S_1 and R_{14} to R_{17} may be dispensed with, being replaced by a variable potentiometer with a linear track. The latter could then be fitted with a scale indicating the setting needed for each relay to energise. Consumption from the remote battery will be low, but it could, nevertheless, be replaced by a suitable mains unit, if a power point is available at the remote position. Alternatively, a source of supply could be obtained from the local unit, but this would involve the use of a third remote lead.

A disadvantage with the circuit is that relays not required may be momentarily energised when changing from one control voltage to the next. If this effect is undesirable it should be capable of being cleared by introducing a slight time delay into the grid circuit of each valve. A suggested modification could consist of coupling the grids of $V_{1(a)}$, $V_{1(b)}$ and $V_{2(a)}$ to chassis via capacitors having values of 0.5, 0.2 and 0.1μF respectively.

Adding Further Relays

The circuit given with this article shows four relays controlled over a single pair of remote leads. More relays can readily be added by the simple process of employing further valves whose cathodes tap into voltages rising in steps of 5 volts, and by continuing the changeover contact circuitry through which the control voltage is routed. It will also, of course, be necessary to provide additional control voltages from the remote unit.

The 12AT7 has a limiting maximum negative voltage of 50. In consequence the maximum number of control functions possible, when using this valve, is ten.

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

RME69 Receiver.—K. Laycock, 274 Leeds Road, Bradford 3, Yorks., would like to borrow or purchase any information on this American communications receiver.

* * *

H.M.V. AM/FM Receiver Model 1622.—G. Escritt, 99 Endike Lane, Hull, Yorks., requests the loan of service sheet or manual.

* * *

R1116A Receiver.—R. W. Ling, 16 Marsh Street, Middlesbrough, Yorks., wishes to obtain a circuit diagram of a battery eliminator for this receiver (120V h.t. and 2V l.t.).

* * *

Peto-Scott "Trophy 8" Pre-selector.—J. Chatterton, 230 Brownley Road, Wythenshawe, Manchester 22, is urgently in need of the circuit diagram for this unit —loan or purchase.

Photo-Tube Keyer.—D. P. Sladen, 155 Sanderstead Road, South Croydon, Surrey, wishes to know if any reader could supply a circuit for such a unit or provide information on where a completed unit could be obtained.

* * *

Reflectograph Model 500 Tape Recorder.—A. J. Ellis, 53 Prestbury Road, Cheltenham, Glos., wants to obtain the service manual or circuit diagram. Having assisted several readers through this feature in the past, he now requires help himself!

* * *

BC624 and Wavemeter Type W1310.—C. W. Austin, 135 Shaftesbury Avenue, Kenton, Harrow, Middx., requires either the service manuals, circuits and/or any modifications to these two units.

A New Voltage Level Indicator for Tape Recorders

The EM87 is a new Mullard voltage indicator tube primarily intended for use as a recording level indicator in tape recorders.

In many recorders the a.f. voltage appearing at the anode of the recording output stage is about 10V, which is insufficient to close the display of currently available level indicators. The EM87 has a grid base of only 10V and in addition it has a high sensitivity in the initial region of the control characteristic (V_g=0V).

Over-modulation of the tape is immediately apparent, since a.f. signals greater than 10V in amplitude cause the luminous areas to overlap, giving a brighter centre portion to the display.

Maximum ratings are: anode voltage 300V, anode dissipation 600mW, cathode current 5mA, and deflection electrode voltage 300V. The heater draws a current of 300mA at 6.3V.

The EM87 has the same overall physical dimensions (72.8mm overall length x 22.2mm diameter) and the same pin connections as the EM84. The fluorescent strip is 32.6mm in length by 4mm in width.

Simple Stereo Balance Indicator

By P. SAMPLE

THIS SIMPLE UNIT WAS BUILT TO PROVIDE AN EASY and cheap method of audibly balancing stereo amplifiers and indicating phase. It was built into an existing pre-amplifier, and is connected to the input circuits whenever it is required.

It was decided that the best signal to balance the relative outputs of each amplifier in the stereo equipment was a short duration pulse with a low repetition frequency. At first it was thought that a valve would be needed. The use of a valve would, however, mean a number of alterations to get the components into the amplifier, and would also increase h.t. and heater current requirements.

Eventually the circuit shown was evolved. This had all the necessary requirements in that it produced a pulse at a frequency of about 1 pulse per second, it had low current drain and, most important of all, required only a few components.

Circuit

The circuit will be recognised as that of a conventional relaxation oscillator, which has been slightly modified.

Such an oscillator usually produces a sawtooth waveform, but the 300pF capacitor in series with the output reduces this to a short duration pulse corresponding to the time during which the neon conducts and discharges capacitor C_1. The frequency of oscillation is determined by the time constant of C_1 and R_1+VR_1. Since the oscillator only requires about 120 volts to operate, a potential divider consisting of R_2 and R_3 is used, the values shown being for an h.t. potential of 300 volts. The output signal is taken from a potentiometer which is part of the resistor through which capacitor C_1 is charged.

The values shown provide ample signal strength to load a Mullard "5–10" amplifier when fed through the auxiliary tape socket on the pre-amplifier. It would be suitable for any other amplifier having an input sensitivity of the order of 100–300mV.

Construction

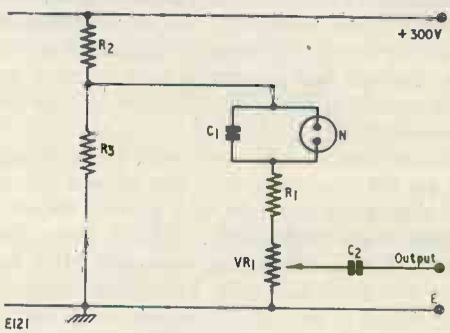
As the object of this indicator is that it can be operated immediately when required, the components are mounted inside the pre-amplifier. Since these are so few, sufficient room will be found in most makes of pre-amplifiers.

The components are mounted on a tagstrip and a hole is drilled in the back of the pre-amplifier chassis for VR_1. The tagstrip is then mounted close to VR_1 and wiring completed. It is important that the oscillator is not placed too near any high impedance signal leads, otherwise there is likely to be stray pick-up. Since the oscillator is running all the while, it would be disturbing to hear a slow ticking noise whilst using the amplifier.

The neon employed is of the miniature type found in mains indicators, although any similar type would suffice. The series resistor must be removed.

It is necessary for there to be a spare position at the input of the pre-amplifier. The two inputs of this position are joined together and the output of the oscillator is fed to the common connection. The sensitivity of the input should be similar to that given above and also should not have any frequency correction.

In the writer's case, the output of the oscillator is permanently connected to the spare pair of inputs. All that is then necessary, to use the indicator, is to set the input selector switch to the appropriate inputs and adjust VR_1.



Components List

Resistors (all ¼ watt)

R_1	3.3MΩ
R_2	150kΩ
R_3	100kΩ

Capacitors

C_1	0.25µF 350w.v.
C_2	300pF

Potentiometer

VR_1	500kΩ pre-set
N	Neon (see text)

Operation

The volume control is set at the position normally used for stereo reproduction and VR_1 adjusted until the pulses are at sufficient volume; VR_1 need not be adjusted again. The balance control can then be set to give a sound source mid-way between the speakers.

The oscillator also gives a very good indication when the speakers are correctly phased and is much better than the usual method of putting on a mono disc of a solo voice and changing leads until the impression is gained that the speakers are in phase.

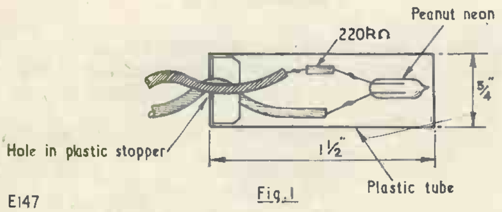
Using this indicator, the sound comes from a definite source between the speakers when they are in phase, and the difference is noticed immediately if the speakers are switched out of phase.

a soldering iron ECONOMISER

By B. B. RAFTER

Few things can be more infuriating to the radio man than to return to the bench after an absence of an hour or so, only to find that his best soldering iron is still switched on, wasting watts and its own bit. The writer's somewhat restricted work-place leads especially to this sort of thing, since the switch feeding the iron is tucked away in a corner and is not very visible. Having left the iron on for several hours three times within ten days, it was decided that something *must* be done at once and a search in the spares box for a solution was commenced.

The obvious answer was some form of warning light on the iron itself, and this turned up, after a short search, in the form of a peanut 80 volt neon left over from other work. Such a neon, fitted to the mains lead, would do very well. But how to house a wire-ended bulb with series resistor, for which there is no official holder, in a completely safe manner?



E147 Fig. 1

A further search brought up a small plastic tube 2½ in long by ¾in in diameter which once contained throat tablets. This was cut down to 1½in in length and a small hole pushed with a screwdriver through the tight-fitting plastic stopper. Through the hole was pushed an odd twelve inch length of plastic-covered flex to the bared ends of which were soldered a 220kΩ quarter-watt resistor and the peanut neon, as shown in Fig. 1. The joints were then covered with small strips of insulating tape and the whole assembly pushed home into the plastic tube.

It remained to connect the other ends of the flex across the terminals of the bayonet plug on the end of the iron lead. With a few further strips of tape the flex was then fixed onto the iron lead as

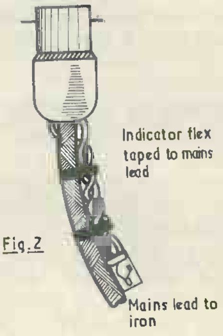


Fig. 2 E148

illustrated in Fig. 2. When the iron was switched on the small orange glow from the neon occurred at eye-level over the bench.

The soldering iron has not been left on since fitting this device. Indeed, the author's wife has now ordered one to be made for her electric flat-iron!

Television for "Northern Star"

Shaw Savill Line's new passenger liner *Northern Star* (22,000 tons) will be fitted with a television system providing a completely co-ordinated internal and off-air service all over the world. This is to be supplied and installed by Marconi s Wireless Telegraph Co. Ltd., to an order negotiated by Marconi Marine.

Northern Star's passengers will be able to receive local television programmes at ports of call, and will also have the added facility of closed-circuit telecine and live television programmes while the liner is at sea.

Following similar installations for the Orient Line's *Oriana* and *Canberra*, this will be the third sea-going t.v. system to be supplied by Marconi's.

Northern Star is being fitted out at Vickers Naval Yard at Newcastle-upon-Tyne.

Simple
Transistor Square Wave Oscillator

By H. T. SLINGO

A SMALL PORTABLE SQUARE WAVE OSCILLATOR can be an extremely useful item of equipment. It may be used for signal tracing, both a.f. and r.f., and for morse practice if the on-off switch is replaced by a key.

The unit described in this article is very simple and cheap to make as well as being small and easily portable. In the original oscillator, two OC71's were used, but almost any small audio or "red spot" transistor should be suitable.

The Circuit

The circuit (Fig. 1) consists of a multivibrator which, with the components specified, oscillates just above 1kc. The frequency of oscillation could be altered by changing C_1 and C_2, larger values lowering the frequency and conversely smaller values raising it. The square wave produced is shown at Fig. 2 (*a*). Although not perfect, it has a rise time of 3μ secs., which ensures that the waveform is quite rich in harmonics.

Circuit Operation

The arrangement is basically an R.C. coupled amplifier with its output fed back to the input. Suppose that the collector current of TR_2 is rising. There is in consequence a fall in collector voltage, and the base of TR_1 is made more positive via C_1.

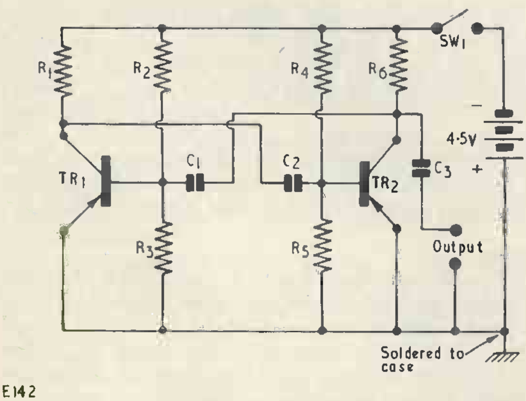


Fig. 1. Circuit diagram of the Simple Transistor Square Wave Oscillator

This causes the collector current of TR_1 to decrease and the collector voltage to rise. The base of TR_2 is thus made more negative by the amplified potential reaching it via C_2. The result is that TR_2 passes a comparatively heavy collector current. The collector potential of TR_2 falls steeply causing the base of TR_1 to be driven positive beyond the cut-off point.

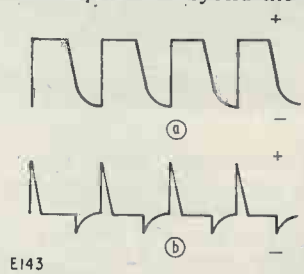


Fig. 2. (a) output waveform and (b) differentiated waveform

With TR_1 non-conducting, feedback ceases, the length in time of this condition being determined by the time constants in the circuit. During the cut-off period, the base of TR_1 grows less and less positive, the charge in C_1 leaking away through the base-emitter junction R_2, R_3 and TR_2. When the cut-off

Components List

Resistors (all $\frac{1}{8}$ watt)
R_1, R_6 15k$\Omega\pm$10%
R_2, R_4 270k$\Omega\pm$10%
R_3, R_5 47k$\Omega\pm$10%

Capacitors
C_1, C_2 0.005μF, 250WV paper
C_3 0.02μF, 350WV paper

Transistors
TR_1, TR_2 Mullard OC71 (see text)

Miscellaneous
SW_1 Single pole toggle switch
Battery EverReady 4.5V pocket lamp battery No. 1289
Sockets, Wander plugs
Case 2-oz. tobacco tin

point is passed, TR_1 conducts with a rising collector current. The feedback is now from the collector of TR_1 via C_2 to the base of TR_2, and the original process is reversed until another cycle commences. The number of oscillations in each second is determined primarily by the time constants of C_2 R_5 and C_1 R_3, but all circuit constants including the transistors and applied voltages, have an appreciable effect. It is advisable therefore, to employ the specified component values, if the results given by the prototype are to be duplicated.

Notes and Constructional Details

The oscillator will function reliably when the supply voltage is reduced to 1.5, but the output falls off quite considerably. The battery consumption is low, being 0.5mA only at 4.5 volts, and the battery should, therefore, have a considerable life.

Construction is very simple, the case for the prototype being a 2 oz. tobacco tin which holds all the components and the battery quite snugly. The battery fits at one end and is kept in position by a small tinplate bracket soldered to the bottom of the tin. (See Fig. 3.) The battery is made finally secure by fitting the lid. The remaining space in the tin was used for the oscillator components, the necessary holes being punched in the lid to take the switch and the output sockets. The remaining components can then be mounted, miniature resistors and capacitors being used where possible to conserve space. It should be noted, as the layout is very compact, that the transistor lead-out wires need to be fairly short (about ¾ in) and that a heat shunt should be used to prevent unnecessary heat reaching the transistor elements whilst soldering.

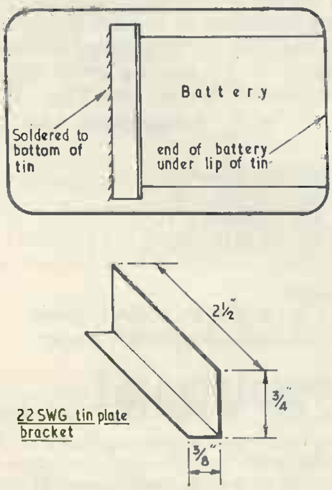


Fig. 3. Showing method of mounting the battery within the case

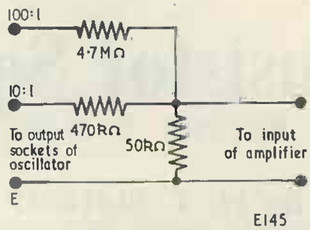


Fig. 4. Simple attenuator

The photographs give inside and outside views of the oscillator in its prototype form. The type of tin employed may be readily identified, and it is, of course, possible to give the tin a coat of enamel which will obliterate the existing printing and impart a "professional" finish to the unit. The potentiometer shown in the photograph was used for experimental purposes, being discarded after the circuit had been finalised to that given in Fig. 1.

Results

When it was completed, it was found that the prototype gave an output of 4 volts amplitude, peak to peak, this approximating to a square wave. (Fig. 2 (*a*).) Mark-space ratio was about 50:50, the rise time was 3μ secs, and frequency of oscillation was just above 1 kc.

When a 2,000Ω earphone was connected to the output, the resultant sound was well audible two or three feet away. However, connecting the earphone seriously distorted the waveform.

When a load of 5,000Ω was connected in place of the earphone, the waveform at Fig. 2 (*b*) was obtained. This waveform is given because of differentiation by C_3 and the 5,000Ω resistor. The output voltage also drops to about 3 volts peak-to-peak.

Uses

It is, of course, possible to use the unit for audio frequency tracing in amplifiers, etc., but it will need attenuating if the amplifier has a useful degree of gain. This attenuator would need to have a fairly high input impedance if the waveform is to be preserved in its original shape and observed on an oscilloscope, a suitable attenuator is shown in Fig. 4.[1]

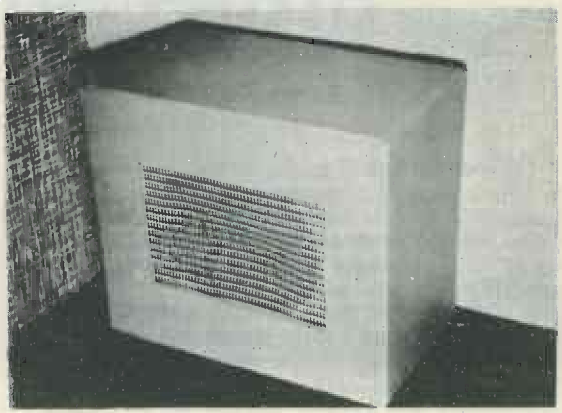
Finally, the unit can be used for signal tracing in radio frequency circuits. This was tried with both an f.m. and a t.v. receiver.

The output of the oscillator was connected to the aerial socket via a 100pF capacitor and it was clearly audible from the loudspeaker with both receivers. It is advisable, when this type of test is being carried out, to disconnect the aerial from the receiver in question, since the harmonics of the oscillator could otherwise be transmitted to neighbouring receivers.

[1] This attenuator, especially when used to give 100:1 reduction may cause integration with rounding off of the waveform if the input circuit to which it connects has appreciable capacity.—EDITOR.

A Simple LOUDSPEAKER BOX

By M. J. PITCHER, B.Sc.



Cabinet making presents a problem for many radio and hi-fi experimenters. In describing the construction of a simple loudspeaker box our author also passes on a number of practical hints which will be of use in the building of a wide variety of cabinets

HOW MANY HOURS DID YOU SPEND BUILDING YOUR amplifier, or radio tuner? How long did you spend fixing up a loudspeaker baffle or knocking together a box for the loudspeaker? Too many constructors spend good money and hours of valuable time with nuts, bolts, wire and soldering iron, and too little time on the box from which the sound comes. If your inclination is to cut a hole, more or less in the middle of a piece of scrap wood, fix your speaker to it and hang it on the picture rail, this article is for you.

It is hoped to show that with very little skill and simple tools it is possible to make boxes that are a delight both to the eye and the ear. The techniques described can also be applied to making cabinets for all kinds of equipment.

The dimensions shown in Fig. 1 were specially chosen to suit some plywood that was left over from a previous job. They hold no special magic. It has been found, however, that any speaker up to 7in diameter gives very acceptable quality when fitted in this box. The use of the bass lift control in the associated amplifier gives more than adequate compensation for the comparative smallness of the box.

The eye appeal of the box depends on the covering material, and this will be discussed later. The shape of the speaker opening is also important in this respect. A square opening is easier to produce than a round one, and it is easier to cover the edges; it

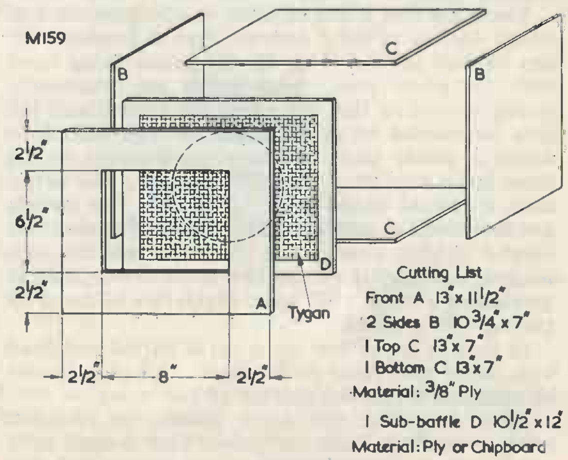


Fig. 1. Exploded view of loudspeaker box

is also easier on the eye. The square opening requires the speaker to be mounted behind it on a sub-baffle, but the errors made in cutting and truing up the circular opening for the latter are safely hidden from view.

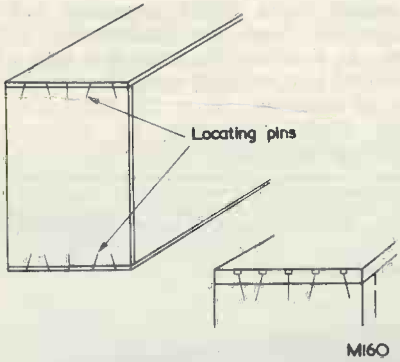


Fig. 2. Pinned butt joint showing positions and angles of locating pins

Cutting the holes, round or square, presents by far the biggest problem, so this will be disposed of first. The wood is marked exactly where the cut is to be made, a hole is drilled near the line on the waste side, and the waste is cut out with a coping saw. If this tool is unfamiliar it should be explained that it looks rather like a fret-saw, but has a thicker, smaller frame, and widely spaced teeth that ensure very rapid cutting. It is a very versatile tool and will repay its very modest cost many times over.

The sides and front of the box are best made of ⅜in birch ply. Veneered ply can be bought, but this merits special joints to hide the raw edges, and it is best avoided. Most timber supply shops are able to cut material to size on an electric saw thus producing nice square edges. It is well worth the trouble of finding such a source of supply, especially if you are not too handy with saw and plane.

There are two kinds of joint to consider. A box which carries nothing heavier than a loudspeaker can be butt-jointed (Fig. 2), the joints being fixed with 1in panel pins. Such joints are reasonably strong providing that the edges are square and the pins hammered in at an angle. If you intend to house a power pack or heavy components in the same box a stronger joint will be needed. The writer used a pinned tenon joint. (Fig. 3.) The tenons are first marked and cut using the coping saw. Be careful to keep your cut on the waste side for each tongue, but exactly on the line at the root. Aim at producing a "won't fit" joint which can be eased by paring with a chisel.

In both types of box the front is butted and fixed with panel pins fixed at an angle. All pins should be punched under the surface of the wood.

After assembly, the edges should be rounded using a medium rasp, or plane, and sanded to a finish with medium sandpaper. All joints, pin-holes, blemishes and gaps due to poor carpentry can be filled with Polyfilla. This is superior to "plastic wood" because it does not shrink and can be sanded to a smooth finish much more quickly. It is also much cheaper, but has a longer drying time and should be left overnight.

The box may now be given a coat of wood primer. If you are using a "one coat" type of paint such as Valspar, thin a small quantity with 20% turps substitute and use as a primer. When dry, sand down and paint additional coats without thinning, until the required depth of colour is achieved.

At slightly greater expense the box can be covered with self-adhesive plastic film. This is available in a great variety of attractive patterns including wood veneer. This film needs a smooth non-porous surface and one, or more, coats of paint are essential.

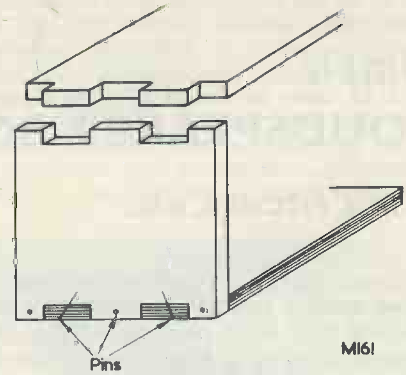


Fig. 3. Pinned tenon joint

To the writer's mind the most attractive finish, and the speediest, is to use the plasticised fabric which is used as a covering for record players, etc. Using latex adhesive on both fabric and box the whole job can be completed in half an hour. Care is necessary in this case to lay the material down accurately without air bubbles, for wherever it touches it stays—forever.

The speaker opening in the sub-baffle can be covered with a piece of Tygan, or similar material. This can be fixed with latex adhesive. An alternative and quick method of attachment to chipboard is to staple the material down with an office stapling machine, the same means serving on the softer kinds of plywood.

The speaker can now be mounted on its sub-baffle, and in turn mounted in the box, by screwing through to the front panel. If the back of the box is on view it can be covered with peg-board, or similar material. If a plywood back is used a few half inch holes should be cut to relieve the pressure.

The cost of the timber to make the box itself will be about six shillings. Covering the box with paint or material, according to taste, will cost a few more shillings. So, to make yourself a box that will produce a reasonable quality of sound, and please the rest of your family with its appearance.

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

part 3

understanding radio

By W. G. MORLEY

In last month's issue we described potential and potential difference, and discussed some typical cells and batteries. Also introduced was the subject of resistance, with which we shall now continue.

Ohm's Law

We know already that if we apply an e.m.f., which can be measured in volts, to a conductor there is a flow of current, which can be measured in amps. As it must do, the conductor possesses resistance. Let us now examine the relationship between the voltage of the applied e.m.f. and the current which flows. If the resistance were to remain constant we would find that increasing the voltage of the e.m.f. caused a corresponding increase in current; this being a situation which is simple to visualise. If an e.m.f. of 5 volts causes a current of 1 amp to flow, it is not surprising to find that an e.m.f. of 10 volts causes a current of 2 amps to flow.

Let us now examine what happens if we change the value of the resistance. A certain conductor allows a current of 2 amps to flow when an e.m.f. of 10 volts is applied. If we double the value of the resistance, we will find that the e.m.f. of 10 volts only causes a current of 1 amp to flow. Again, this is easy to visualise, because an increase in resistance must obviously cause a decrease in the current which flows. If we wished to maintain the 2 amp flow of current when the value of the resistance had been doubled we would have to increase the e.m.f. from 10 to 20 volts. The same relationship holds true if the resistance is altered by any other factor and, to sum up, it may be said that if the voltage of the applied e.m.f. remains constant the current which flows varies inversely as the value of the resistance. We can say also that, to maintain a constant current, the voltage of the applied e.m.f. varies directly as the value of the resistance.

Both these statements may be combined in the following equation:

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

in which R represents the value of the resistance, E the e.m.f. and I the current. The unit employed to measure resistance is the *ohm*, and resistance in ohms can be substituted directly in the equation when E is expressed in volts and I in amps.

A quick example will help to demonstrate the use of the equation. When an e.m.f. of 6 volts is applied to a conductor, a current of 2 amps flows. What is the resistance of the conductor?

We know that

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

so that, substituting for E and I, we get

$$R = \frac{6}{2}$$

Therefore $R = 3$, and the resistance of our conductor is 3 ohms.

The equation may also be expressed as:

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

$$E = IR.$$

These last two forms are merely alternative ways of saying the same thing.

We have introduced the unit of resistance, the ohm, and we can say (from the equation) that if an e.m.f. of 1 volt causes a current of 1 amp to flow, the resistance is 1 ohm. The term ohm is frequently abbreviated to Ω (this being the large Greek letter "omega"). In radio work multiples of ohms are frequently encountered, giving us the kilohm (kΩ) which is equal to one thousand ohms, and the megohm (MΩ) which is equal to one million ohms.

All conductors possess resistance, and this can be a nuisance if it limits our ability to pass a current along a conductor. On the other hand, most radio circuits require that resistance be *purposely* inserted at certain points. In this instance we employ a component which has been specially made to offer resistance, the component being known as a *resistor*.[1]

When we referred to the relationship between the voltage of the applied e.m.f. and the current which flows through a conductor we inserted the qualification "if the resistance were to remain constant". In practice, varying the e.m.f. applied to a conductor *can* change its resistance, mainly because it may suffer a temperature change and partly because the change in applied e.m.f. causes a change in resistance on its own account. The temperature change just referred to is due to the fact that the temperature of a conductor rises when a current is passed through it, this being combined with the further fact that conductors offer different resistances at different temperatures. In radio work, resistors which are intended to present fixed values of resistance are so designed that changes in resistance due to the applied e.m.f. are sufficiently small to be of no consequence in most applications, and the effect does not normally give trouble. If the resistance offered by a conductor is such that current truly varies inversely as voltage (that is, that there is no change of resistance for changes in applied e.m.f.) the conductor is said to obey Ohm's Law. Frequently the expression $R = \frac{E}{I}$ is described as being "Ohm's Law" but, to be pedantic, such a statement does not exactly represent the case.

Resistors which obey Ohm's Law may be described as *linear resistors*.[2] This is to differentiate them from *non-linear resistors*, which are components whose resistance may vary markedly with applied e.m.f.

We introduced the subject of resistance last month by way of conductance, stating that these are reciprocal units of measurement. The basic unit of conductance is the *mho* (the word "ohm" spelt backwards)and it satisfies the following equation:

$$\text{Conductance (in mhos)} = \frac{1}{\text{Resistance (in ohms)}}.$$

Thus, a resistance of 3 ohms is the same as a conductance of 1/3 mho. Mhos may be encountered in radio work occasionally as millimhos (one thousandth part of a mho) and micromhos (one millionth part of a mho).

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[1] In early literature, and in some electrical references, the term "resistance" may be used instead of "resistor".

[2] Because, if a graph is drawn for their current and voltage relationships, it becomes a straight line.

Resistivity

The ability of a material to pass an electric current is defined in terms of its *resistivity* (or, sometimes, *specific resistance*). The resistivity of a material is normally expressed in terms of the resistance given between two opposing faces of a cube made from the material, each side of the cube having a length of 1 centimetre. (Some figures for resistivity may refer to a cube having 1 inch sides.) Resistivity is quoted at a particular temperature, because temperature changes can cause changes in the resistance of the material. We saw last month that the resistance of a conductor in wire form varies directly as its length and inversely as its cross-sectional area. It is, in consequence, possible to determine the resistance of a wire from its resistivity when the latter is quoted in ohms per centimetre cube.

TABLE 1

Material	Approximate Resistivity in microhms (=millionths of ohms) per cm. cube at 20° C.
Aluminium . .	2.8
Brass	7.5
Carbon	30–190
Copper	1.7
Eureka	48
Iron	10
Phosphor Bronze	11.5
Silver	1.6

Table 1 gives approximate figures for the resistivity of familiar conductors. It will be noted that the best conductor in the group given in the Table is silver, and that the second best conductor is copper. Also included is Eureka, this being an alloy from which "resistance wire" is drawn. Eureka is a special alloy designed to offer a relatively high resistivity together with low change in resistance for change in temperature. Other resistance alloys with similar characteristics to Eureka are Constantan and Advance.

An alternative method of expressing resistivity is more convenient when evaluating the resistance of wires. In this case the resistivity is defined in ohms per circular mil foot. This is the resistance of a wire, drawn from the material, which has a length of one foot and a diameter of one mil (=0.001in).

Power

We must now leave the subject of resistance for a short while and introduce the concept of power. This diversion is necessary because power plays an important part in the design and characteristics of practical resistors.

When a current flows through a conductor it causes the temperature of the conductor to rise. In consequence work has been done, in that electrical energy has been converted into heat. Power defines the rate of doing work and, for electricity, is defined in units known as *watts*. A watt is equal to the product of e.m.f. in volts and current in amps; so that, if an e.m.f. of 1 volt causes a current of 1 amp to flow in a conductor, the resultant conversion to heat is that given by a power of 1 watt. The relationship may be expressed as follows:

$$P = EI,$$

where P is power in watts, E is e.m.f. in volts and I is current in amps. The term watt may be abbreviated to the single letter W, and multiples and subdivisions likely to be encountered in radio work are kilowatt (kW) which is equal to a thousand watts, and milliwatt (mW) which is equal to one thousandth of a watt. Power is normally represented in a formula or equation by the letter P.

Electrical units of power are frequently encountered in our everyday life. A 100 watt 200 volt electric light bulb is not, for instance, an unfamiliar object. Such a bulb contains a conductor whose temperature is raised to incandescent level for a power of 100 watts when an e.m.f. of 200 volts is applied. Since power in watts is equal to the product of e.m.f. in volts and current in amps, the current which flows through the bulb is 0.5 amp.

Electrical energy may be converted into forms other than heat. In a loudspeaker it is converted into sound waves and, in an electric motor, it is converted into rotary motion.[3] In all cases where work is done, this may be defined in watts.

The expression just given for power may be combined with those defining the relation between resistance, voltage and current. Thus, we may have:

$$P = \frac{E^2}{R}$$

$$\text{or } P = I^2 R.$$

When the *cost* of electric energy has to be calculated, a unit commonly employed is the *watt-hour*. This unit defines the work that has been done by electric current over a given period, and is equal to the product of power in watts and time in hours. Thus, a 100 watt bulb running for 20 hours represents an expenditure of 2,000 watt-hours. 2,000 watt-hours will similarly have been expended if a 2 kilowatt electric fire has been switched on for 1 hour. The unit normally employed in Britain is the *kilowatt-hour*, this being equal to one thousand watt-hours. The kilowatt-hour is also known, in this country, as the Board of Trade Unit (B.O.T.U.).

Wirewound Resistors

After our necessary diversion with power we may now return to the general question of resistance, carrying on in particular to practical resistors as are used for radio work.

[3] Some of the power applied to the loudspeaker and electric motor will be expended in the form of heat, partly because of the inevitable resistance of the conductors employed. Efficient design can maintain this wasted power at a low level.

Practical resistors may be divided into two general categories. These are wirewound resistors and resistors employing carbon. Carbon resistors may be manufactured in a number of different ways, and we shall deal with these after we have discussed the wirewound types.

Basically, a wirewound resistor comprises a former made of insulating material on which is wound a length of resistance wire in spiral form. See Fig. 9 (*a*). The ends of the wire are clamped to metal bands fitted round the tube, the latter being terminated in *tags* to which solder connections may be made, or in *lead-out wires*. (Fig. 9 (*b*).) Lead-out wires are normally made of tinned copper wire (i.e. copper wire with a thin outer layer of tin to prevent corrosion and facilitate soldering). The wire and former assembly is usually covered with an insulating protective coating. This may be a bulky "cement", or a relatively thin coat of varnish. One or more *taps* may also be made into the resistor, as shown in Fig. 9 (*c*).

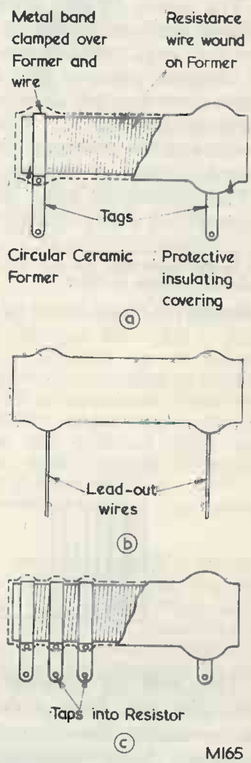


Fig. 9 (a). The construction of a typical wirewound resistor

(b). Lead-out wires may be employed instead of tags

(c). Taps may be made into a wirewound resistor, as shown here

The power expended in a resistor is converted to heat, the amount of power the resistor is called upon to handle being dictated by the circuit into which it connects. If a resistor has to handle a significant degree of power it is necessary to allow at least part of the heat generated inside it to escape; otherwise its temperature may rise to an excessive level and cause an undesirable shift in its resistance, a burn-out in the resistance material, or damage to the insulating materials employed in its construction. The most convenient method of cooling a resistor is by radiation of heat from its surface and by convection currents in the air which surrounds it.[4] Both these methods of cooling take place from the surface of the resistor; with the consequence that the greater the surface area of the resistor the greater the power it can dissipate.

Wirewound resistors can be manufactured economically with much larger surface areas than carbon resistors. They may also operate at higher temperatures than carbon resistors without risk of resistance value shift or burn-out. As a result, wirewound resistors are almost inevitably employed when high powers have to be dissipated.

The usual former material for the typical wirewound resistor shown in Fig. 9 (*a*) is ceramic, and the insulated coating may consist of a fired ceramic or vitreous paste or of a silicone-bonded resin. All these coverings are capable of withstanding temperatures around 250° C. Where lower temperatures are envisaged the covering may be given by a moulded phenolic resin or similar plastics material.[5]

The resistance wires employed with wirewound resistors are also chosen for optimum characteristics (mainly with regard to shift in resistance value) within the temperature range envisaged.

TABLE 2

Wirewound resistor wattage rating	Typical overall dimensions of resistor (excluding tags or lead-out wires)	
	Diameter	Length
4	0.5in	0.65in
8	0.5in	1.4in
10	0.7in	1.4in
20	0.75in	2.2in
40	1in	3.75in

Table II illustrates typical wattage ratings and dimensions for wirewound resistors employing the construction of Fig. 9 (*a*), these applying when the resistor is operated in free air. If the resistor were completely or partly enclosed, or if the ingress of cooling air were limited, the wattage ratings given in the table would have to be reduced.

Next Month

In next month's issue we shall conclude our discussion on wirewound resistors, and carry on to carbon resistors.

[4] In the latter case the hot air around the resistor rises, allowing cooler air to take its place.

[5] Bakelite is a typical, indeed the original, phenolic resin.

COMPACTRONS

by

P. T. VARNEY

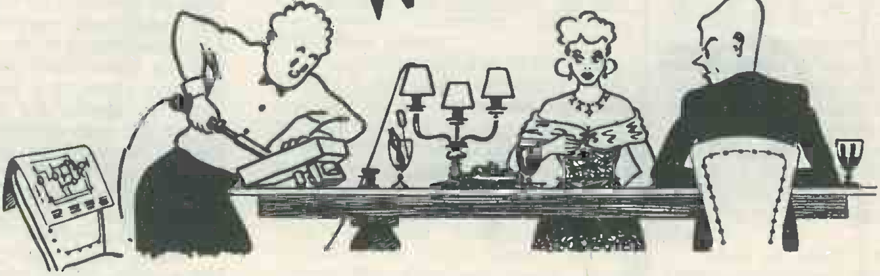
The idea of putting two valves in the same envelope has been widely employed in the past, but recently the General Electric Company of America have considerably extended the idea by including up to four valves in the same glass envelope. These valves will, for obvious reasons, be know as "compactrons".

The first two valves of the series are mainly intended for use in domestic superhets, although may other uses will certainly be found for them. These two valves will enable the ordinary "four plus one" superhet circuit to be constructed using only two valves—the power rectifier being incorporated in one of the valves! The first of the valves will be used as a converter and i.f. amplifier; it contains two sections which are roughly equivalent to a 12BE6 and a 12BA6 in the same envelope. The second valve will be used as a detector (diode), audio amplifier (high μ triode), power output (tetrode) and h.t. rectifier.

The valves will be of a similar design to the present miniature types, but will have bulbs of somewhat larger diameter in order to accommodate the various sections. The height is expected to vary between about 1 in. and 2¾ in., according to type. A special 12 pin base is used in order to provide the necessary number of connections to the various sections of the valve. The pins are in a ¾in diameter circle protruding from a glass base of about 1⅛in diameter.

At the moment the valves are being developed mainly for domestic radio and television equipment, but the manufacturers are making plans for designing and producing up to about a hundred types of compactrons for all kinds of uses. It is expected that the price of each compactron will be about twenty per cent lower than the total price of the conventional valves which it can replace.

IN YOUR WORKSHOP



This month, Smithy the Serviceman, aided by his able assistant Dick, investigates a mysterious line output stage fault. He also discusses noise limiting circuits and the new Mullard PC97 tuner unit triode.

"ON ITS OWN, KELLY'S EYE!" The muttered words were just audible across the Workshop.

"Shiny Ten, Downing Street!"

Puzzled, Smithy the Serviceman put down his soldering iron.

"Legs, Eee-*leven*!"

Smithy turned round and his perplexed expression deepened. His assistant seemed to be entirely engrossed in the television chassis on his bench.

"One and Two, just a doz!"

There was silence for a moment.

"Oh yes, I forgot that one. On its own, the Temperance Seven!"

Smithy looked more closely at his assistant. The latter, having just taken a voltage reading in his receiver, turned round and caught the full intensity of Smithy's scrutiny.

Poor E.H.T. Regulation

"Is everything O.K.?" asked Dick, slightly alarmed at Smithy's expression.

Smithy was disconcerted at the complete lack of concealment in his assistant's youthful and innocent face, and he momentarily forgot the question he had prepared.

"It was funny you should look round then, anyway," continued Dick artlessly, "because I was just about to tell you how I've successfully traced rather a queer snag."

As always, Smithy was hooked by the mention of a peculiar fault.

"Oh yes," he said, the phenomenon which had previously caused him to turn round slipping from his mind, "what was it?"

"Well," replied Dick, "to start at the beginning, this set came in with insufficient height and a bad case of 'blooming'. The vertical scan was reasonably linear, so I left the frame timebase alone for the time being."

"Fair enough," commented Smithy. "Incidentally, by 'blooming' I suppose you mean the effect given when the picture expands in size as you increase brilliance?"

"That's right," said Dick. "In this case I could get a fairly dim picture resolved which looked quite O.K., apart from the lack of vertical height. But when I turned the brilliance up to a normal setting the picture 'bloomed' out like billy-oh. If I turned the brilliance control further the picture faded out completely, and I had to turn the control right back and wait for a few moments before I could even get back to the dim picture."

"It seems a fairly classic case of line output stage trouble," said Smithy. "The 'blooming' effect is due, of course, to poor e.h.t. regulation. As you increase brilliance you increase the e.h.t. current drawn by the tube. The poorly regulated e.h.t. voltage then goes down, giving you the effect of the picture expanding."

"I've never," interjected Dick, "quite understood exactly why the picture expanding business takes place."

"What happens," explained Smithy, "is that when e.h.t. drops there is a reduction in the velocity of the electrons travelling to the final anode. In consequence, these electrons spend a longer time in the field given by the deflector yoke and, therefore, suffer greater deflection. So your picture 'blooms' out."

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

"Fair enough," said Smithy. "Now let's get back to the line output stage. (Fig. 1 (*a*)). You had a second effect in which, after you had advanced the brilliance control, the picture faded out completely and you had to wait several moments with the brilliance turned fully back before it reappeared. That second effect was almost certainly due to the fact that the heater of the e.h.t. rectifier was only getting sufficient power from the line output transformer to just warm up to emitting temperature in the first place. When the line output transformer was loaded by increasing the brilliance, the power available for the e.h.t. rectifier heater dropped. It went below emitting temperature and you lost your e.h.t. The delay before e.h.t. reappeared was needed to allow the rectifier to heat up again."

"I thought, myself, that something like that was happening," said Dick.

"You were quite right then," replied Smithy. "A minor point to bear in mind, when both e.h.t. voltage and e.h.t. rectifier heater power suffer from bad regulation, is that this means that both the e.h.t. circuit and rectifier heater circuit are receiving insuffcent power from a *common source*. You can, then, fairly safely forget about poor e.h.t. regulation occurring in the e.h.t. circuit only."

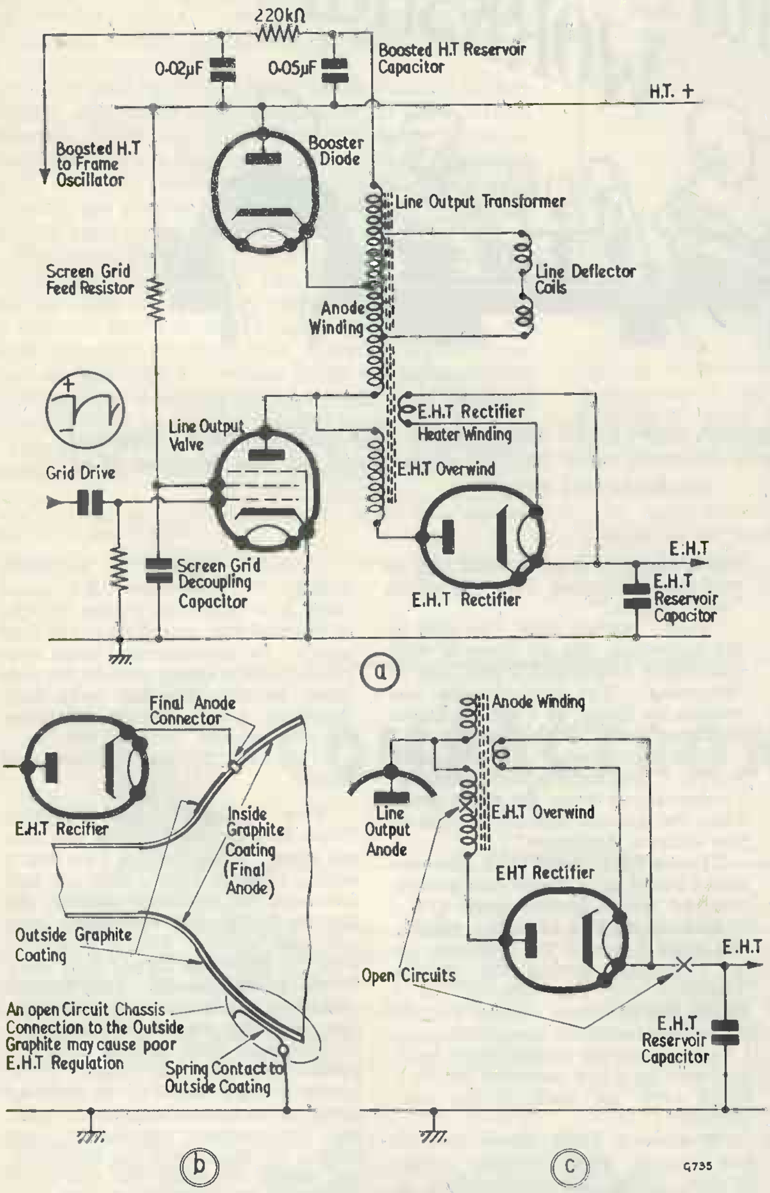


Fig. 1 (a). The basic line output circuit employed in Dick's television receiver. The capacitors and resistor in the boosted h.t. circuit are given typical values

(b). The e.h.t. reservoir capacitor of (a) will, in practice, be formed by inside and outside graphite coatings on the cathode ray tube. If the chassis contact to the outside coating is open-circuit, poor e.h.t. regulation may result

(c). Poor e.h.t. regulation may also result if an open-circuit appears in the e.h.t. circuit, as in either of the two examples shown here. A spark bridges the gap for a period until the open-circuit points finally burn away

"What would cause poor regulation in the e.h.t. circuit?"

"There aren't many things," admitted Smithy. "A low e.h.t. reservoir capacitance due to bad earthing of the outside graphite on the tube could conceivably do it, (Fig. 1 (*b*)), although this fault doesn't always cause excessive 'blooming'. You may occasionally have an open-circuit in the line output transformer overwind, or in the e.h.t. connection to the tube, (Fig. 1 (*c*)). A spark can bridge the gap here and allow e.h.t. with poor regulation to appear for quite a while before the open-circuit finally burns away. Anyway, in this particular case, we don't need to worry about things of this nature because of the common fault which has also reduced rectifier heater power."

"Seeing that I had the slow rectifier warm-up effect," broke in Dick, "the first thing I did was to change this valve."

Smithy looked a little puzzled.

"There's no harm in changing the rectifier," he commented, "but I don't quite see the logic of doing so."

"I did it," said Dick, "because I thought that, if the rectifier cathode were only *just* hot enough to emit, this could be due to a fault in either the cathode or the filament. The rectifier could then insert quite a lot of resistance into the e.h.t. circuit on its own."

"Ah, I see," said Smithy, light breaking in. "Anyway, there's no harm in changing it, and you might have been lucky. My own experience with valve e.h.t. rectifiers is that they're either 'on' or they're 'off', as it were, and you don't get the case where they insert the few odd megohms needed to cause 'blooming'. *Did* changing the rectifier clear the snag?"

"No," admitted Dick. "I next swapped the line output valve and the booster diode, but there was no joy here, either. After that I took a few voltage measurements. The h.t. applied to the anode of the booster diode was 195 volts, so I assumed that the circuit had enough h.t. to work with. I then checked the boosted h.t. voltage, and I found that this was only 250 volts above chassis at the boost reservoir capacitor, instead of the usual 500 or 600 volts. So that's it!"

"What's it?"

"The fault, of course," said Dick impatiently.

"But what *is* the fault?"

"Why the line output transformer! If you aren't getting enough boost volts it's obvious that the line output tranny is up the wall and needs replacing."

Low Boost Voltage

Smithy sighed and sat down.

"Dear, oh dear me," he said, "will you *never* get rid of that line output transformer complex of yours? Just because you've swapped a couple of bottles and taken two voltage measurements you immediately jump to condemning the line output transformer. Anyone would think you *enjoy* changing line output transformers!"

"Well, *couldn't* it be the cause of the trouble here?"

"Of course it could! But there are several other things a darned sight simpler to replace than the line output transformer and they could just as easily cause the fault. For instance, the screen-grid feed resistor to the line output valve could have gone high. Again, if the screen-grid has a bypass capacitor this could have gone leaky or open-circuit."

"Wait a minute," broke in Dick, "I can understand a leaky screen-grid capacitor causing trouble, because it would reduce screen-grid voltage. But I don't see how an open-circuit capacitor could cause the fault as well."

"It can do with some circuits," replied Smithy. "You see, the screen-grid bypass capacitor allows the screen-grid to retain a high potential during the latter part of the scan when the valve passes most current. You would, in fact, be surprised at the loss in line output power that results in some sets if this capacitor goes open-circuit. Another snag which could cause the trouble is insufficient drive to the line output grid, although this would normally also play tricks with horizontal linearity. Any components connected across sections of the line output transformer anode winding, such as capacitors or width or linearity controls, can also cause the trouble although here again horizontal scanning in the reproduced picture would probably suffer as well. Finally, there is the possibility of trouble in the boost reservoir capacitor."

"Well, it isn't leaky," remarked Dick defensively, "because I checked for that after I found the boost h.t. voltage was low."

"Then perhaps the capacitors' gone open or low value. The boosted h.t. reservoir capacitor is a very busy component. you know, and it suffers more electrical strain than most of the other paper capacitors in the set."

Smithy's last words were lost, because Dick had already rushed to the spares cupboard. He quickly found a replacement component and soldered it into circuit in place of the boost capacitor previously fitted. Hopefully, he switched on the receiver and waited for it to warm up.

The screen came to life and exhibited a comfortably bright picture with considerable vertical overscan. Dick adjusted the brilliance control and was pleased to see that the previous "blooming" effect was completely absent.

"That's cleared the e.h.t. snag. Smithy," he said, exultantly. "All I've got to do now is to get the vertical circuits working properly. Where previously I had vertical underscan I now have vertical overscan."

"There's a knob at the back for that," chuckled Smithy. "If you'd looked a bit more closely at the circuit for this set you'd have noticed that the frame oscillator gets its h.t. from the boosted h.t. line. When the boosted h.t. voltage was low someone must have turned the height up to overcome it. All you've got to do now is to turn it down again!"

Dick had the grace to look slightly abashed, and Smithy returned to his bench.

Tuner Triode

It was about half an hour later (after Dick had returned his repaired television receiver to the rack and had successfully treated another) that the muttering commenced again.

"One and Three, unlucky for some!"

Smithy paused and listened expectantly.

"Two-Oh, blind twenty!"

There it was again.

"Two and One, key of the door!"

Smithy turned quietly.

"All the Twos, dinkey-doo!"

As had occurred previously, his assistant appeared to be completely absorbed in his work.

"Two and Six, bed and breakfast!"

By looking very carefully, Smithy was just able to make out the movement of his assistant's lips.

"Three-Oh, blind thirty!"

"*House*!" yelled out Smithy.

The effect on Dick was galvanic. He suddenly lost his balance and fell sideways off his stool, the screwdriver he had held in his right hand describing a graceful parabola in the air. At the same time his feet became entangled with his soldering iron cord, causing the iron to trace out an arc of a circle whose radius was the free length of lead from Dick's legs. Smithy avoided the iron nimbly as it flashed past him, noting simultaneously that a crash from the vicinity of the sink indicated that the flying screwdriver had reduced the meagre Workshop stock of cups by one. He was, however, too late to avoid Dick's stool, which toppled neatly over on to his left foot, the seat edge falling precisely on his instep.

Smithy's roar of anguish caused Dick to look up from his prone position on the floor, whereupon he thoughtfully devoted his attention to the spectacle of the dancing Serviceman. After some moments he was distracted by a smell of burning. He got up to retrieve the soldering iron. which was by now almost lost in a cloud of vapourised linoleum. Dick quietly put his stool into its correct position by his bench, and sat down on it.

"What on earth," he asked eventually, "possessed you to do *that*?"

Smithy was, for once, completely at a loss.

"Do what?" he gasped weakly.

"Yell out at me like that. I nearly shot out of my skin!"

"It's your own fault," retorted Smithy, recovering himself. "You shouldn't have kept muttering Tombola numbers all the time.

"Tombola?"

"Housey."

"Oh, you mean *Bingo*!'

Grunting in affirmation, the Serviceman aggrievedly took off his left shoe and sock, and very carefully inspected his foot for injury. There was not the slighest evidence of abrasion, of bruising, or of any other damage whatsoever.

"I don't *think* there are any bones broken," Smithy remarked eventually, in a relieved tone of voice.

His thoughts returned to his assistant.

"Anyway, what *was* the idea of saying those numbers all the time?"

A gleam of pride eame into Dick's eyes.

"I was practising," he said, grandly. "You may not know it, but I'm the new official number-caller for the Bingo Club at 'La Vie Bohème'."

"Where?"

" 'La Vie Bohème'. You know, Joe's Caff."

"I thought it was 'El Picador' since he got the bamboo wallpaper up."

"He put a Formica top on the counter last week," explained Dick, "so he's changed it again. He always changes the name when he gets something new in."

Smithy absorbed this news quietly, and a thought struck him.

"What happened to the previous official number-caller?" he remarked.

Dick looked a little uncomfortable.

"Well, there *was* a bit of a punch-up," he remarked, "You see, he got Number Six upside down and called Doctor's Orders during the Snowball House. Nobody's seen him since."

Smithy chuckled.

"It sounds a dicey occupation," he grinned, "and I should watch it, if I were you. Anyway, it's about time we got back to the grind."

"I suppose so," replied Dick. "Incidentally, have you seen this new t.v. set I've got here? It doesn't use a cascode in the tuner input stage at all—just a single triode,"

"Ah yes," said Smithy. "That'll be the new Mullard PC97."

"You don't sound very surprised," commented Dick aggrievedly.

"I'm not," replied Smithy. "For one thing, triode input stages have been used in the States over at least the last three years."

"I didn't know that," said Dick. "Anyway, how can you get a triode to amplify at v.h.f.? Surely, it would oscillate like the clappers!"

"Not if you neutralise it," said Smithy. "Although, even then, you want to design the valve so that the capacitance between grid and anode is as low as possible. With a conventional cascode like the PCC89 the capacitance between anode and grid of the earthed-cathode triode is of the order of 1.9pF whilst that of the earthed-grid triode is approximately 4.1pF. (Fig. 2 (*a*)). The Mullard PC97 has a much lower

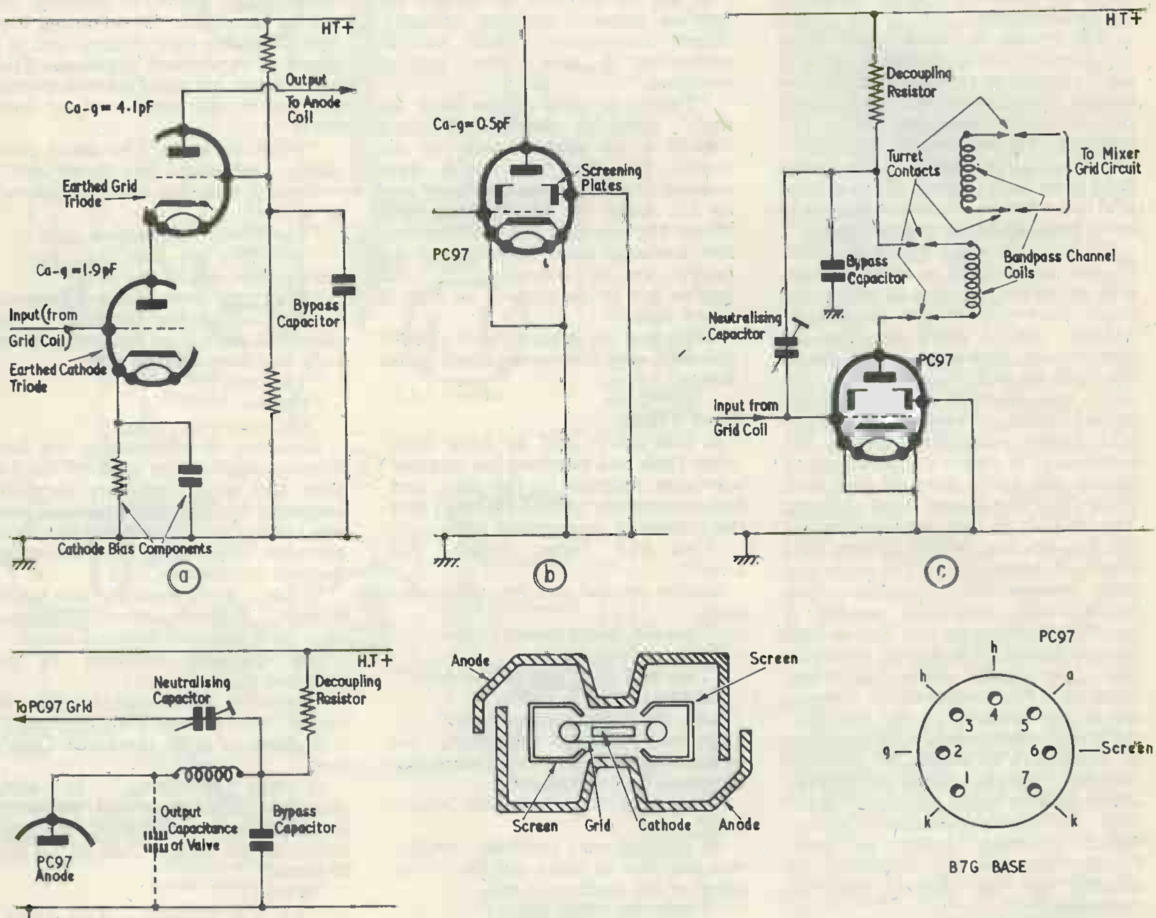


Fig. 2 (a). The basic cascode tuner unit amplifier. The grid of the upper triode is normally held at approximately half the full h.t. potential. The anode-grid capacitances quoted are those for the PCC89

(b). The anode-grid capacitance of the Mullard PC97 is maintained at the very low level of 0.5pF

(c). Neutralising the PC97 by coupling the remote end of the anode coil to the grid via a neutralising capacitor. The bypass capacitor has a relatively low value, a typical figure being 100pF. The decoupling resistor may be 1 to 5kΩ, and the neutralising capacitor have a range of some 2 to 12pF

(d). The anode circuit of the PCC97 can be represented as a pi tuned circuit

(e). The internal structure of the PC97, showing the effect of the screening plates. The special shape of the anode also contributes towards the low anode-grid capacitance

(f). The pin layout of the PC97. Two cathode pins are available

capacitance between grid and anode, this being around 0.5pF only."(Fig. 2 (*b*)).

"I see," said Dick, musingly. "Of course, with the cascode the lower, earthed-cathode, triode works into the low cathode impedance of the upper triode. This low impedance should keep voltage gain in the lower triode down, in any case, and thus help in preventing oscillation."

"That's pretty near it," said Smithy, "although you do in practice neutralise the lower triode of a cascode."

But Dick was pursuing his ideas in his own way.

"And, of course, there's no risk of feedback in the upper triode," he continued, "because the earthed grid comes between cathode and anode."

"W. G. Morley," remarked Smithy encouragingly, "could not have put it more succinctly."

"Do you really think so?" exclaimed Dick, forgetting his train of thought.

"Definitely."

"Well, I suppose I am a bit of a gen kiddy at times," said Dick modestly. "I *do* know, you know."

"I'm quite certain you do," replied Smithy soothingly. "Anyway, let's get back to the PC97. As you have just, in your masterful manner, explained, the basic make-up of the cascode assists towards stability. The very low anode-grid capacitance of the PC97 also assists towards stability, because, amongst other things, it makes neutralising requirements much less critical."

"How *do* you neutralise it, Smithy?"

"By getting a neutralising voltage," replied Smithy, "from the h.t. end of its anode coil." (Fig. 2 (*c*)).

"But that point's decoupled to chassis!" protested Dick.

"Not by all that much it isn't," said Smithy somewhat inelegantly, "because you use a decoupling capacitor having a lowish value around 100pF. This lowish value brings you back to the old pi tuned circuit (Fig. 2 (*d*)) in which the coil is really tuned by the decoupling capacitor and the output capacitance of the triode in series. The r.f. voltage on the end of the coil remote from anode will be 180° out of phase with that at the anode itself, and so you've got a nice little bit of neutralising voltage all ready for feeding back, via a capacitive trimmer, to the grid. Since the value of the decoupling capacitor is fairly low, enough r.f. appears across it for neutralising purposes."

"It's very neat, isn't it?" commented Dick. "One thing I notice is the extreme simplicity of the circuit around the triode as compared with the usual cascode arrangement."

"That's a considerable advantage of the triode," said Smithy, "and it makes tuner unit design simpler and cheaper. You will usually find, incidentally, that the bypass capacitor for the anode coil is of the feedthrough variety, this being done to keep inductance in this part of the circuit down to a minimum. I should add also that, in practical tuners, adjustment of the neutralising trimmer will not normally be done by the likes of us; it will, instead, be carried out at the factory with special test equipment."

"How is the capacitance between grid and anode brought down to a value as low as 0.5pF?"

"By putting C-shaped screening plates around the two backbones of the grid," said Smithy, "that is, the two thick vertical wires which support the grid wires. (Fig. 2 (*e*)). Although these plates kill the relatively high capacitance between the backbones and the anode they still leave free access from the working areas of the grid to the anode. The screening plates come out to a separate pin which may then be connected to chassis."

"This all seems very knobby," said Dick approvingly. "Any other points?"

"Oh yes," said Smithy. "The PC97 has got a frame grid, with all the advantages that *that* confers. And the cathode comes out at two pins (Fig. 2 (*f*)), which reduces cathode lead inductance."

"Won't the gain of a single triode be lower than that of a cascode?"

"It may be a little lower," said Smithy, "but that doesn't necessarily matter, because you can pick up the lost gain very easily in the i.f. strip anyway. The limiting factor to receiver sensitivity is *noise-factor*, and the noise factor of a tuner input stage using a PC97 is of the same order as that of a cascode stage."

"Well, the PC97 certainly seems to be a welcome introduction as far as I'm concerned," commented Dick. "If only because it may simplify tuner circuits and make servicing easier!"

"I'm quite certain you're right there," commented Smithy, looking at the clock. "Anyway, it's about time we got back to work again."

Interference Limiter

Obligingly, Dick returned to his bench and peace descended on the Workshop once more.

But not for long.

"Three-Oh, blind thirty!"

Dick was taking up again where he had left off.

"All the Threes, feathers!"

Smithy started. He'd forgotten that one. A poignant and long-forgotten scene of wartime canteen Housey schools filled his mind, and he sat down dreamily for a moment.

"Five and Seven, Heinz Varieties!"

"Wait a minute," called out Smithy. "You've forgotten one."

Dick looked round.

"Which one is that?" he asked.

"Four and Five," said Smithy, "Half-Way!"

"I haven't heard that one before," admitted Dick. "I'll have to remember it for the next session. Anyway, there aren't many out-of-the-ordinary nembers after thirty-three. There's All the Sixes, clicketty-click. After which you get All the Sevens."

"I know that one," said Smithy proudly. "All the Sevens, walking sticks!"

Dick glanced at him in surprise.

"Walking sticks?"

"That's right; the sevens look like walking sticks."

Smithy's assistant pondered.

"I don't think much of that one," he pronounced eventually. "It's dead corny."

"All right then," said Smithy irritably, "What's your version?"

"All the Sevens," replied Dick firmly, "Sunset Strip!"

Smithy looked blank.

"I'm completely lost there," he remarked, after a moment. "You'll have to explain it to me."

However Dick knew that, with Smithy, such explanations tended to become involved, and he decided to change the subject.

"Let me first complete this t.v. chassis," he said, craftily. "It shouldn't take long; all that's wrong with it is weak and distorted sound."

"Oh yes," said Smithy, rising once more to the bait. "Have you checked back to the grid of the voltage amplifier triode?"

"I have," replied Dick, "and it gives a good fat hum when I touch it. So the triode and output pentode should be in pretty good trim."

"Try the sound interference limiter diode," said Smithy. "See what voltage it has on it with reference to chassis."

Obediently, Dick located the interference limiting diode (Fig. 3 (*a*)) and checked the voltage on both its anode and cathode.

"There ain't any volts," he pronounced shortly.

"Fair enough," said Smithy. "Then it's pretty certain that the resistor between h.t. positive and the diode anode has gone open. Very common fault, that."

"Yes, I've met it before," said

Dick equably. "Incidentally, I've never quite been certain how these sound interference limiter circuits work."

"It's easy enough, really," said Smithy. "Normally, the diode is held in a conducting condition by reason of the current flowing through it from the h.t. supply via the resistors above and below it. In consequence, the a.f. applied to its anode appears on its cathode, and may then be passed on to the following a.f. stages. A capacitor is connected across the lower resistor and the combined time constant, when the diode is conducting, is sufficiently low to anable the diode cathode to 'follow' the a.f. voltages on the anode."

Smithy paused to light a cigarette.

"Now you will note," he continued, "that the sound detector is so connected that the rectified i.f. signal at the top of the detector load is negative-going. If an interference pulse is applied to the sound detector, the latter causes this to be rectified to a sharp-sided negative-going pulse. This pulse is applied to the anode of the noise limiter diode and makes it go negative, thereby causing the diode to stop conducting. The cathode of the diode cannot go negative as quickly as the anode during the pulse, because of the capacitor across the lower resistor. Therefore, no a.f. at all is applied to the a.f. stages for most of the duration of the pulse and the latter is, in consequence, limited."

"Very smart," remarked Dick. "And quite a simple little circuit, too."

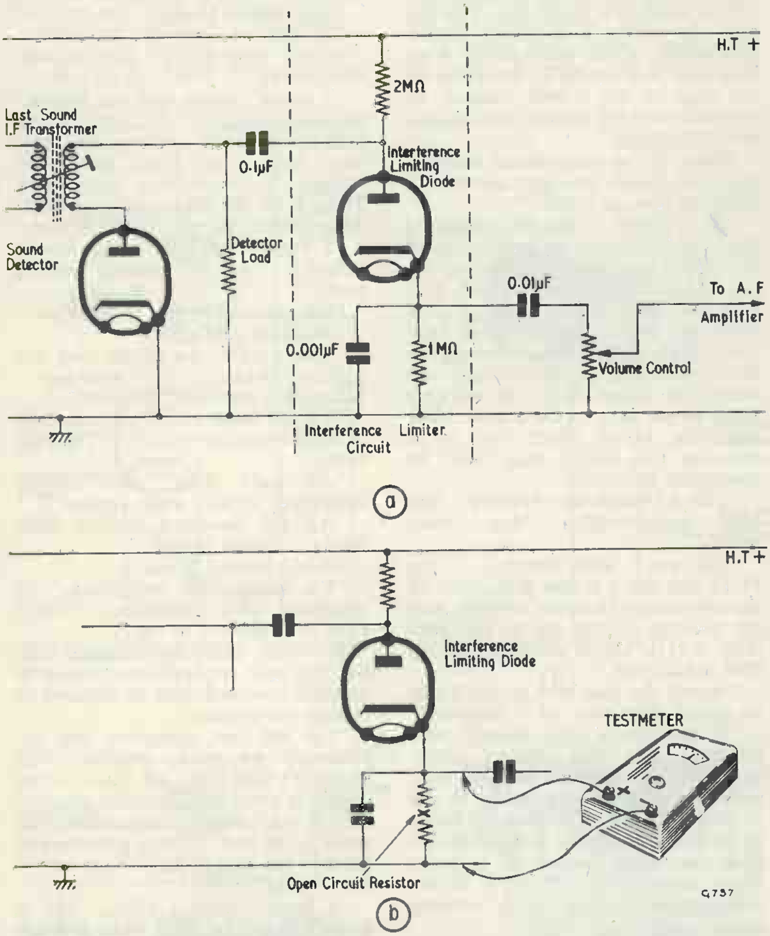


Fig. 3 (a). A typical sound interference limiting circuit with representative values where applicable. Thermionic diodes are shown for reasons of clarity. The sound detector circuit is meant to illustrate the polarity of the rectified signal only, and omits i.f. filter components after the diode (b). If the lower resistor of the pair in series with the interference limiting diode is open-circuit, a moving coil testmeter may not indicate this fact directly. However, applying the testmeter will cause current to flow through the diode and sound to be reproduced by the receiver at normal, or nearly normal, level

"It's an effective one as well," said Smithy, "and you'll find it used in a very high percentage of the television receivers you service, the diode being either a thermionic valve or a crystal diode according to make and model. The resistors in series with the diode require high values, and these may lie between 0.5 and 10MΩ. It's a common fault for one of these resistors to go open, whereupon the sound becomes weak and distorted, as occurred with your set. Most frequently, it's the top resistor which goes faulty because this normally has the higher value of the two."

"I knew it was the top resistor in my case,'" said Dick thoughtfully, "since there was no voltage on the diode. However, if it had been the bottom one I might have been led up the garden, because my meter would still have given me a voltage reading on the diode which was lower than the h.t. voltage. The drop would be caused by the meter current drawn through the top resistor, but it might well have made me think the circuit was O.K."

"That's true enough," said Smithy, "and it might be advisable to finally check between the h.t. positive line and the diode if you wanted to be absolutely sure. In practice, however, you would almost certainly find that the act of connecting the meter across the open-circuit lower resistor (Fig. 3 (*b*)) would bring back the sound at full, or nearly full, level, because the meter would draw current through the diode once more. The fact that sound returned would tell you that there was something very queer with the lower resistor."

"You're assuming the use of a moving-coil meter here, aren't you?"

"Oh yes," said the serviceman, "A very high resistance valve voltmeter probably wouldn't, for instance, draw enough current through the diode to make it work properly. At the same time, such a meter would tell you that the diode was very nearly at h.t. potential, so you would know where the fault was anyway."

"Yes, of course," said Dick. "I hadn't thought of that."

The Last Word

He looked round the Workshop, noting the large quantity of successfully repaired receivers stored neatly on the racks.

"Do you know, Smithy," he continued, "I think we've done jolly well today. I reckon we can describe ourselves as representing the apex of this establishment!"

"Apex of the establishment?" said Smithy, puzzled. "I don't get it."

"What I mean," grinned Dick, "is that we're Nine-Oh, Top of the Shop!"

Acknowledgement Fig. 2(e) is taken from *New Product Information—PC97* published by Mullard Limited.

INCREDUCTORS

by

J. B. DANCE, M.Sc.

THE INCREDUCTOR IS A NAME GIVEN TO A COMPARAtively new type of inductance designed in America, the inductance value of which can be altered by changing the magnitude of a direct current passing through one of the windings. Increductors are small devices, comparable in size with the smallest a.f. transformers and are manufactured by C.G.S. laboratories, Inc. of Wilton, Connecticut.

One type of increductor consists of two windings on a toroidal ferrite core. One of these windings is used in the signal circuit and the other is the control winding. Direct current is passed through the latter and produces magnetic flux in the toroidal core, thereby changing the incremental permeability of the material of the core. The inductance of the windings will also be altered, as it is proportional to the incremental permeability of the core material.

Increductors have obvious uses in sweep circuits. For example, if a sawtooth current waveform is passed through the control winding of an increductor, the signal winding of which forms part of the resonant circuit of an oscillator, the oscillator frequency can be made to sweep repeatedly over quite a wide frequency range. Thus the increductor is a very useful component in panoramic work.

A third winding known as the bias winding may be used in addition to the signal and control windings; it enables a desired mean value of inductance to be obtained around which the instantaneous value can be varied by passing an alternating current through the control winding. Increductors with three windings are also useful when the signal circuit is to be controlled by two independent quantities. It is possible, further, to obtain the required control of inductance by moving the pole of a permanent magnet towards the toroidal core.

Inductance Range

The inductance of the signal winding when no control current flows through the control winding is known as the starting inductance. Practical increductors with starting inductances varying from about 0.01 mH to 10 H have been made. These components can be used at frequencies varying from d.c. to about 500 Mc/s.

The "inductance change ratio" is an important parameter in increductor design. It is the ratio of the maximum to minimum signal winding inductance as the direct current in the control winding increases from zero until the core is saturated. Maximum to minimum inductance ratios of 400 to 1 have been obtained using increductors for audio frequency work, whilst ratios of 3 to 1 have been obtained in components suitable for use at 300 Mc/s.

Q Factor

The Q factor of increductors is important. At low audio frequencies the Q may be 80 to 120, but rises to about 250 with frequency, eventually dropping to about 5 at 500 Mc/s. If the signal input is large, the Q may be reduced below the value for a small signal owing to the flux produced in the core by the current flowing in the signal winding.

The control power required varies from about 1/100 watt to 10 watts. The increductor control winding should preferably be fed from a "constant current source", as it is a current controlled device.

Control currents can be used to change the inductance of certain types from 100 mH to 100 H, whilst some types can handle 100 watts at 150 Mc/s. The temperature coefficient of inductance is usually between 0.01 and 0.02% per degree Centigrade. The signal windings have a capacitance of about 50 to 100 pF at audio frequencies and about 1 pF at v.h.f. response speeds in the microsecond region have been obtained.

The control winding resistance may be 100Ω to 2kΩ for control currents of about 10 to 200 mA, but it is always possible to reduce the number of turns and increase the control current providing that the number of ampere turns is maintained.

A typical American type is being produced under the type number 6XBK4 at $13.60 (about £5) and can be used from 3.7 to 216 Mc/s.

One can only wonder whether, in the future, radio receivers (or even transmitters) will be tuned by means of a potentiometer, the resistance of which controls the inductance of increductors in the tuned circuits.

NEWS AND COMMENT . . .

Computers

Most of us probably heard in our schooldays the statement that if a dozen monkeys sat at typewriters hitting the keys indiscriminately everyday for so many billion years they would, at some point in that time, produce a complete Bible. The Royal Air Force to illustrate the tremendous operating speed of an electronic computer they are to install, say that it could read and record every word in the Bible in under four minutes!

The computer will be at the famous Hendon Station which is to become a Computer Centre and the focal point of the world-wide R.A.F. supply network. The Centre will have a formidable task as it will have to deal with more than 700,000 different items ranging from "V"-bomber mainplanes to split pins situated in all parts of the world; as it can handle 4,000 messages an hour it will no doubt fulfill its task. The human element will not however be missing as a staff of 200 will be required, largely for the purpose of running the ancillary equipment and maintaining communication links with every station and depot in the Royal Air Force at home and overseas.

All the above may seem rather far removed from the applications of electronics as represented by the articles in this magazine, but it has always interested us that however advanced radio scientists may become they still maintain an interest in publications such as this. We were very amused a year or two ago when a leading British pioneer radio scientist complained to us that his copy of the "Constructor" kept disappearring from his desk—having been borrowed by his associates!

Transistors in Cars

This is not another reference to the misuse of radios in public places, but to a further possible extension of the use of transistors.

The Delco-Remy Division of General Motors Corporation in the U.S.A. is at present testing a partly transistorised ignition system that eliminates the capacitor and contact points in an otherwise conventional set up. With no points to wear out relatively quickly, the transistorised ignition system should greatly reduce the time required for maintenance.

It is thought that motor cars may become a major user of these tiny devices.

Radio Shows

Some eyebrows were raised last year when it was first announced that a section of the National Radio Show would be allocated to piano makers. At the German radio exhibitions they apparently go much further in the direction of "sideshows". Dance competitions, beauty contests, fashion shows, popular concerts, sporting and gymnastic displays, afternoon and evening dances, and even a giant firework display are considered quite appropriate.

It was noticeable at Earls Court that, apart from colour television, personalties and exhibits of general interest seemed to attract the public. After all, one piece of radio or television furniture is much like another, except for gold radio cabinets of course, and to the uninitiated the "innards" are just a wonderful mystery. The Metropolitan Police stand for example always seemed to attract attention, and a traffic policeman discussing the rules of the road automatically had an audience; very interesting but hardly radio.

Readers of this magazine would no doubt like to see more of a constructional nature exhibited—manufacturing processes, illustrated talks, and demonstrations and discussions on technical problems. We must however always remember that the primary purpose of the Show is to sell British radio manufactures throughout the year and the present style of exhibition is possibly the most suitable for this purpose.

B.B.C. T.V. Promotions

A lesser known aspect of B.B.C. activities is the sale of t.v. programmes to networks in other countries. A special department having the above designation was formed in March 1960 and in its first year sold more than 1200 programmes to over 50 countries, and the number sold increases each month.

The programmes are of all types, drama, outside broadcasts, light entertainment, talks, schools and childrens programmes and sporting events. They have included "Face to Face", "Spycatcher", "Andy Pandy", "Lifeline", "An Age of Kings", "Hancocks Half Hour" and "Whacko".

The General Manager is Ronald Waldman who says that the Sales Section has exerted an influence on world television far greater than its size would lead one to expect.

Quotation

"Children enjoy seeing cowboys shooting each other in Westerns because they simply don't believe it". "What they fear is insecurity. If they see other children or even small animals ill-treated or abandoned on the screen, it really does upset them. This is a point that is sometimes overlooked"—Lord Boothby during the course of his address at the opening of the National Radio Show at Earls Court.

In Brief

● The Plessey Company, The Automatic Telephone & Electric Company and Ericsson Telephones recently announced that they had been considering the benefits that would come from pooling their interests in the communications field. As a result, proposals for a merger of the three companies are being put to their respective shareholders.

The Plessey Company recently acquired the Philco Corporation holding in Semiconductors Ltd. of Swindon. This company is now wholly owned by Plessey.

● Visitors to B.B.C. establishments will notice that the Commissionaires are wearing a freshly designed uniform which has the open-necked style much favoured by police forces and other uniformed organizations nowadays.

● The British Sound Recording Association has a special whole day Audio Convention to mark its Silver Jubilee Year. The Convention will be held at the Institute of Electrical Engineers on Saturday 14th October commencing at 10 a.m. Several distinguished speakers will give talks on subjects of interest to sound recording enthusiasts.

Following the Convention there will be a Silver Jubilee Dinner at the Howard Hotel, Norfolk Street, Strand, for members only. At the Dinner Timothy Eckersley will give

(continued on page 224)

Radio Astronomy

PART 1

by

FRANK W. HYDE
F.R.S.A., F.R.A.S.

Space observation from the surface of the Earth has, over recent years, been greatly extended by the introduction of Radio Astronomy techniques. Radio Astronomy is still a very young science and, because of this, it offers especial scope for the imaginative amateur who will already be conversant with the basic electronic principles involved. This is, indeed, a field in which it fell to an amateur, Grote Reber, to produce the first Radio Telescope and thereby pave the way for all later research.

The article which follows is the first of an important series commissioned from the foremost amateur authority in this country. Our author, Frank W. Hyde, appeared recently in the B.B.C. television programme "The Sky at Night" and is scheduled to appear again in the future.—Editor.

THE PURPOSE OF THIS SERIES OF ARTICLES IS TO introduce the radio enthusiast to a new and exciting field of electronics. This field is called Radio Astronomy. It is the newest branch of the age-old science of astronomy representing as it does another step forward in man's endeavour to solve the mysteries of the environment in which he finds himself—the horizons are boundless.

The first astronomers had only their eyes as instruments of observation, yet though some of these observations are records from antiquity, it is a matter for admiration that they have been noted with both accuracy and method. Various instruments came into being, some were portable and some remain as monuments to astronomical work. Such a one is the Jai Singh observatory in India. This observatory, with its columns and staircases, its triangles and knomens, bears witness to the extensive efforts of astronomers in days gone by. Man was able to view the universe outside his world through the optical window, obscured though it was by the atmosphere. It is perhaps a little ironic that the very medium which makes life possible in the form known to man, should be the means of limiting his exploration of the universe from the earth. With the advent of the optical telescope this window became less obscured, it being opened a little wider and, with this new horizon, many old ideas had to be discarded in order to make way for the new ones derived from more accurate observation. In this world of optics the amateur played an important part. Indeed, astronomy is one of the sciences which owes so much to the efforts of amateurs that the history of astronomy abounds with names like Newton, Halley, Herschell, Lord Rosse and many others in this country and abroad. From the times of Galileo[1] much headway was made and, with the growth of industry and the development of optical engineering, larger and more versatile instruments added to our knowledge of our extra-terrestrial surroundings.

The heading illustration shows the author inside the observation shed. The instrument in use is a spectroscope.

A New Window

At the point in optical astronomy when the limits became more and more frustrating a new window was opened in the spectrum. This time it was some way removed from the optical window. Like so many new discoveries, this window was uncovered during investigations into problems quite unconnected with astronomy. Search was being made for the cause of interference on radio telephone links. This work, which began in the field laboratories of the Bell Telephone Company, was entrusted to Karl Jansky. He spent a considerable amount of time

[1] 1564–1642.—*Editor*.

seeking the causes for the interference on these networks. After much experimenting he built equipment and an aerial which was steerable. This he christened "The Merry-go-Round". It cannot be too greatly emphasised that the work carried out by Jansky ranks as one of the fundamental discoveries of science. The difficulties which arose and the problems which had to be solved in the frequency range of 10 Mc/s and upwards in those early days were quite formidable. Jansky began his work about 1930. In his now famous paper in which he reported the results of his work these words were used: "In conclusion, data have been presented which show the existence of electromagnetic waves in the earth's atmosphere which apparently come from a direction that is fixed in space. The data obtained give for the co-ordinates of this direction a right ascension of 18 hours and a declination of −10°." This was, of course, a part of the sky we know as the Milky Way.

After the presentation of his report he was transferred to other work and did not himself pursue the matter further. The discovery made headlines but was soon forgotten. However, another American, Grote Reber, was intrigued by Jansky's work and began his own investigations.

Reber was an amateur who, having covered all the Dx activities, was looking for new fields to conquer. His scientific training led him to attempt work at very high frequencies on the grounds that greater resolution was obtainable. This was true in theory, but the practice at that time was insufficiently advanced for him to make progress. Eventually, in 1937, he completed a 31-ft diameter dish and, working at 160 Mc/s, he was able to confirm Jansky's work. The intensity of the radiation at 160 Mc/s was considerably less than that which Jansky had found at 20 Mc/s. We now know that this is part of the normal spectrum and that generally the intensity falls with increase of frequency. Reber's dish was the first instrument to be called a Radio Telescope. Thus, for the first time, the seal of practice was placed on what was to become an ever-expanding field of research. Though the designation Radio Astronomy had not then been given to this field of endeavour, there were others working in it, both professional workers and amateurs in the communications field studying the effects of radio fade-outs. The activities of the sun and its effect on the earth's magnetic field enhanced atmospheric static and sudden increases in noise level at the time of solar flares. Strangely enough little attention was paid to the sun as the origin of these effects, the general opinion being that it was due to the changes in the condition of the ionosphere. This was true, of course, but was the secondary effect of the radiation from the sun. It was believed that the noise received originated in, or near, the E layer of the ionosphere. A number of workers had formulated ideas on the subject although there was little exchange of information, but among amateurs there was an active investigation in progress. The writer became seriously interested in extra-terrestial sources at this time, that is in the period between 1935–38.

It is interesting to note that another amateur, D. W. Heightman, in a review in *Wireless World* of amateur activities in 1937 records that he had experienced increased noise level which he attributed to charged particles from the sun arriving at his aerial. The first positive identification of electromagnetic waves from the sun was established by Southworth in America and Hey in England in 1942. During the war the rapid move forward of electronics made possible more efficient receivers and aerials. The technique of high frequencies rapidly developed, principally due to radar requirements, but little information could be circulated. Immediately after the war the new science of radio astronomy blossomed and grew extremely quickly. History will now record that this new window on to the universe, opened accidentally by Jansky in 1932 in America, was seized upon by scientists in England and Australia, for it was within the Commonwealth that the principal work in the years immediately after the war, was carried out. The impetus reached America and rapidly expanded there, also. A chronicle of that early work would take up too much space in these articles but reference will be made, from time to time, to particular aspects as equipment is described.

Radio Telescope Operation

When the words Radio Astronomy are used it generally follows that thoughts turn to the great 250-ft steerable parabola at Jodrell Bank. This is, of course, at the moment, the largest radio telescope of this type in the world. It is not, however, necessary for a radio telescope to follow this design. Indeed, there are as many variations in arrays as there are techniques. This, perhaps, is the right point at which to proceed to a simple explanation of the operation of a radio telescope.

It has already been stated that the new window through which we observe the universe is removed some distance in the electromagnetic spectrum from the optical window. In fact it covers the region from about 30,000 Mc/s or 1 centimetre wavelength to 10 Mc/s or 30 metres wavelength. In each part of this spectrum some particular aspect of extra-terrestial radiation may be studied. Generally speaking, however, those radiations falling in the region between 10 and 50 Mc/s are subject to very considerable modification by the ionosphere and are indeed studied for that reason. The first Russian satellite enabled much information to be obtained about the ionosphere by the use of the two frequencies of 20 Mc/s and 40 Mc/s. The writer's own recordings of the signals from that satellite at 40 Mc/s show very well the effects of the ionosphere, particularly absorption and the Faraday rotation; the complete set of these is being issued in a *Memoir on Earth Satellites*, published by the British Astronomical Association.

To understand the operation of a radio telescope a comparison with an optical telescope may be made. Using the reflecting telescope as the example, reference to Fig. 1 shows at (*a*) an optical arrangement and at (*b*) a radio arrangement. The optical telescope receives light waves which are reflected by the primary mirror to a secondary mirror or prism and thence to the eye-piece where the image may be examined. In the radio telescope the radiations are received at the reflector, collected by the aerial, passed to the receiver and thence to a recording device which may be an oscilloscope, a tape recorder or a pen recorder. The analogy is thus a very close one. In the optical telescope the mirror receives the energy as light, in the radio telescope the aerial receives the energy. The magnification of the optical telescope is determined by the ratio of the focal lengths of the eye-piece and the primary mirror. The magnification of the radio telescope is determined by the gain of the receiver. The optical telescope enables the image to be studied by means of an eye-piece; the radio telescope does this by a direct audio recording, or by observing an oscilloscope, or making a permanent record on a paper roll. The recorder is, therefore, the eye-piece of the radio telescope. The pen recording has the greatest advantage since it is a permanent record which can be stored. There are many instances where records have been subsequently examined in the light of new knowledge and facts confirmed. This will be dealt with in greater detail later.

It will be clear from the analogy of these two techniques, the optical and the radio, that there are the same opportunities for amateurs in radio astronomy as there were in optical work, for the radio enthusiast already has the know-how of electronics and communications. It will be apparent that the essentials of a radio telescope are (i) an aerial, (ii) a receiver, and (iii) a recording device. With this simple equipment some idea of what goes on in this new field can be obtained. The simplest of all the arrangements is the ordinary television set. Those who live in fringe areas will be all too familiar with the effects of solar outbursts. In June and July this year they were especially prominent. The outburst in June was, in fact, the cause of poor results from the writer's investigation this year of the occultation of the Crab Nebula at 27 Mc/s. After very strong outbursts, those who live in the north particularly will have observed the effects of the Aurora Borealis on the B.B.C. television channels. This takes the form of shadows, reminiscent of sound on vision, accompanied by rapid fading and a low rumbling sound somewhat like an Underground train approaching from a tunnel. It is not however necessary to wait for spectacular outbursts to apply this simple technique. All the normal channels will give opportunities to study extra-terrestrial radiation. If a channel is selected different from that of the local television transmitter, and provided the channel selected does not have a transmitter located to the south of the receiver, an aerial can be arranged so that as the sun crosses the meridian it passes through the beam of the aerial. When this happens an increase in the noise from the receiver will be noticed and also the "snow" on the screen will be increased. This will begin before transit of the sun and continue after for such a length of time as is determined by the beam width of the aerial. The familiar "H" of Band I, or the yagi of Band III arranged for horizontal polarisation will be a suitable aerial to use, and those who are more ambitious can stack them in order to get a narrower beam. If the assembly can be made steerable so much the better, for as the aerials are swung across the sun the rise in "noise" and "snow" will be more easily detected.

Growth of an Observatory

The writer began post-war activities with quite simple gear. Most of the equipment assembled together before the war had been lost or destroyed by enemy action. Work was begun again in a back garden with an assembly not dissimilar from that of Jansky in form. It consisted of a wooden framework some 6ft square with supports on two sides to hold a cross bar in position. On this bar were mounted three sets of yagi aerials, in pairs. Spacing between pairs was one-quarter wavelength, and the spacing between sets one wavelength. The whole group could be moved in declination and the whole frame rotated about a centre point by means of the wheels at each corner of the framework. It could be moved to any part of the garden because the centre pin was an old piece of 1in steam pipe just driven in the ground where convenient. It had to be moved quite often as there were complaints that it got in the way of the washing. From this simple beginning to the present site of 6½ acres is an example of the fascination which the field of radio astronomy can have. Though every amateur interested may not be able to expand to this extent, it must be made clear that it does not mean that he cannot contribute useful facts and make worthwhile observations. Indeed, the most useful work on the satellites was done with quite simple aerials. Later articles will contain details of these and also of two types of radio telescope specially designed by the writer for this series. They will be of such a size that the average back garden will accommodate them quite easily.

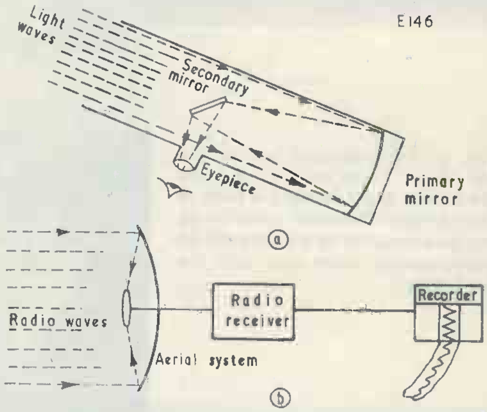


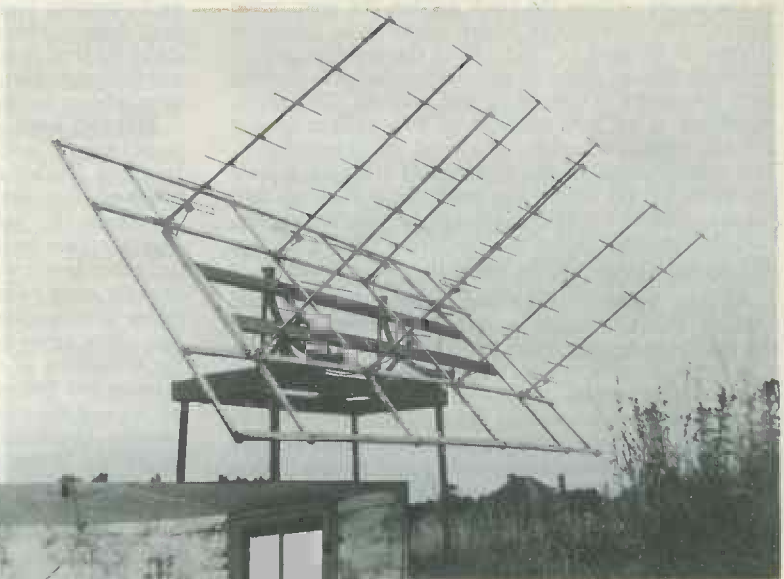
Fig. 1. (a) The reflecting telescope and (b) the radio telescope

To complete the picture, the history of the growth of the writer's observatory concludes this first part

The Martello tower from the entrance to the observatory

One of the steerable arrays for **240** *Mc/s. These are free to move in azimuth and altitude and may be used as two steerable units in an interferometer or as a triangulation interferometer when used with the fixed array*

The 9in Coude refractor which is used for planetary studies and also for solar work



The fixed array for 240 Mc/s. This is fixed in azimuth but steerable with respect to altitude. Used alone it constitutes a radiometer

A general view of the receivers and recorders. This is the "eyepiece" of the radio telescope

The western array of the 27 Mc/s interferometer. It is 75ft long, 27ft wide and 27ft high, being fixed in azimuth but steerable in altitude of the series. From the back garden the next move was to the workshop where there was about a quarter of an acre of land. Here the satellite aerials were established and also an interferometer operating on a frequency of 240 Mc/s was erected. The interferometer is an arrangement of two aerials spaced a finite distance apart measured in wavelengths. The combination of the outputs of the two aerials produces fringes within the main polar diagram and is analagous to the Michelson optical interferometer. Detailed description of the operation of this system and its variations will be given in later articles.

As time went on it became evident that a special field of interest would be the lower frequencies of the radio spectrum from 18 Mc/s to 35 Mc/s. It was for this reason that the site on some derelict marshes was rented. Aerials were set up in this case some 1,000 feet apart with the equipment housed in a caravan. Special observations of the outer corona of the sun were undertaken including the occultation of the Crab Nebula by the sun. These observations were so satisfactory that it was decided to look for a more permanent site for a full-scale observatory. Such a place was found at Beacon Hill, St. Osyth.

This site covered some 6½ acres at high tide and 10 acres at low tide, with 500 feet of private foreshore and a Martello Tower. Moreover, there was 180° of clear view optically from east to west, the open sea being to the S.S.E. There were dwelling-houses nearby but in all cases well behind the site of aerials and at a lower level. Thus electrical interference would be at a minimum and freedom of operation for any work assured.

The tower itself was built along with eleven others on this stretch of coast for the repulsion of a Napoleonic invasion which, like that nearly 135 years later by the German armies, never materialised. A great deal of money was spent on them and the average cost was some £20,000 in the years between 1805 and 1810. Three of them had moats of which the tower now described is one. The tower itself is some 32 feet high and oval in shape, about 140 feet in circumference. The walls are from eight to twelve feet in thickness of old English bricks, about 50,000 to a course. There are three floors proper, plus cellars in the lower level below the moat floor. The first floor is reached by a bridge and drawbridge from the moat wall. The distance between the moat wall and the tower is some 35 feet. The moat is a dry one and about 14 feet deep. A well is provided in the moat for drinking water. The whole stands on a hill some 50 feet above sea level. There was also a battery on the seaward side on which cannon were mounted. Two of these are still at the side of the tower and will form an entrance to the bridge. During the Second World War a 2ft thick concrete roof was added and this provides the platform for the optical telescope dome. The first floor is used as a workshop and store. It is here that aerials are constructed where there is ample space to work indoors in bad weather.

One of the interesting features is the central pillar which supports the top floor by a continuous doming and provides support for the radial flooring of the first floor. This pillar is of such dimensions and stability that it is intended to house in the cellars a north/south and an east/west beam siesmograph, thus adding to the usefulness of the observatory.

The top floor is set out with two small and one large rooms and are allocated to an instrument room, a library and a lecture room. The lecture room also serves to house the special long trestles on which the pen recordings are laid out side by side for comparison. The normal speed at which the recorders are operated is 12in per hour, consequently each twenty-four hours occupies 24 feet of paper and requires a good deal of space when laid out. This again emphasises that in radio astronomy the collection of records over a long period of time is necessary before conclusions can be drawn. Comparison of the charts over weeks, and in some cases months, enables the short and long term changes to be noted. It was this constant reference to previous recordings that enabled radio astronomers in Australia to locate times of radio emission arriving from the direction of Jupiter. It will be seen that these continuous recordings are of the utmost value since they can be examined again and again in the light of developments from later observations.

There are four radio telescopes in operation at this observatory. They are all of the interferometer type and work in various combinations with each other. The largest arrays are those of the 19 Mc/s Jupiter aerials and consist of 9 half-wave dipoles each. These are mounted on poles some 14 feet above ground level and thus provide a narrow polar diagram in the north/south direction and when combined with a similar array 800 feet away to the west form an interferometer of 18 wavelengths spacing. The slope of the ground to the sea was fortunately at the correct angle of elevation needed for the purpose and thus simplified the arrays considerably. Pre-amplifiers are located at each termination point of the arrays and the signals are carried by high frequency cables to the instrument room containing the receiver and phase switching apparatus.

The next largest of the telescopes is that which operates on 27.5 Mc/s. The arrays are large in that each one consists of a corner reflector 75 feet long, with a 27 feet high vertical screen and a 27 feet wide horizontal screen. The screens are made of wires spaced a fraction of a wavelength apart and fixed to the supports. The whole assembly is mounted on hinged bases and can be tilted through 90° elevation. The aerial dipoles, of which there are 4 in tandem, are placed at the focal point of the reflectors. The pre-amplifiers are placed at the foot of the centre frame and from here again the signals are fed by high frequency cable to the receiver in the instrument room. The aerials are in this case placed 22 wavelengths apart and the principal work on which this telescope has been engaged is the evaluation of the extent of the sun's corona, particularly at the time of the occultation of the Crab Nebula by the sun in June of each year. The western aerial array of this telescope is shown in one of the illustrations and shows the construction very well.

There are two more radio telescopes and these are in operation at the high frequency end of the spectrum. The arrays are of a different type and in one case consist of a reflector 10 feet square covered with ½in chicken netting. Four yagi aerials are arranged on the reflector and their output fed to a pre-amplifier. The whole assembly is supported on a unit which enables the aerial to be rotated in azimuth and also moved in altitude. The aerials can thus be pointed to any part of the sky. Used alone the assembly forms a simple radio telescope or radiometer. There are at the site two of these arranged as one leg of an interferometer working in combination with another group of 8 yagis fixed east and west but steerable in altitude. With this system a very small area of sky, 40 minutes of arc by 40 minutes of arc, can be examined. The receivers are largely well known communication types. There are two CR100, one CR150 (used for time signals and very low frequency static observations), one S27 with a range of 27 to 150 Mc/s, a Bendix, covering 100 to 150 Mc/s, a very high frequency receiver with a range from 500 to 3,000 Mc/s, two R208 receivers covering 10 to 60 Mc/s. To this have been added many other units, some of original construction and some modified surplus equipment. The three pen recorders form the most expensive part of the equipment, but are, of course, essential for work held to professional standards. The illustrations show various aspects of the radio side of the observatory and also the optical units, the captions explaining the details.

There will possibly be some terms used in this first article which are unfamiliar to some. As the series proceeds these will be explained. The next article will deal with aerials and their applications. As far as possible the endeavour will be to carry theory and practice together so that by the end of the series those interested will be examining for themselves the statements made and locating the positions of some of the more powerful sources. There will be scope for readers' own ingenuity in construction and those more concerned with the indoor work will find such items as phase detectors and electronic phase switches of interest. The application of transistors to this field is also of importance, and those interested in this aspect will perhaps be stimulated to design ancillary equipment to the specifications given. Any such designs put forward, together with a working unit, will be put to the test at the writer's observatory.

(To be continued)

R.A.F. and Weather Experts in Space Experiments

The Air Ministry Meteorological Office and the Royal Air Force are to assist scientists of Bristol University in experiments into the relationship between solar modulation and cosmic particles entering the solar system.

The experiments, aimed at discovering more of what goes on in interplanetary space, are being conducted by a team from the H. H. Wills Physics Laboratory of the University, under Dr. C. J. Waddington. Already the team have sent up balloons, carrying stacks of photographic emulsion, from the new Air Ministry Meteorological Station at Shanwell, Fife, and from R.A.F. Cardington.

Unlike ordinary meteorological balloons those carrying the emulsion stacks have special valves which, by releasing excess gas, enable them to drift at a chosen height, usually about 115,000ft. Normal balloons go on rising until they burst. The balloons are tracked by radar and at a pre-determined time the loads are dropped on parachutes.

Electrically-charged cosmic particles originating from outside the solar system come into conflict with solar magnetic fields as they approach the earth, and some at least of them are deflected. Some of those particles that reach the upper atmosphere pass through the photographic emulsion—which is similar to the emulsion on an ordinary film but much thicker—and when the emulsion is developed, rows of silver grains give a "picture" illustrating the behaviour of the particles. The effect of their entry into the solar system is rather like that of a stick thrown into a bramble bush: only those coming from a "lucky" direction or thrown very hard, get through, says Dr. Waddington.

Although the experiments do not have any direct bearing on future space travel, the information gained supplements that gained from space probes and satellites, and increases knowledge of interplanetary space. Meteorological officers have provided suitable locations for the launchings and track the balloons' flights by radar.

Cover Feature

A Constructor visits the U.S.A.

THE PRESENT STATE OF THE RADIO AND TELEVISION industry in the United States reflects, as well as any, that country's tremendous economic progress of recent years. "The Hi-Fi" is an essential part of the furnishing of every home of modest pretensions. The television set now takes up a comparatively inconspicuous place among the several electrical and mechanical gadgets which are a part of the functioning of the modern American household. But to speak in the singular here is an understatement since it is usual to find, in addition to the main set in the lounge, another in the hobby room and perhaps a discarded model of the early 'fifties at the back of the garage.

Colour Television

How soon will it be before this main set in most homes becomes a colour receiver? Even the manu-

W3KWH, Steel City Amateur Radio Club clubhouse. The building is 25 x 45ft inside, with two operating rooms, meeting room, kitchen and rest rooms. The building is situated on the club's own property which is slightly over one acre

View from the kitchen of SCARC looking towards the two transmitting rooms. The 10, 15 and 20-metre room is on the left and the 6 and 2-metre room on the right

facturers are hesitant to forecast at the present stage Colour television got away to a false start following the first transmissions, and only one home in a hundred can boast the ownership of a colour receiver. Now, having taken a more cautious view of the situation, some of the manufacturers who withdrew their sets after the early disappointments have squared their shoulders and are back in the market. Colour is still expensive, but improvements in design have made the service man's life much easier and this is a great incentive to the dealer to increase his sales. Installation of a colour set involves little more trouble than in the case of black and white: it is usual to expect that a set will work properly as soon as it is plugged in and it is quite often unnecessary to demagnetise the tube.

Improved reliability in the newer sets is borne out by the fact that fewer buyers are taking out a service contract, which can cost as much as £25 per annum. They are safe in doing this because many adjustments can be made without removing the back of the receiver and a tube replacement is no longer a major operation.

Certainly the omens for the future of colour t.v. are good at the moment. Three major networks give a coast-to-coast coverage and the main limitation on colour-fidelity would seem to be the taste of the individual viewer when turning the knobs.

Hi-Fi

The hi-fi market continues to provide a steady income to the numerous manufacturers of ready made or kit-built tuners and audio components. While we in England must be content with an hour or so of stereosonic broadcasting each fortnight, stations in many American cities provide daily two-channel programmes of high quality. This has been one of the best features of the localised (and sponsored) radio system, in that, given the financial backing, a station can afford to use its a.m. and f.m. transmitters to provide a stereo service. Makers of equipment have met the situation by offering combined a.m./f.m. stereo tuners of advanced design and handsome appearance. Nevertheless, stereo has not swept the field as reports in the trade have suggested. True, the radio gramophone industries have spared no efforts to popularise the idea—in typically American fashion one recent publication devotes a full-length article to the subject of winning the interest of the womenfolk. But one gains the impression that the sceptics still have the upper hand. As one person remarked to the author: "Once you have got over the novelty, it is just like listening to any other system". While talking about hi-fi, it is worth noting that British audio equipment, particularly the loudspeakers and amplifiers, are still highly thought of by many audiophiles in the U.S.A.

Tape recording as a hobby occupies a rather interesting situation when compared with current practice in Britain. While a good selection of quality domestic recorders—the equivalent of those in the upper price range in this country—is available, there is not the proliferation of cheap or medium priced machines which we have seen on the British market during the past three years. One undoubted reason why the disc has not given way so readily to tape is that the disc recordings have been so much cheaper in the U.S.A. and are becoming cheaper still. One large record company is currently operating a "two for the price of one" campaign, and this is in the 12in l.p. classical range. It is less of an economic proposition to make tape recordings from the radio as an alternative to buying discs, even when the price of tape is so much lower than it is here.

Red Rask, W3RXT, chief v.h.f. operator at SCARC transmitting at the 6- and 2-metre position on 2-metres

The Home-Constructor

The home-constructor, using the word in the strict sense, is probably rarer in the U.S.A. than in this country. After passing the "experimental one valver" stage, the radio enthusiast is inclined to look to the many excellent kits for his more advanced models. While it is true that the end product may be superior, the individual learns very little about wireless fundamentals merely by following the instructions supplied in the parcel, and this is a matter of regret to the die-hards. A notable absence in the American scene is that of the government surplus components and equipments with which we are familiar here. The constructor goes to his local "ham" shop or writes to one of the big mail order stores in New York or Chicago and expects always to buy new, or at best from the bargain counter. Apart from the replacement of faulty components, kits obviously give the best value for money. The effect of this is that there is probably more uniformity among home radio projects, in distinct contrast to the numbers of British constructors whose main pride is in building equipment with components salvaged from the most unlikely places or bought for a song in Lisle Street.

First impressions of an amateur radio store are misleading, until one realises how large a proportion of its business goes through the mail. Distances alone in the United States are a sufficient explanation for this. The personal shopper is in the fortunate position of being able to examine the complete range of goods in comfort; the assistants are helpful, but not obstrusive, and when asked for advice prove to be remarkably well informed. An oustanding feature of any store is the quantity of radio literature on show: American books which reach this country represent only a fraction of those published and manuals are available at various stages of difficulty for beginners and experts alike on every aspect of radio. Copies of the store's catalogue —fully illustrated and running to several hundred pages—are given freely, or sent to you for the cost of the postage.

The Radio Amateur

In no country is the radio amateur received among his fellow enthusiasts with more cordiality than in the States. Certainly the visitor has no difficulty in linking up with the American hams, who constitute more than two thirds of all radio amateurs in the world and represent every conceivable walk of life. It is easier there for anyone to get on the air than in most other places. The "Novice" licence, which permits transmission of c.w. and phone on certain sections of the 80, 40, and 15 metre bands, can be secured after only a modest test. Within the year that the licence is valid the amateur is encouraged to increase his knowledge and skill in preparation for the Technician and General Class licences, by which stage he will have attained a standard roughly equal to the G.P.O. requirements and will enjoy similar band facilities to those granted in this country. The really keen man goes on for his "Extra Class", which calls for advanced theory and a code rate of 20 w.p.m.

A subject for heated discussion among hams at the moment is that of Citizens' Band Radio. This concerns the allocation of 22 channels* in part of the 27 Mc/s band by the Federal Communications Commission for the private use of any person over the age of 18, without the need for an examination. Within the terms of the licence Citizens' Radio is not intended for use as a hobby in itself, for radio experimenting, or for general contacts of a random nature to unknown stations. No doubt the regulations could be more clearly stated, but it is implicit that these frequencies should be used rather in the same way as the private or business telephone. In the event Citizens' Band is being treated by many people as an easy way into "ham" radio, and qualified amateurs are rightly indignant at this intrusion by the "gossipers on eleven metres". The restriction to 5 watts input has not retarded its popularity, and a number of manufacturers have been quick to bring out receivers which conform to the F.C.C. design requirements, at prices ranging from £35 to £70 for a complete station. There is little chance of the wavelengths being withdrawn despite vigorous protests from amateurs, but there are hopes of some change in the regulations.

The undoubted climax to the present visit was an evening spent by the author at W3KWH, the Steel City Radio Amateur Club, a few miles outside Pittsburgh. Even in the States it is a rare experience to visit a club in its own premises, the club-house ("shack" is hardly the word to use here) being built entirely by the members, mostly from information acquired from books! W3KWH enjoys a commanding position 1,340 feet above sea level. There are 34 members, who are a fair cross-section of the community with the inevitable bias towards the electrical trades, but with a nice blend of the arts and science in that they include a music teacher and a research physicist. Some idea of the excellent accommodation can be seen from the photographs. A feature of the construction which caused great excitement is the electrical under-floor heating. When this was switched on for the first time every television picture in the area shrank to the size of a postage stamp and a minor emergency in the public supply followed. Matters were improved, but the treasurer soon found that the bill for electricity threatened to wreck the club finances and they have since reverted to a more conventional form of heating.

* There is a twenty-third channel in the Band which is shared with stations in other services.—EDITOR.

Variable Output Voltage Stabilised Power Supply

By **HUGH GUY**

IN THIS ARTICLE THE REQUIREMENTS FOR A STABLE source of supply voltage are discussed, and a practical solution based on the use of a cascode circuit is described in detail.

The performance of the complete supply, component parts for which are readily available separately, is summarised in the following specification.

Specification

Mains Input
110, 205, 225, 245 volts a.c. 50/60 cycles.

Outputs via Socket or Terminals
(*a*) 300/350 volts at 175mA. Fully stabilised. Unit must be derated for lower output voltages as follows: 275V, 160mA, 250V, 150mA.
(*b*) 6.3V a.c. 3A. (Unstabilised.)
(*c*) 400–500V d.c. (Unstabilised).

Ripple
Less than 1mV.

Output Impedance
At zero frequency: Zo is less than 1Ω.
At 100 c/s: Approx. 1Ω at loads up to 40mA d.c. Less than 1Ω for loads in excess of this. (Measurements made when drawing signal current of 10mA a.c.)

Stability with Mains Variations
10% mains fluctuation produces less than 0.15% variation in output voltage.

Polarity
Chassis may be connected to either positive or negative, or left floating.

Meter Facilities (Optional)
0–200mA, f.s.d.: 0–500V, f.s.d.

Necessity for Stabilisation

Every electronics experimenter periodically finds a need for a supply of h.t. and l.t. voltage during the course of testing one or another of his pieces of equipment.

To meet this need he may temporarily tap the supplies of an existing unit or perhaps use a simple power pack he has constructed especially for such tests.

There are disadvantages and dangers in either of the above solutions to the supply problem. In the first instance tapping an existing supply may overload it. At the same time the risk of temporary short-circuits (almost unavoidable during a testing phase) may permanently damage the parent unit. Inevitably the ripple voltage of the supply will be worsened. The worst hazard, however, is the probability of interaction and resultant instability due to the loading of one circuit on another. Testing, say, a timebase circuit on a supply derived from an amplifier could cause instability in both circuits. Similar trouble can be experienced with supplies obtained from a specially constructed power supply if several different units are operated from it simultaneously.

However, the main problem associated with supplies of this type is that of varying output with load; that is, the regulation problem. On circuits drawing only a few milliamps—a simple pre-amplifier for example—the output voltage obtained from the supply will be very much higher than that available when a heavier load of a hundred milliamps or so is drawn. The disadvantage of such a supply is that its output voltage is neither regulated nor controllable. A graph illustrating this typical variation is given in Fig. 1.

The following considerations show what is ideally required from an h.t. power supply. It must provide an output voltage which:

(1) Remains constant as the output current is varied from zero to full load.
(2) Can be set to any predetermined level over a wide range.
(3) Does not fluctuate with mains supply variations.

In addition, as an extension to the first requirement, rapid variations of load current in one circuit loading the supply must not be conveyed to any other parallel circuit. In other words the first requirement must apply regardless of the frequency with which the output current is varied.

This requirement is specified as a permissible output impedance. The ratio of permissible voltage change to required load current change gives this figure, and for the stabilised power supply described here, is less than 1Ω. This means that with an output of 300 volts the output current can be varied from zero to the full load of 175mA with less than 0.175 volts change.

A performance of this high order rates this power supply as an instrument well up to laboratory standard, a purpose to which it is well suited.

Output Regulation

The simple unregulated supply mentioned earlier can be modified to provide a controllable output. The easiest way of doing this is to provide a supply which delivers a higher voltage than that ever likely to be required and to connect a variable resistor

R_V in series with the output. This arrangement is shown in block form in Fig. 2.

The output resistor is adjusted to give the required voltage on load, as indicated by the voltmeter V. For very light loads a large value resistor is required in circuit to drop the excess voltage. Heavier loads demand a lower value of resistor but of fairly high power rating.

For steady load requirements, the solution of Fig. 2 is adequate, but it offers no protection against mains or load fluctuations.

Where the load current alters either periodically or in a random manner, its effect on the output voltage could only be cancelled by a compensating variation of output resistance. At this point, of course, manual operation is no longer practicable and some sort of automatic control is required.

This automatic control is provided by the electronic system of regulation.

Electronic Regulation

In the electronically regulated power supply, a valve replaces the variable resistor used in the simple pack. This valve, connected in series with the output of the pack, must be capable of handling the maximum current delivered by the supply.

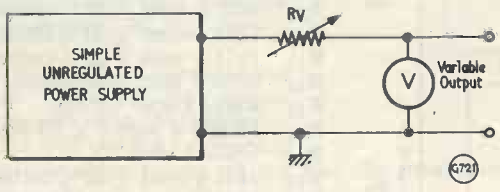


Fig. 1. Output voltage variation with load

When this current is high, more than one valve may have to be paralleled to pass the required current. The grids of these control valves, as they are called, are also connected in parallel, and will be controlled by a correcting signal derived from the output of a sensitive directly-coupled amplifier. In turn the input to this high gain d.c. amplifier is produced by comparing a sample of the stabilised h.t. output with a fixed reference voltage. Any variation between the level of the sampled stabilised h.t. and the fixed reference voltage will then be amplified and fed to the series control valve, altering its resistance in such a way as to reduce the change in h.t. level.

This application of the principle of negative feedback is used extensively in electronic circuit design, and in this instance forms the basis of the regulator section of the stabilised power supply.

The process can be followed in a step-by-step analysis of Fig. 3, where the regulator section is seen in simplified form. It consists of three main stages, viz.: the series control valve, the high gain amplifier coupled directly to it, and a voltage reference provided by a neon tube. Current flowing through the d.c. amplifier must pass through the neon tube and, though this current will vary, it is a characteristic of neon tubes that the voltage across the tube will remain substantially constant. This means that for widely varying h.t. voltages, the cathode of the d.c. amplifier stage (to which the neon is connected) will remain at a substantially constant potential.

When the h.t. output is loaded its level will inevitably drop. Likewise the d.c. amplifier grid

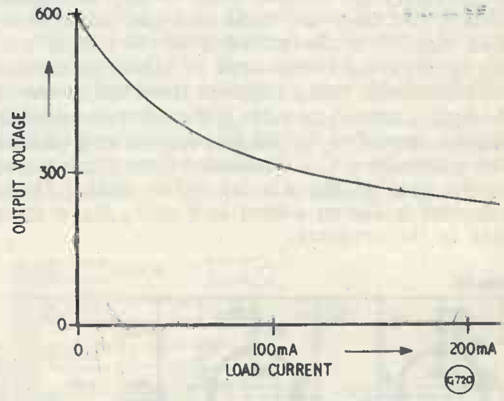


Fig. 2. The elements of a controllable voltage supply

voltage, derived via the potential divider, R_1, V_R and R_2, will drop by a corresponding fraction.

Now the grid voltage of the amplifier will be negative with respect to the stabilised cathode voltage, and the reduction in grid level occasioned by the loading will increase this negative bias. Accordingly, the amplifier anode current becomes reduced, the drop across the anode load R is similarly reduced, and the negative bias on the control valve decreases.

This in turn permits the required load current to

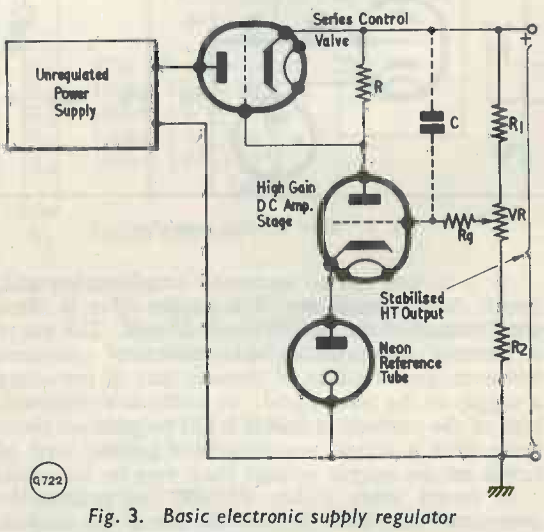


Fig. 3. Basic electronic supply regulator

flow through the control valve at a decreased anode-to-cathode voltage drop and the net fall of output voltage is reduced.

For the regulator section to operate there must inevitably be a finite fall in output voltage, since regulation is effected by amplification of the change thus caused. This is a basic requirement of any such error-actuated servo system.

Obviously if only a very small change of output level is permissible then a very large amplification is necessary to achieve this. Now, as explained earlier, not only are these changes caused by the load regulation characteristic of the supply but by any alternating component of signal generated in the equipment being supplied from the power unit. As high a gain as possible is therefore required from the d.c. amplifier for all frequencies and to achieve this a capacitor C is connected from the h.t. output to the grid of the d.c. amplifier stage. This a.c. coupling is shown dotted in Fig. 3. R_g is the grid leak to the coupling.

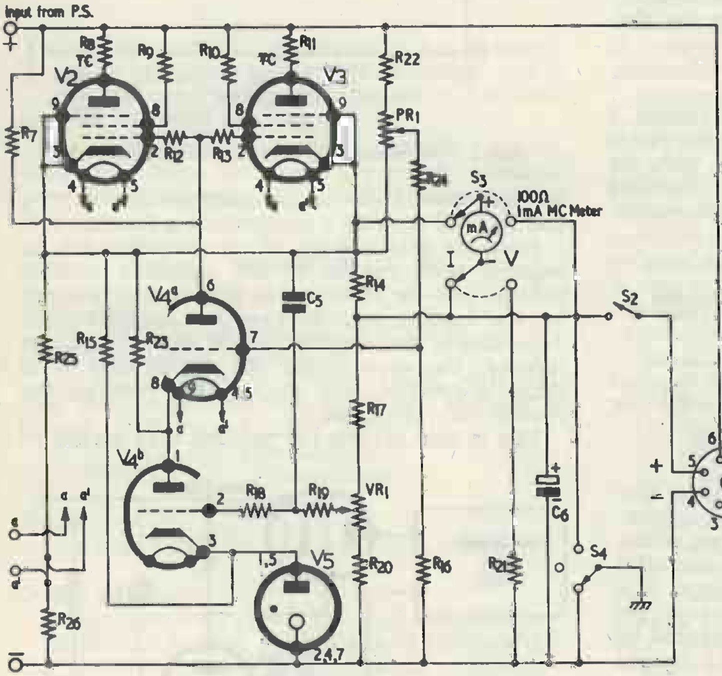


Fig. 4. Basic cascode amplifier

As a further aid to increased amplification and, hence, better regulation, a pentode valve is often used instead of the simple triode shown. The use of a pentode generates its own series of problems however, and the first of these is that of providing a supply to the screen grid. In addition a disadvantage of the pentode is that it is apt to generate more noise than a triode, resulting in a greater level of ripple on the output voltage than may be tolerable.

In recent years it has become the practice to overcome these difficulties by the use of the cascode circuit.

The cascode circuit is an arrangement of two triode valves in series (one acting as the anode load to the other) by means of which a gain approaching that of a pentode is attainable without the disadvantages of the latter. Fig. 4 shows a typical arrangement.

Practical Circuit

The Power Supply Section

Figs. 5 and 6 show the detailed circuit of the complete stabilised power supply. Mains voltage is supplied to the power pack via a double pole on-off switch, S_1, and a fused mains selector link. The basic power supply section comprises a centre-tapped h.t. transformer T_1 feeding a full-wave rectifier V_1 followed by a capacitor input filter C_1, C_2, L_1, C_3, C_4.

The output voltage obtained from the supply section must always be greater than the highest stabilised voltage required, and consequently when

Components List

Resistors

R_7	1MΩ ½ watt 5% Hi-Stab
R_8	10Ω ½ watt ±20% carbon
R_9	68Ω ½ watt ±20% carbon
R_{10}	68Ω ½ watt ±20% carbon
R_{11}	10Ω ½ watt ±20% carbon
R_{12}	1kΩ ½ watt ±20% carbon
R_{13}	1kΩ ½ watt ±20% carbon
R_{14}	0.5Ω 1 watt wirewound
R_{15}	47kΩ 2 watt carbon
R_{16}	150kΩ ½ watt 5% Hi-Stab
R_{17}	56kΩ 1 watt 5%
R_{18}	1kΩ ½ watt ±20% carbon
R_{19}	100kΩ ½ watt ±20% carbon
R_{20}	22kΩ 1 watt ±20% carbon
R_{21}	500kΩ 1 watt 5% Hi-Stab
R_{22}	220kΩ ½ watt 5% Hi-Stab
R_{23}	220kΩ ½ watt 5% Hi-Stab
R_{24}	100kΩ ½ watt 5% Hi-Stab
R_{25}	22kΩ ½ watt ±20% carbon
R_{26}	47kΩ ¾ watt ±20% carbon
PR_1	100kΩ carbon preset
VR_1	25kΩ 1 watt pot. wirewound

Capacitors

C_5	0.05μF, 300V, paper
C_6	8μF, 450V, electrolytic

Valves

V_2	EL81 Mullard
V_3	EL81 Mullard
V_4	ECC81 Mullard (12AT7)
V_5	85A2 Mullard

Switches

S_2	s.p.s.t. toggle
S_3	d.p.d.t. rotary wafer
S_4	3-way rotary

Miscellaneous

M	0–1mA 100Ω m.c.
SK_2	I.O. valveholder

the supply is unloaded, the voltage at the rectifier cathode is about 540 volts. To reduce the overall size of the unit, electrolytic capacitors are used in the ripple filter. To withstand the maximum voltage produced, two capacitors are connected in series-parallel, as shown, in each element of the filter. Now the negative terminal of the electrolytic capacitor is connected to the capacitor can. Furthermore the complete unit is designed to enable either the positive or the negative terminal of the h.t. to be connected to chassis or for both terminals to be left floating. This arrangement is useful if two supplies are used, one as an h.t. supply and another as a bias supply. Alternatively, the outputs of two (or more) packs may be connected in series to obtain a high output voltage.[1] To achieve this, it follows that one power supply must have its output "floating" above (or below) earth potential.

For these reasons the electrolytic cans must be isolated from the chassis and special insulating card is used for this purpose. To equalise the voltage across each, resistive voltage dividers are connected in parallel with each capacitor arrangement—R_3, R_4, and R_5, R_6.

Resistor R_1 is to restrict the peak value of the current flowing through the rectifier.

The unstabilised h.t. is made available as an output on pin 6 of the octal outlet socket.

The Stabiliser Section

V_2 and V_3 in the circuit of the stabiliser section shown in Fig. 6 are the two series control valves, connected in parallel. These types are the well known television line output valve, the Mullard EL81, ideally suited to this purpose. Parasitic "stopper" resistors are connected in the anode, screen-grid and control-grid circuits of each valve.

The stabilised output is taken from the control valve cathodes via meter circuitry selected by switch S_3, and an on-off switch S_2 to the output terminals.

V_4 is the cascode, consisting of the Mullard double triode ECC81; while the neon reference tube V_5, providing a nominal 84 volts reference, is the Mullard 85A2. Ignition and maintaining current is fed from the stabilised output via R_{15}.

The voltage dividing chain mentioned earlier will be identified here as resistors R_{17}, R_{20} and VR_1 connected across the stabilised output, in series with the 0.5Ω meter shunt R_{14}. The variable control VR_1 enables the stabilised output voltage to be set to any level between 250 and 350 volts.

Components C_5 and R_{19} comprise the a.c. feedback coupling used to minimise the output impedance of the supply, whilst the insulated electrolytic C_6 connected directly across the output limits reflected transients from the load.

The cascode stage anode load R_7 is of very high value in order to obtain the maximum a.c. amplifier gain, and as a result the current through the cascode stage is low—0.5mA at the most. To improve the gain still further extra current is diverted through the lower triode via R_{23}, thereby increasing the mutual conductance, and hence gain, of the stage.

The network R_{22}, R_{24}, R_{16} and PR_1 enables an extremely low output impedance to be obtained by forming an auxilliary feedback loop, operating in a similar manner to the main feedback loop. Connected between the stabilised and unstabilised h.t.

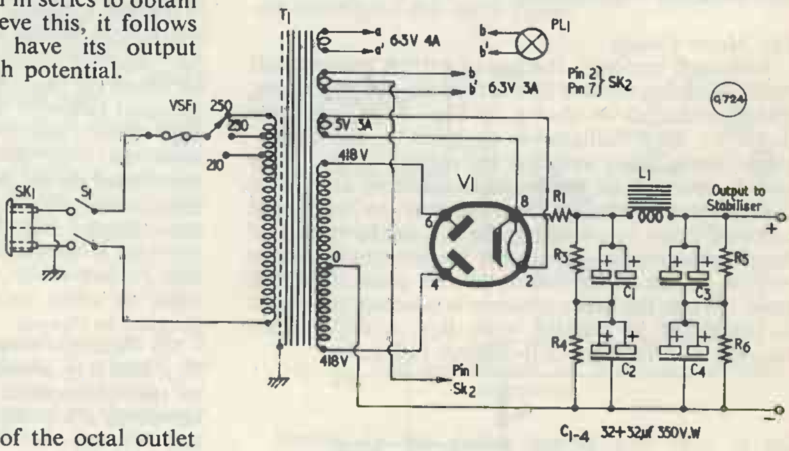


Fig. 5. Basic power supply circuit

Components List

Resistors

R_1	47Ω 3W wirewound ±20%
R_3	100kΩ 1W ±20%
R_4	100kΩ 1W ±20%
R_5	100kΩ 1W ±20%
R_6	100kΩ 1W ±20%

Valve

V_1	GZ34 Mullard

Capacitors

C_1 C_2	32+32µF, 350V, in parallel
C_3 C_4	32+32µF, 350V, in parallel can types, clip fixing, 1⅜in dia.

Transformers

T_1	418–0–418V r.m.s.
L_1	10H, 180mA d.c.

Miscellaneous

SK_1	3 pin shielded plug, Bulgin P162
S_1	d.p.s.t. toggle
VSF_1	Combined voltage selector panel and fuse-holder with 3A fuse
F_2	0–500mA fuse
PL_1	Pilot bulbholder, Bulgin D180 and 6.3V, 0.15A bulb

[1] Power packs may be connected in series only if the insulation to chassis of all power pack components is sufficiently good to withstand the high voltages which result.—*Ed.*

rails, the preset variable control permits the grid of the upper triode to be set at an optimum level so that, in conjunction with the setting of VR_1, it is possible to obtain an output impedance of zero ohms. That is, zero output voltage change over the entire current range. The output impedance may even be made negative under certain conditions so that, as the load is increased, the output voltage rises. This is useful when h.t. must be supplied to a unit some way from the supply, when the leads connecting the two units may have appreciable resistance or impedance.

In general the setting of PR_1 is not critical, but instructions are given later showing how the control may be set for best results.

The Meter Circuit

Although optional, the use of a 1mA moving coil meter is recommended and serves the dual function, when connected as shown in Fig. 6 of voltmeter (0–500V), and milliameter (0–200mA), the appropriate scale being selected by means of S_3. This switch operates as meter scale selector, and is so connected that the h.t. voltage may be read, and adjusted prior to switching the h.t. on by means of S_2. In one position, the meter is connected in series with R_{21}, the meter multiplier, to read 500V full scale. When the other position is selected, the meter is connected in parallel with R_{25}, a 0.5Ω shunt resistor, and then reads 0–200mA full scale.

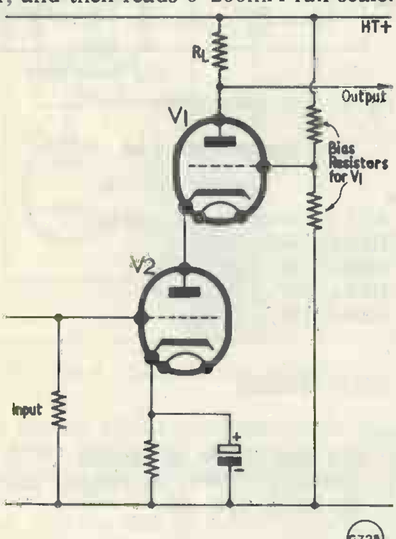


Fig. 6. Stabiliser section

L.T. Supply

Two 6.3V low tension windings are provided on the h.t. transformer, one set supplying the stabiliser circuit, and the other being connected to the output terminals and socket. The first mentioned l.t. supply is connected to the junction of a voltage divider, R_{25} and R_{26}, to ensure that the heater-cathode voltages on all the valves is not exceeded and that the effects of capacitive coupling of hum are minimised.

A centre tap to the second l.t. supply is brought out to pin 1 of the octal socket. The pilot lamp is connected to this supply providing quick evidence of accidental l.t. short-circuits in the unit being supplied by the pack.

Assembly and Wiring

Layout and wiring details are left entirely to the reader, as it is appreciated that in many cases the stabiliser section will be added to an existing power unit. Suffice it to say that the wiring layout is by no means critical and only the following points require careful observation:

(1) The negative side of the supply and stabiliser should not be electrically connected to the chassis. Any existing earthed connections of this sort must be lifted off the chassis and carried by means of terminal strips in the same manner as the positive high tension leads. The only earthed link is taken from the wiper of S_4 as indicated in Fig. 6. As mentioned earlier the earthed cans of the electrolytic capacitors, C_1, C_2, C_3, C_4 must be insulated accordingly, and the only permitted exception to this rule is the earth connection to the screen of the transformer which, being connected to the laminations in some makes of transformers, should be bonded to chassis.

(2) Parasitic stopper resistors R_8, R_9, R_{10}, R_{11}, R_{12}, and R_{13}, should in each case be mounted close to the appropriate valve pin. Because the EL81 valve has a top cap anode connection, stoppers R_9 and R_{11} can be soldered directly to the top cap connectors at one end, the wire downleads being taken from the other ends of the resistors.

(3) The series-connected electrolytics, which may have to be added as replacements in some existing power supplies, should be mounted clear of the rectifier and series valves, which tend to operate at a fairly high temperature. Enlarging on this theme it is important to ensure that the entire unit is adequately ventilated, since it has to dissipate up to about 100 watts or so.

Readers who have difficulty in obtaining a trans-transformer having the ratings of that employed in the unit described here may employ, as an alternative, the Electrovoice transformer type 110*D, which is available from H. L. Smith & Co. Ltd.*, 289 *Edgware Road, London, W.*2. *The Electrovoice component has secondary windings giving* 6.3*V at* 3*A centre-tapped;* 6.3*V at* 3*A centre-tapped;* 5*V at* 3*A; and* 450–425–0–425–450*V at* 200*mA. One* 6.3*V* 3*A winding may supply the heaters of* V_2, V_3 *and* V_4, *and the* 425*V h.t. taps replace the* 418*V taps in the original transformer.*
—EDITOR.

With regard to the choice of components, the parts recommended may be obtained from many of the usual sources advertised in *The Radio Constructor*.

Testing

After construction, carefully check the wiring against the appropriate diagrams, and ensure that all loose and surplus blobs of solder are removed from the chassis. Plug the valves into their corresponding sockets and fit the pilot lamp in its holder. Then connect the unit to the mains after fitting the fuse link at the correct mains voltage setting.

By means of S_1, and with S_2 at the "h.t. off" position, switch the mains on. Set S_3 to give a voltage indication in the meter.

The pilot lamp will light up and, when the valve heaters have warmed up, the stabilised h.t. voltage will be indicated on the meter.

Turning the control VR_1 from its minimum to its maximum position should cause the h.t. to vary from about 190V to 350V.

If an external voltmeter is available it should be connected between pin 6 of the output socket and the "h.t."−terminal to read the unstabilised h.t. voltage. In the absence of any internal short-circuits this will be between 500 and 540V.

While still unloaded, the voltage drop across each of the electrolytic smoothing capacitors C_1, C_2, C_3, C_4 should next be checked. In each case the voltage should not exceed 300. If the drop across C_1 is widely different from that across C_2, or if this state of affairs exists with C_3 and C_4, then an extra bleeder resistor should be connected in parallel with the one already across the condenser with the higher voltage on its terminals.

Next, with the voltmeter connected between pin 5 and the chassis of the power unit, S_4 should be turned to its centre position, thus isolating the output from the chassis. The reading on the power unit meter should remain unaltered, but the test voltmeter should not record any voltage. If a reading is observed, then its value should be approximately the same as that obtained when the test voltmeter is connected between the "h.t."− terminal and the chassis. Both readings should be zero as soon as any load is connected in parallel with the test voltmeter. Any standing voltage indicates an insulation leak which should be corrected.

Finally, connect the test voltmeter with its positive terminal to the chassis and its negative terminal to "h.t.−". Switch to the "positive-earthed" position on S_4 whereupon the same voltage as is indicated on the power unit meter will be obtained.

This completes the static tests to be performed on the stabilised power unit.

A further test of a slightly more complicated nature need only be followed by those constructors concerned with obtaining the optimum performance from the unit. This may be accomplished as follows:

The output impedance of the supply is required to be a minimum, perhaps even negative, at one particular setting of the h.t. voltage, chosen by the constructor as a specific voltage for a range of equipment he is designing or using.

Assuming for the sake of discussion that this value is 300 volts, then PR_1, the preset control, must be adjusted in conjunction with a test circuit as shown in Fig. 7.

A load comprising a fixed resistance of about 1.7kΩ in series with a variable resistor in 15kΩ or so is connected across the stabilised output, in series with an on/off switch. The 1.7kΩ resistor should be of about 50 watts rating and may comprise several lower wattage and higher value components connected in parallel. The maximum power dissipated in the 15kΩ variable resistor will be about 12.5 watts.

An h.t. battery delivering the same voltage—300 here—is arranged with a voltmeter between its positive output and that of the supply, as shown in Fig. 7, the negative terminals of the supply and the battery being linked. The test voltmeter should preferably be of the multi-range type and should be set initially to the 300V range.

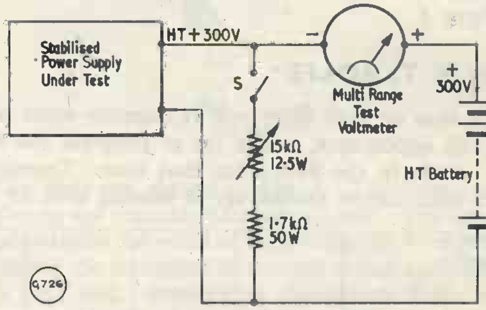


Fig. 7. Test arrangement for minimising output impedance

Switch on the power supply and after it has warmed-up, with S in Fig. 7 open, switch the h.t. on.

The test voltmeter will now indicate a small reading which should be reduced to zero by fine adjustment of the variable output control on the power supply. As the reading falls, so the multi-range meter scale should be changed until finally its most sensitive scale is in use. This, say, is the 0 to 1V scale.

When this scale is zeroed by final adjustment of VR_1 then switch S should be closed to pass current through the load. Depending on the initial setting of the preset control PR_1 the test voltmeter reading will either be positive or negative.

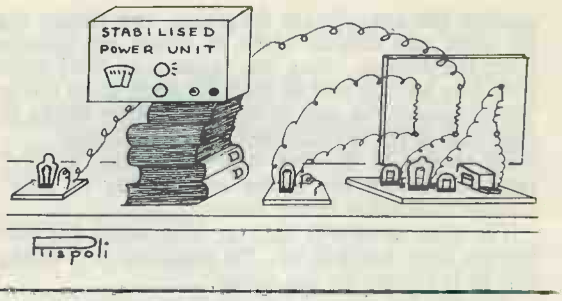
First reduce the variable part of the load to zero, leaving only the 1.7kΩ part in circuit. This gives full load conditions. PR_1 should now be adjusted to give a minimum reading on the test voltmeter.

Open switch S and if necessary reset VR_1 to obtain a zero reading, then adding the full load and re-trimming PR_1 again. This process should be repeated until the minimum change in voltage occurs between maximum and minimum loads.

Now adjust the variable load and note the maximum excursion of voltage change as the load varies from its full to minimum value.

The maximum voltage excursion, V_c, divided by the load current I_c drawn at this voltage gives the effective output resistance of the power supply. If the voltage rises as the load on the supply is increased then V_c is negative and the power supply has a negative output impedance.

The supply is now adjusted and completely ready for use. Readers will find this superior circuit extremely reliable and versatile. The prototype has been in use now for some hundreds of hours at up to eight hour stretches and no troubles have been experienced at all.



Interpretation of Transistor Data

Part 1

By **V. T. ROLFE***

IT WAS IN 1948 THAT THE TRANSISTOR FIRST MADE its appearance, and a lot of progress has been made in the field since that time. Transistors are used almost exclusively in hearing aids, as well as being used in computers and as d.c. converters, and a number of manufacturers are making transistorised record-players and portable receivers.

* Mullard Ltd.

To the newcomer, who may think in terms of valves, the concept of a transistor as a current amplifier is perhaps difficult to grasp, and low input impedances are difficult to get used to at first. In addition, each manufacturer seems to have his own method of presenting the transistor data, which leads the beginner into even more confusion. It is hoped, in the ensuing paragraphs, to clarify the position by examining some transistor features and to present them in a simplified form, together with a few words of explanation.

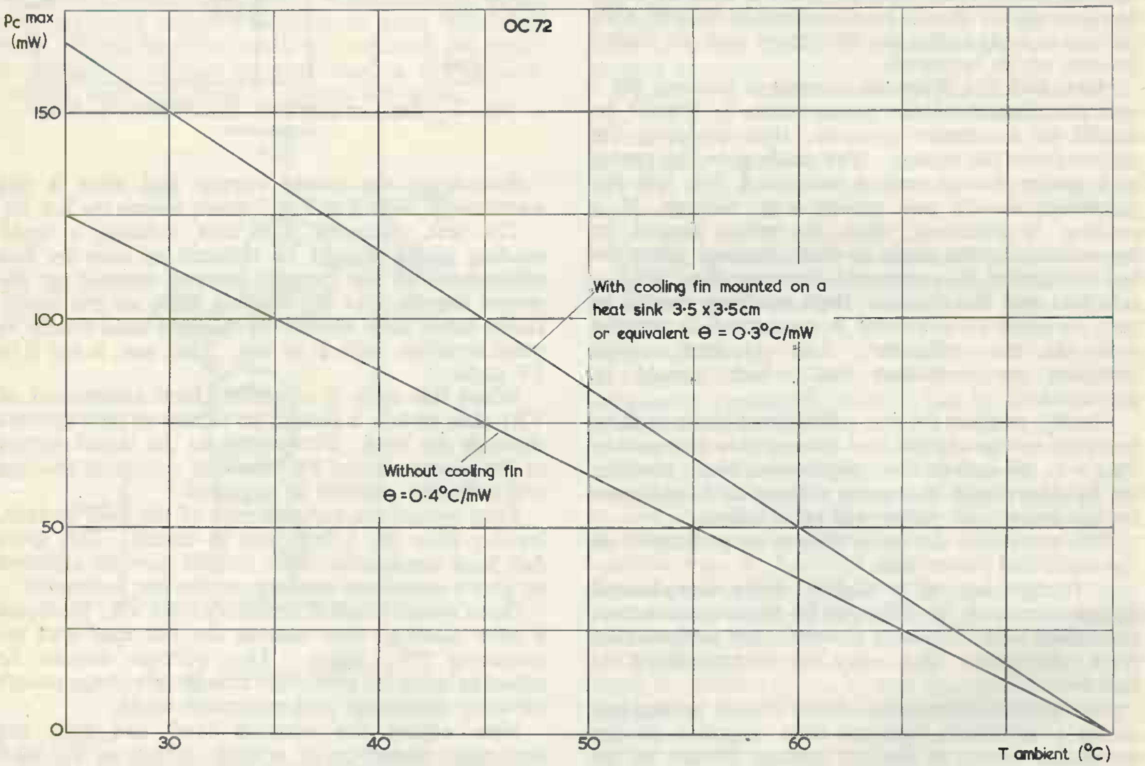


FIG.1

Limiting Values

It is perhaps as well to begin by defining the

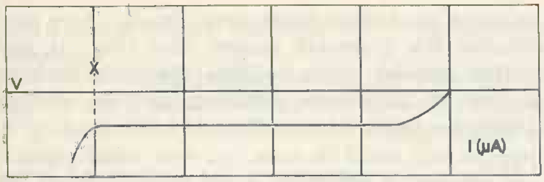


FIG.2a M168

limits of transistor ratings. An appreciation of these limits may save the beginner from completely ruining the transistor. As these are relatively expensive it is as well to take care. Most manufacturers warn users about the dangers of reversed voltages and overheating when soldering, and these remarks should be heeded.

With valves, the principal limiting values are the maximum anode dissipation (p_a max.), the maximum anode voltage (V_a max), and the maximum cathode current. These ratings depend on the physical construction of the valve. The dissipation depends on the physical size; the maximum voltage on the spacing between electrodes; and the maximum cathode current on the cathode area, and various other features of the cathode. There are three

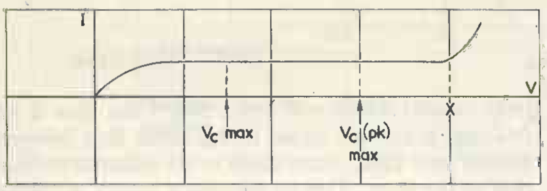


FIG.2b M169

similar ratings which apply to transistors—the maximum collector dissipation (p_c max.), the maximum collector voltage (V_c max.), and the maximum collector current (I_c max.).

Taking these in turn, the maximum collector dissipation depends upon the temperature at which it is desired to operate. Germanium has a particular restriction on temperature and the maximum junction temperature for the majority of germanium transistors is 75° C. The maximum junction temperature is probably the most important of all transistor ratings. In order to determine the maximum dissipation, one further factor is required—the "thermal resistance" (θ). This relates the dissipation of the transistor to the junction temperature rise, and for small signal transistors it is usually of the order of 0.4°C/mW. The dissipation can now be calculated, since:

Permissible rise of junction temperature = Max. junction temperature—ambient temperature = $p_c \times \theta$

$$\therefore p_c = \frac{T_{junction} - T_{ambient}}{\theta}$$

As an example, a transistor with a maximum junction temperature of 75° C and a θ of 0.4° C/mW, operating at an ambient temperature of 55° C, will have a permissible collector dissipation of $\frac{20}{0.4} = 50$mW.

For quick reference, it is possible to plot a curve of p_c max. against $T_{ambient}$ as in Fig. 1.

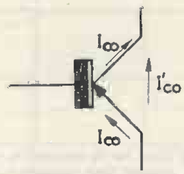


FIG3 M170

Two lines are shown in Fig. 1. The lower one applies to the transistor already quoted. The upper one illustrates the effect of improving the θ value by mounting the transistor in a metal clamp and fixing to a heat sink. Permissible dissipation under the same conditions will now be 66.6mW.

Collector Voltage

Readers who are familiar with crystal diodes will recognise the curve of Fig. 2 (*a*) as the inverse characteristic of a diode.

The point x is shown as the "turnover" point, and normally the maximum peak inverse voltage is rated as 75% of the turnover value.

The collector junction of a transistor consists essentially of a diode biased in the reverse direction, so the curve of Fig. 2 (*a*) may be inverted as shown in Fig. 2 (*b*), and applied to junction transistors.

In this case, x is known as the "softening voltage". The peak voltage to which the collector is allowed to swing ($V_{c(pk)}$ max.) is then about 75% of x. The

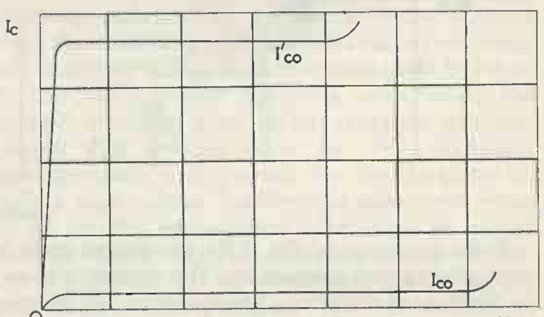


FIG.4 M171

maximum average or d.c. value of collector voltage V_c max. is half of the peak value. Thus with a sinusoidal input, operation at V_c max. allows the collector voltage to swing up to $V_{c(pk)}$ max. and down to zero. There is, however, one further point to be considered. The voltage ratings given apply to grounded base operation, a condition which is basically stable. When transistors are operated in grounded emitter the circuit is not so stable. One of the effects of operating a transistor in this type of circuit is that the softening voltage is reduced. In order to understand this it is necessary to consider the grounded emitter circuit more fully.

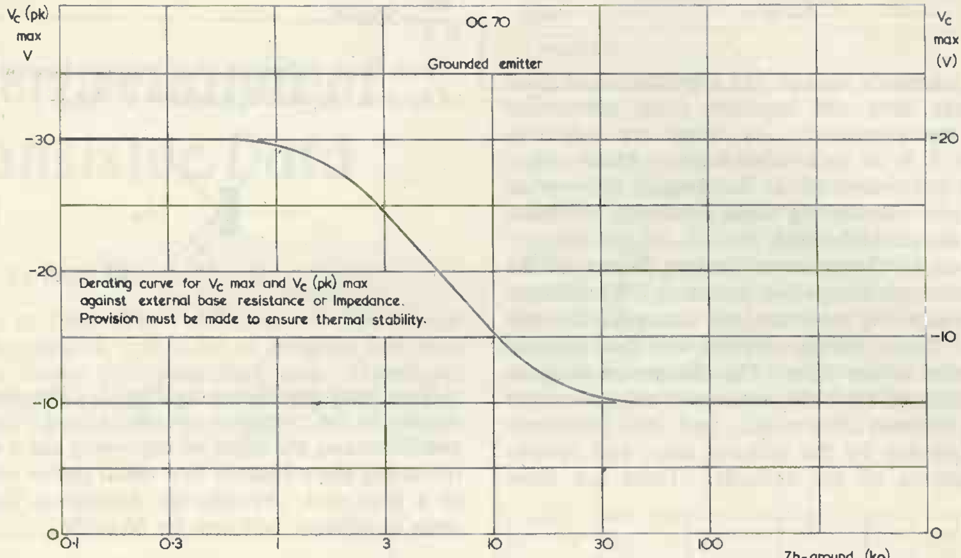


FIG.5

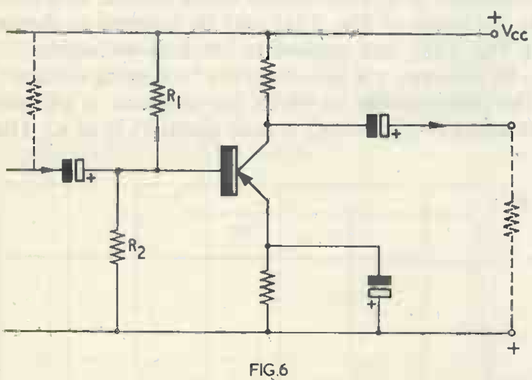


FIG.6

From the graph of Fig. 2 (*b*), at voltages up to V_c max., the current is constant. This current is known as the leakage current I_{co} (the subscript "c" denoting collector, and "o" that there is no input current) and consists of a current flowing between base and collector, the emitter being open-circuit. If we now consider the grounded emitter case (Fig. 3), the voltage applied tends to bias the collector-base junction in the reverse direction, and the leakage current I_{co} flows between these two points.

If the base is connected to the emitter, this is the only current which will flow. But if the base is left floating, a current equal to I_{co} must flow between emitter and base, since there is no external connection to the base. Due to transistor action, a current flows between emitter and collector equal to $\alpha' \times I_{co}$, where α' is the current gain in grounded emitter.

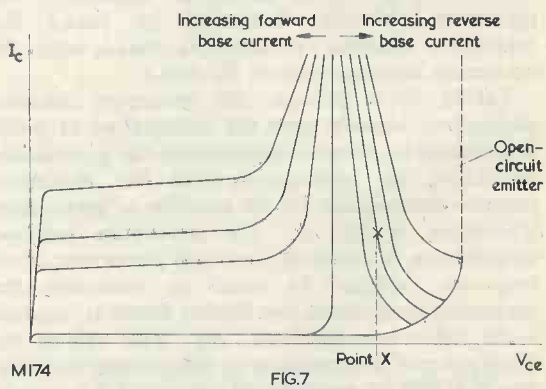


FIG.7

The value of α' in this case is lower than quoted in the data, as it is at a very low current level. This higher value of leakage current is denoted by I'_{co}. (It is common practice in transistor literature to use a single prime (′) to denote grounded emitter values, and a double prime (″) to indicate grounded collector values.)

If we now superimpose the I'_{co} curve on that of I_{co}, we get a graph such as that shown in Fig. 4. It is also found that the turnover voltage occurs at a lower value, and this must be taken into account by the manufacturer in fixing the limiting values. The two curves apply to the conditions of open-circuit base and short-circuit base respectively, and intermediate values of base impedance will give intermediate values of turnover voltage. A derating curve, such as Fig. 5 may be given to cover this.

The base resistance or impedance, $Z_{b\text{-ground}}$ in this case is the effective resistance between base and earth. In the typical circuit of Fig. 6, this is equivalent to R_1 and R_2 in parallel, i.e.

$$Z_{b\text{-ground}} = \frac{R_1 \cdot R_2}{R_{1+2}}$$

So far we have only considered the influence of the softening voltage on the ratings. But in certain applications, (e.g. switching circuits) where linearity is unimportant a larger voltage/current excursion would be obtained if the device could be operated beyond this point. It is therefore necessary to investigate the characteristics beyond the softening voltage. Fig. 7 shows these characteristics for a transistor used in a grounded emitter circuit. For normal values of base current, the transistor reaches a region where the collector current rises very rapidly for a small increase in collector voltage. This is known as the avalanche region. With reversed base current (as may be used in switching circuits to cut the transistor off rapidly) a larger voltage excursion can be permitted providing the collector current is low. The characteristic then turns back on itself and goes into avalanche region. This extension of the permitted working range is useful in some applications and it is therefore becoming common to publish a voltage/current rating chart defining a permissible area of operation, such as shown in Fig. 8. Precautions must be taken to keep the transistor operating point within the specified working area. This is fairly straightforward with resistive loads, but when inductive loads are used, it is possible for the transistor to reach a high-voltage high-current state even when cut-off on the base (point x on Fig. 7), unless precautions are taken to limit the voltage swing. The importance of the avalanche ratings is not confined to switching circuits. It is also of importance in car radio output stages for instance, where interference pulses arriving at the base can cut the

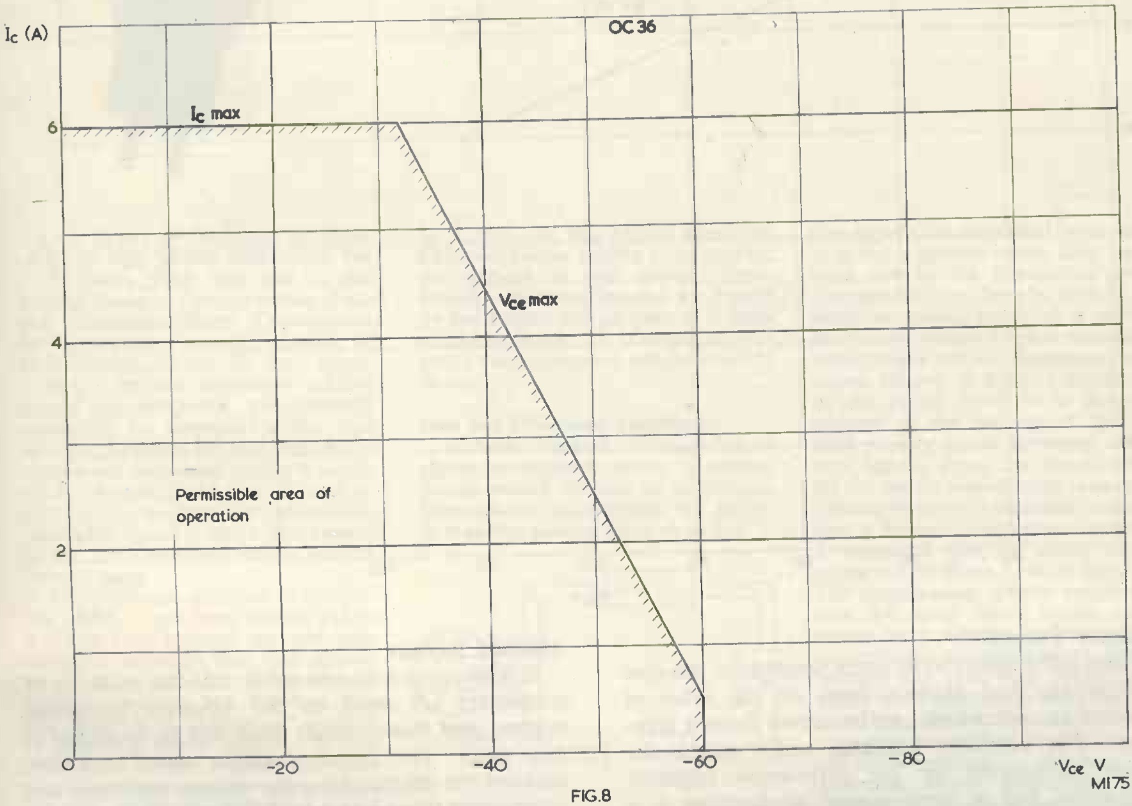


FIG.8

transistor off and a high peak voltage can occur (at a high current level) at the collector due to the rapid change in current through the output transformer.

As the current is increased, however, the value of α (and hence α') falls, so this may in itself set a limit to the useful current range. This effect is illustrated in Fig. 9.

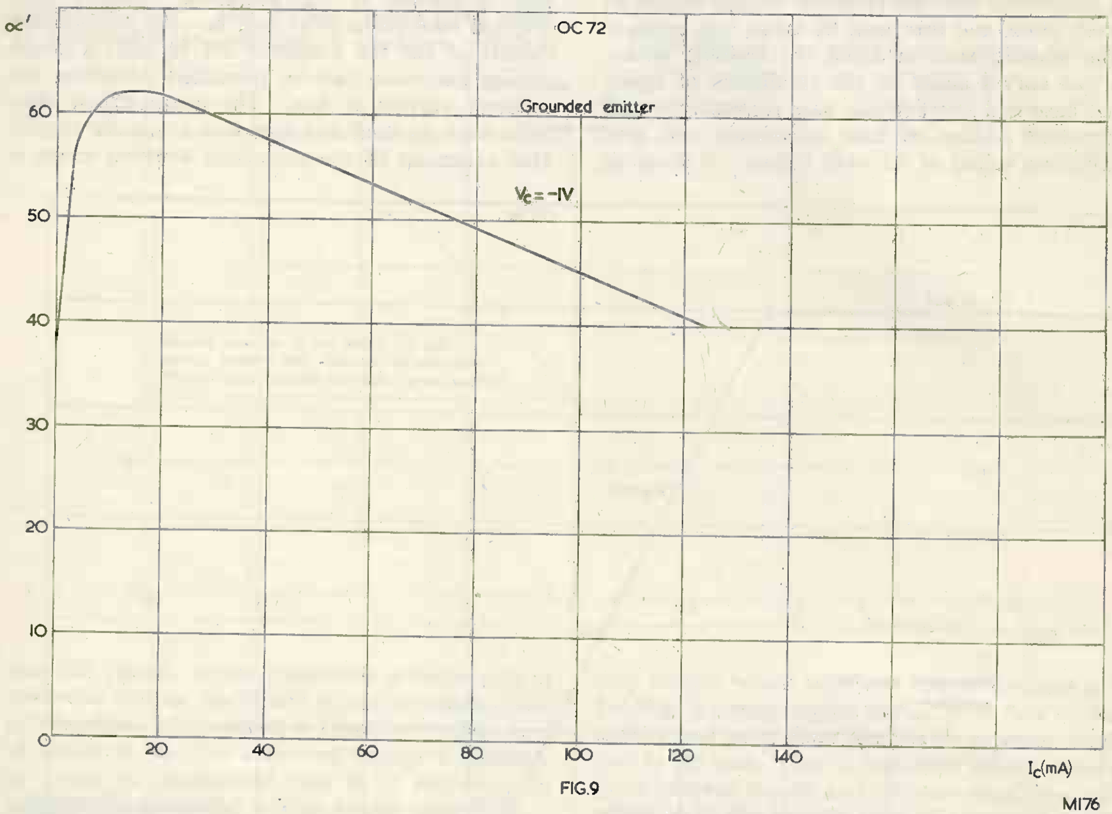


FIG.9

Collector Current

There still appears to be some doubt as to whether there is any real physical limit on the value of collector current which can be drawn from a transistor. For normally operated audio stages, the current is limited by the permissible collector dissipation, but in some special applications it is possible to operate the transistor at very low voltages (in the knee) and obtain very high currents.

Absolute Ratings

It is important to remember that the majority of transistors are rated on the Absolute Maximum system, and these ratings must not be exceeded at any time. The circuit designer must take into account the effects of supply voltage variations and component tolerances when designing equipment.

(*To be continued*)

British Sound Recording Association Silver Jubilee Convention

The Association has arranged a special whole day Audio Convention to mark its Silver Jubilee Year. This will be held at the Institute of Electrical Engineers, commencing at 10.0 a.m. on Saturday, 14th October, 1961.

The programme includes: "Non-linear Distortion Measurement", by J. Somerset Murray, B.A., A.M.I.E.E.; "Some Highlights in the History of Sound Recording", by H. A. M. Clark, B.Sc.(Eng.), M.I.E.E.; "The Cocktail Party Problem", by Prof. Colin Cherry, D.Sc.(Eng.), A.M.I.E.E.; "Studio Acoustics", by C. L. S. Gilford; "Recording and the Artist", by Peter Andry.

Registration for the Convention costs 30s. for non-members, or £1 for members of the Association.

Following the Convention the Association Silver Jubilee Dinner will take place at the Howard Hotel, Norfolk Street, London, W.C.2. This commences with the Reception at 7.30 p.m., and after the Dinner will feature an illustrated talk on "Twenty-five years of B.B.C. Recording", by Timothy Eckersley. Tickets for members and guests only cost 30s.

Tickets for the Convention may be obtained from the Hon. Secretary: S. W. Stevens-Stratten, F.R.S.A., "Greenways", 40 Fairfield Way, Ewell, Surrey.

RADIO *topics*

By RECORDER

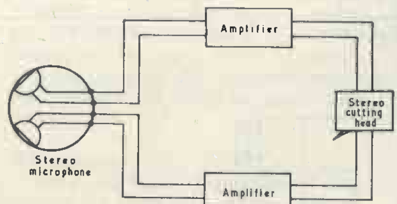
An event of extreme interest to high fidelity enthusiasts has taken place this year in the United States. The American Federal Communications Commission has approved a specific method of broadcasting stereo via f.m. transmitters. In the approved system (based on proposals put forward separately by General-Electric and Zenith) the stereo left and right-hand signals are contained within a single v.h.f. channel, and the system is compatible in that an acceptable monaural signal is given by conventional f.m. receivers tuned to the transmission.

The processes involved in providing left and right-hand signals within a single f.m. channel are not very complex, although they may appear so at first sight to those British readers who are not familiar with the "sum" and "difference" method of handling stereo signals. In the American stereo system the sum signal is transmitted in conventional manner, whilst the difference signal is transmitted on an a.m. subcarrier.

Sum and difference techniques have been used for quite a few years in the United States to reduce the cost of commercially produced stereo amplifiers and, if the functioning of such amplifiers is understood, it becomes easier to appreciate the principles involved in the new broadcasting process. In consequence, I would like to primarily devote some space to such amplifiers. Incidentally, it is worth pointing out that whilst (so far as I know) few if any stereo amplifiers employing sum and difference methods are being produced in this country at the time being, there is no reason at all why they should not appear in the future. So it may, for this reason alone, be well worthwhile getting to grips with the subject at the present time. British references located by myself on the subject are an item in "Technical Notebook" in *Wireless World*[1] and a comprehensive article in *Hi-Fi News*.[2]

Sum and Difference Amplifiers

A basic method of recording a stereo programme on to a gramophone record consists of coupling a stereophonic microphone via amplifiers to the cutting head as in Fig. 1.



E140

The cutting head produces a track inclined at 45° to the horizontal for the left-hand channel, and another, similarly at 45° to the horizontal, and at 90° to the first, for the right-hand channel. When the two channels are exactly in phase and have the same amplitude (as would occur if the sound source were directly in front of the stereophonic microphone of Fig. 1) the combined effect of the two signals on the cutter is to cause it to cut a groove whose only variations are in the horizontal plane. The groove cut thereby is just the same as would occur in a normal monaural record.[3] An important requirement for the reproduction of stereo records is that "a movement of the stylus point in a direction parallel to the surface of the disc shall provide equal, in-phase, acoustical signals from the loudspeakers (of the stereo reproducing system)".[4] This latter point is intended to ensure that a stereo system may reproduce a monaural disc by giving an in-phase output from both its speakers. The reproducing system would also give the same result if the sound source were directly in front of the stereophonic microphone of Fig. 1, because the recording cutter head would cut a horizontal track just like that in a monaural record.

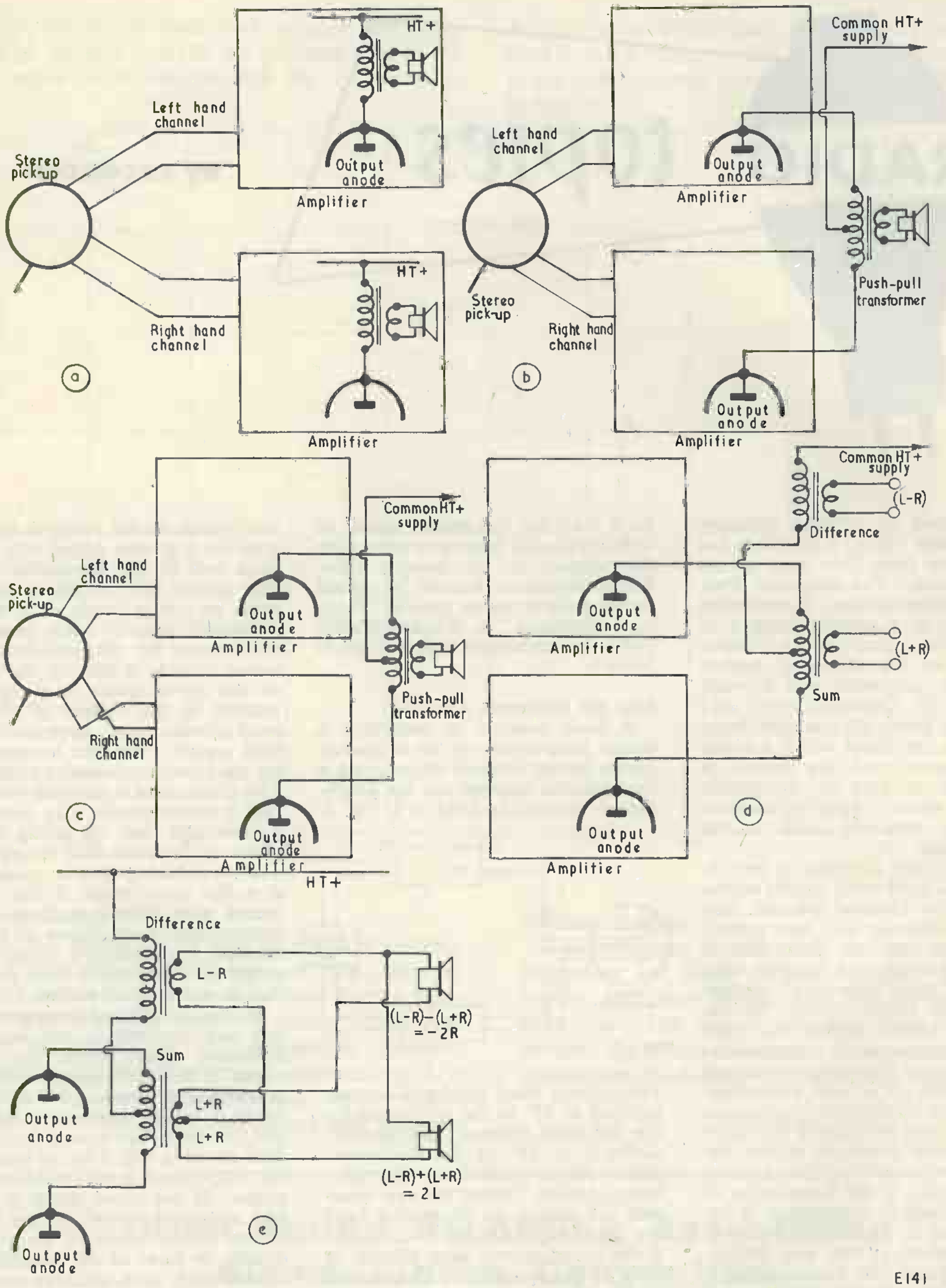
Having established these points we can now proceed to the sum and difference stereo amplifying technique. The conventional method of amplifying a stereo pick-up is to apply it to two separate amplifiers and, thence, to two separate speakers. This we do in Fig. 2 (*a*), in which we are employing single-ended output stages. If our input signal is given by a monaural record, or by a stereo record where the sound source was directly in front of the stereophonic microphone, both speakers must be in phase. So, working backwards, must the output anodes. When, because of the signal, the upper anode of Fig. 2 (*a*) goes positive so

[1] Page 80, *Wireless World*, February 1959. This item refers also to "A Two-way Stereophonic Amplifier" by B. B. Bauer, J. Hollywood and G. Maerkle, *Audio*, October 1958, and "The Bi-Ortho Output Circuit" by Nicholas Pryor, *Audio*, November 1958.

[2] "Economy Stereo Amplifier for Home Constructors", by P. W. Taylor, *Hi-Fi News*, March 1960.

[3] "Stereophonic Record Pick-ups" by F. Oakes and D. V. Charlesworth, *Wireless World*, January 1959.

[4] "Standards for Stereo Disc Records", *Wireless World*, June 1958.



does the lower anode. On the other hand, if we are reproducing a normal stereo recording both anodes will be out of phase, even if only slightly, for a very high proportion of the signals they handle. Also, the amplitudes of the signals at these anodes will vary according to whether the original sound came from the right or from the left.

Let us now connect our two anodes to the outside ends of a push-pull speaker transformer, as in Fig. 2 (*b*) and see what happens. If we now reproduce a monaural record (or a record where the sound source was directly in front of the stereophonic microphone) the effect at the anodes will be exactly the same as in Fig. 2 (*a*). That is, both anodes will go positive at the same moment, and will go negative at the same moment. Since the anodes are in phase their signals will cancel out in the primary of the transformer, and the speaker of Fig. 2 (*b*) will remain silent. If, on the other hand, we attempt to reproduce a normal stereo record, we will find that the signals on the two anodes will, for most of the time, be out of phase (even if only slightly) and will, also, be different in amplitude according to whether the original sound came from the right or the left. Only the signal components which are equal and in phase will cancel out in the primary of the output transformer. Our speaker will now respond to the *difference* between the two stereo channels.

One would expect, and this is borne out in practice, that the *difference* signal from the two channels in a stereophonic system would, on the average, be much smaller than the *sum* signal. Let us next see, therefore, whether we can apply a sum signal to our push-pull transformer. An easy way of doing this consists of reversing the input to one of our amplifiers, as in Fig. 2 (*c*). If, now, we apply a monaural record (or a stereo record where the sound source was directly in front of the stereophonic microphone) our two output anodes will be 180° out of phase; which is exactly right for application to the two ends of the push-pull output transformer. Indeed, the set-up is just the same as if we had a monaural push-pull amplifier, the necessary phase-splitting being carried out in the pick-up itself! With a normal stereo record the two amplifier inputs will not be entirely in phase, but the in-phase components will still add together in the output transformer primary. Our speaker will, therefore, respond to the *sum* signal.

Whereas, in Fig. 2 (*c*), in-phase components cause one anode to go positive, and the other to go negative, out-of-phase components will cause both anodes to go positive together, or negative together, as the case may be. We can, therefore, pick out these out-of-phase components by connecting the primary of a second transformer between the centre-tap of the push-pull transformer primary and the h.t. positive line. See Fig. 2 (*d*). This second transformer will respond to the *difference* signal, in just the same manner as did the push-pull transformer in Fig. 2 (*b*).

If we were to call the left-hand channel signal L and the right-hand channel signal R we may say that the voltage across the secondary of the push-pull transformer of Fig. 2 (*d*) is L+R because it is equal to the sum of the two channels. We can, similarly, say that the voltage across the secondary of the second transformer is equal to L−R, since this is the difference signal between the two channels. (In this last instance we give the minus sign to R rather than to L, because it was the right-hand channel we switched over in Fig. 2 (*c*). R has a plus sign so far as the sum signal in the push-pull transformer is concerned, because we switched the right-hand channel back again in the primary of that transformer.)

Fig. 2 (*e*) shows a secondary circuit which enables us to restore our left and right-hand channels. In this diagram each half of the push-pull transformer secondary gives a signal voltage of L+R, whilst the second transformer secondary gives a signal voltage of L−R. The L−R secondary is in series with both speakers. Tracing out the circuit to the lower speaker, we find that this receives a signal equal to (L−R)+(L+R) which, with the brackets removed, is equal to 2L. The upper speaker has the L+R component from the push-pull transformer reversed, and so it receives (L−R)−(L+R). Taking away the brackets, this is equal to L−R−L−R, or −2R. The 2's cancel out, and so we have obtained the situation where one speaker has a signal which is wholly left-hand channel, and the other has a signal which is wholly right-hand channel. The fact that the right-hand channel signal has a minus sign in front of it merely means that it is out of phase; and we reverse the connections to the speaker to bring it back into phase again.

Advantages

What are the advantages of this system, as compared with a conventional stereo amplifier? To begin with, although we are using single ended outputs, we are getting something approaching push-pull operation in the output stage so far as the sum signal is concerned. Indeed, if there is little phase or amplitude difference between the two channels, the output valves operate very nearly as a fully fledged push-pull stage with all its attendant advantages. The difference signal, on the average, will be much smaller than the sum signal, so we can, if we feel so inclined, skimp on the cost of the second transformer without introducing too much distortion for normal reproduction. There is the further very important point that we are obtaining something which is not all that far short of two push-pull amplifiers whilst using no more output valves than would be required for one! As may be imagined, this not only halves h.t. power requirements but also reduces overall costs very considerably.

Stereo Broadcasting

Having familiarised outselves with the sum and difference stereo amplifier technique, let us now return to the new stereo transmitting system employed in the United States. At the time of writing, the most detailed technical information on the new system appears in a commendably prompt-off-the-mark article by Norman H. Crowhurst in *Radio Electronics*.[5] The details concerning subcarrier and modulation frequencies in the following paragraphs are taken from this article.

In the new system the sum and difference signals are separated at the transmitter. The sum signal then frequency modulates the transmitter carrier in normal fashion, maximum a.f. modulating frequency being 15 kc/s. The treatment of the difference signal is a little more complicated, and may, perhaps, be conveniently approached via an intermediary step. In this intermediary step, let us assume that the transmitter carrier is frequently modulated by a subcarrier of 38 kc/s, and that this subcarrier is amplitude modulated, in its turn, by the difference signal. This represents a feasible method of transmitting the difference signal, but it has the disadvantage that energy is lost in the subcarrier. So let us now carry on to the next step and suppress the 38 kc/s subcarrier, leaving the a.m. sidebands to frequency modulate the transmitter carrier on their own. This is, in fact, exactly what is done in the new American system. To demodulate a suppressed carrier signal it is necessary to reinsert the carrier at the correct frequency in the receiver. In the American system a third frequency, fixed at 19 kc/s, also frequency modulates the transmitter carrier. This frequency may be picked out at the receiver, doubled, and used to reinsert the 38 kc/s suppressed subcarrier.

As with the sum signal, maximum audio frequency with the difference signal is 15 kc/s.

Let us now see what happens in a stereo f.m. receiver which picks up the composite signal. This receiver will resolve, at its discriminator, all the signals which frequency modulated the transmitter carrier. First will be the sum signal, and this will

[5] "Clear Road for FM Stereo", by Norman H. Crowhurst, *Radio Electronics*, July 1961.

appear as an a.f. capable of being passed on to an audio amplifier or any other a.f. circuit in conventional manner. Secondly, we will find the pilot subcarrier, this appearing as a steady frequency running at 19 kc/s. Thirdly we will obtain the sidebands around the suppressed 38 kc/s carrier. These we can apply, after we have reinserted the carrier, to an a.m. detector, the detected output from which then provides our difference signal. (We will, of course, obtain the 38 kc/s for carrier reinsertion by doubling the 19 kc/s pilot frequency.) We now have our sum signal and our difference signal, and all that remains is to change these back to left and right-hand signals. One method of doing this *could* consist of adding them in or out of phase at the output transformers, as in Fig. 2 (*e*). However, it would in practice be preferable to add them in or out of phase by means of simple resistor networks closely following the f.m. discriminator and the a.m. subcarrier detector.

The new American system is compatible because, if the signal is received by an ordinary f.m. receiver, the latter responds only to the sum signal which frequency modulates the transmitter carrier. The 19 kc/s pilot subcarrier and the sidebands around the 38 kc/s suppressed subcarrier may also appear at the demodulator but, even if these frequencies can find their way through a conventional de-emphasis circuit and a.f. amplifier to the speaker, they will still be inaudible anyway. So the f.m. receiver responds to the sum signal only. The sum signal will be capable of offering good entertainment value, since the programme obtained would be equivalent to that given by the stereophonic microphone of Fig. 1 with both outputs paralleled. I should add that, with a stereo f.m. receiver, de-emphasis would not take place immediately after the discriminator. A more convenient point would occur after the left and right-hand signals had been separated.

V.H.F. Dx

I haven't left myself much space for news this month, so I think I had better pass quickly on to some interesting information in a letter from Cpl. D. Sugden, who is serving in Germany. Cpl. Sugden refers to the article by A. H. Uden in the July issue on "TV and FM Dx Reception via Sporadic E" and states:

"This was a very interesting feature but some of the information has now become out-dated frequency-wise. The frequency of the B.F.N. transmitter, Herford, quoted as being 93.00 Mc/s, is, in fact, now 92.9 Mc/s; the change took place at the end of last year. One other point, the Aachen transmitter of West-Deutsche-Rundfunk is now no longer on the air on 89.89 Mc/s. Its present frequency I don't know. The Dusseldorf area B.F.N. transmitter sends out 18kW on 89.15 Mc/s. A point to note is that quite a few of the German transmitters picked up were small output stations, viz.:

Aachen	98.4	5kW
Biedenkopf	91.2	10kW
Dusseldorf B.F.N.	89.15	18kW
Feldburg A.F.N.	94.9	10kW
Flensburg N.D.R.	97.8	15kW
Hamburg N.D.R.	96.3	5kW
Harz N.D.R.	88.2	100kW
,, ,,	96.0	30kW
,, ,,	99.9	100kW
Herford B.F.N.	92.9	10kW
Kleve W.D.R.	91.5	0.25kW
Langenburg W.D.R.	87.9	100kW
,, ,,	95.7	100kW
Linz S.W.F.	97.8	3kW
Munster W.D.R.	94.5	5kW
Nordhelle W.D.R.	93.9	15kW
,, ,,	98.7	15kW
Oldenburg N.D.R.	87.6	100kW
,, ,,	95.4	?
Teutoburger Wald W.D.R.	94.2	100kW
Teutoburger Wald W.D.R.	99.6	100kW
Verden B.F.N.	90.3	60kW

"The other B.F.N. transmitters are as follows:

Berlin	94.3	80kW
Bonn	91.4	3kW
Drachenberg	99.3	80kW
Herford	92.9	3kW
Dusseldorf	89.1	80kW

"In all there are no fewer than about 215 transmitters operating on 41 different frequencies in West Germany and West Berlin. In fact, with a good receiver and aerial, it is difficult to find a station-free spot on the dial. I haven't heard of anyone picking up any of the B.B.C.'s v.h.f. f.m. transmitters over here, but that is due more than anything else to the number of transmitters in operation here than to lack of signals.

"I hope that some of my information will be of help to anyone keen on the subject of v.h.f. Dx reception."

Many thanks for the information, Cpl. Sugden!

Mr. I. C. Beckett of Buckingham, the t.v. Dx king, has sent details of Dx reception over the year. I shall have to leave some of his comments until later but I can just squeeze in part of his letter. The following is a list of identified t.v. signals received by Mr. Beckett in 1961 up to August 2nd, together with the total time over which they were picked up. All reception was in the region 48–68 Mc/s and the receivers were standard commercial British models with simple modifications.

Country	*Total time hrs.*	*mins.*
Italy	58	4
Spain	37	34
Russia	30	14
Hungary	18	35
Czechoslovakia ..	10	10
Germany	8	48
Portugal	8	29
Austria	5	55
Sweden	3	49
Rumania	3	42
Poland	1	33
France..	—	15

A New Mullard Audio Triode Pentode

A recently introduced addition to the Mullard "World Series of Audio Valves" is the ECL86 triode-pentode.

Unlike its predecessor the ECL82, the new valve has been developed exclusively for a.f. applications and offers higher sensitivity consistent with high output, making practicable the use of a greater degree of negative feedback. A signal voltage of 50mV at the triode grid will produce 3W of audio output at the pentode anode in a typical single-valve amplifier.

The triode section of the ECL86 has an amplification factor of 100, and a mutual conductance of 1.6mA/V.

The anode dissipation of the pentode section is 9W, and its mutual conductance 10mA/V (Ia=36mA).

Special care has been taken in the design of the valve to keep the hum and microphony to a minimum. Maximum hum level referred to the triode grid is 4 microvolts. No special precautions against microphony are required in equipment where the input voltage is not less than 5mV for an output of 50mW.

The ECL86 is particularly suitable for use in stereo amplifiers. A medium sensitivity stereo pick-up gives an output of 70mV, which is substantially more than the valve requires to give full output.

Using two of the new valves Mullard engineers have designed a stereo amplifier that gives a power output of 3W per channel with a total harmonic distortion of 3%.

The ECL86 has maximum diameter of 22.2mm and a maximum seated height of 71.5mm. The base is B9A.

The JR1/JTL
Stereo Tape Recorder Unit

PART 2. By G. BLUNDELL

The JR1/JTL Stereo Tape Recording Unit offers stereophonic record and playback facilities, together with instantaneous tape monitoring. It is employed with a stereo amplifier. The unit can also allow all tape tracks to be recorded and played back in conjunction with a monaural amplifier or amplifiers, the instantaneous monitoring facilities still being retained for this application

THE VARIOUS ESSENTIAL PARTS OF A TAPE RECORDER are as follows. There is firstly the recording head, which is fed with the programme plus high frequency biasing. Secondly, there is the playback head for reproducing the signal recorded on the tape and, thirdly, there is the erase head which removes the recording prior to the new one being made. The three essential parts of the circuit are, therefore, the recording amplifier, the playback amplifier and the bias oscillator.

The sensitivity of the recording amplifier is approximately 100 millivolts and is intended to be used in conjunction with the same amplifier which is reproducing the recorded signal. Fig. 18 shows a block diagram of the Jason stereo amplifier J2-10, which is arranged so that the first part of the preamplifier may be disconnected from the tone control circuits. If, for example, one wished to make a tape recording from a gramophone record, the sequence of events would be as follows. The signal from the gramophone pick-up would be suitably corrected and equalised in the first stage of the J2-10 amplifier and then fed to the tape unit, where it would be recorded on the tape through the recording amplifier.

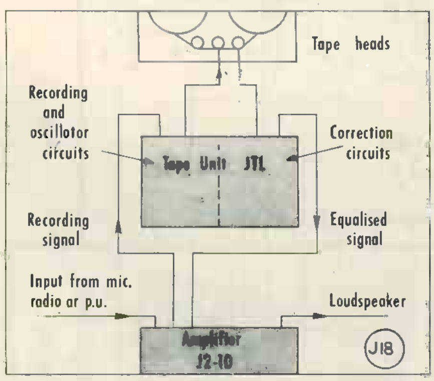


Fig. 18. Tape connections—one channel only

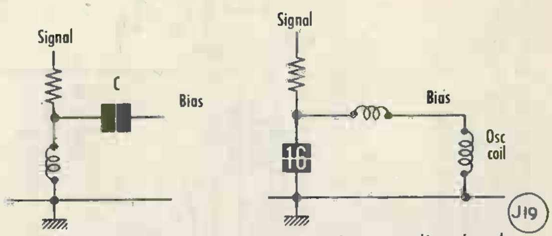
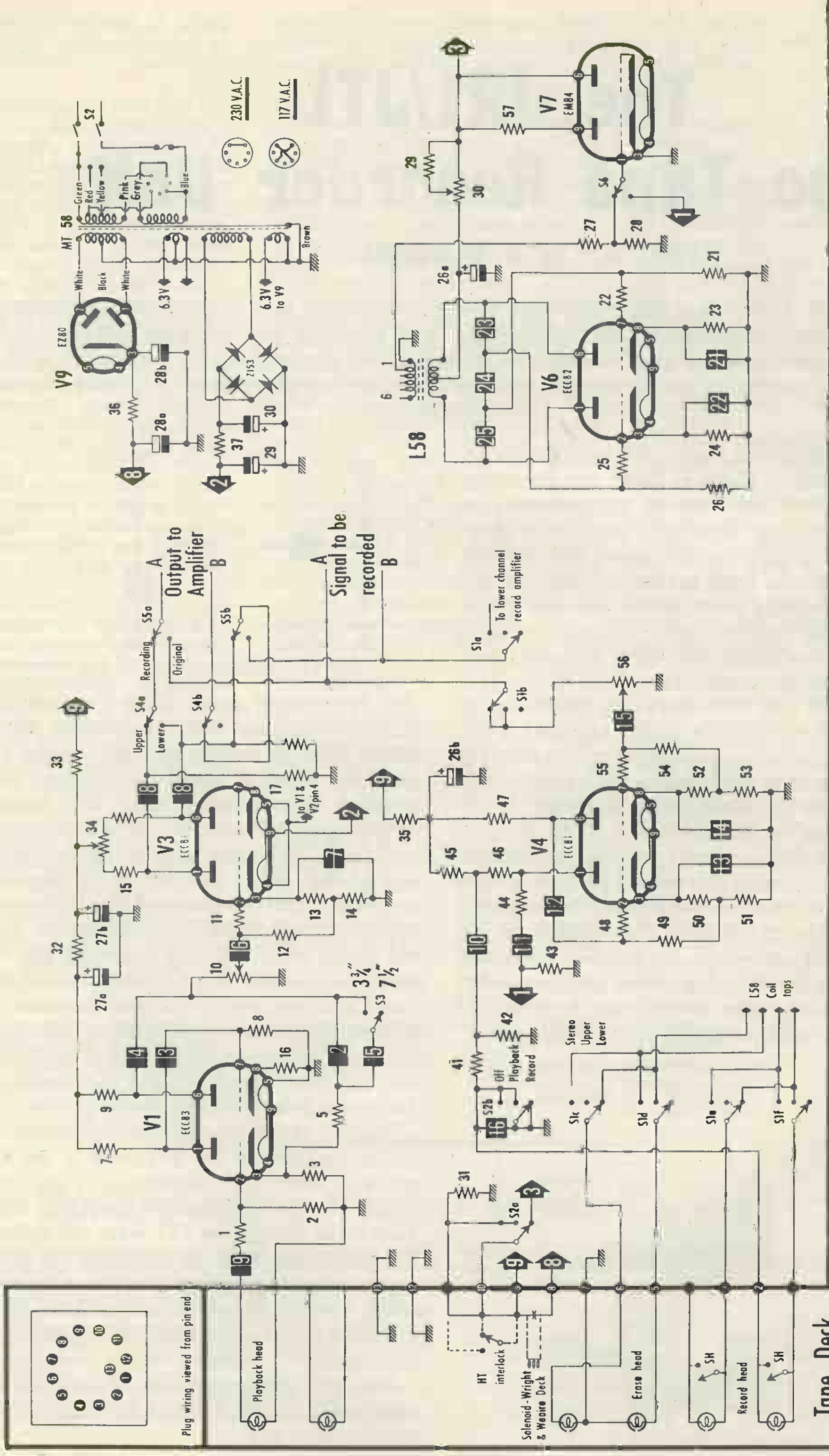


Fig. 19. Methods of feeding the recording head

The reproduced signal from the tape, after being suitably amplified and corrected in the tape unit, would then be connected back to the J2-10 main amplifier where it would be amplified to the loudspeakers in the normal way. This recorded signal is fed into the amplifier before the tone control circuits so that these circuits would operate on the reproduced signal but not affect the signal being recorded. The two parts of the J2-10 amplifier are therefore operating independently, the first part on the signal which is being recorded, and the second part on the signal which is being reproduced. These two signals are not, of course, the same due to the time which the tape takes to travel from the recording head to the reproducing head. The J2-10 amplifier will also play directly from a tape head, and therefore there is a further flexibility in that, with the aid of another tape deck, tape recordings may be copied.

The addition of the JTL unit to an amplifier in no way alters its operation. When the monitor switch is in the "Original" position, the amplifier behaves as though the JTL were not connected to it. Therefore, there is no necessity to change over inputs when one wishes to make a recording—anything which can normally be heard through the amplifier may be recorded just by switching on the JTL unit.

This ease of use can also be achieved with some other amplifiers by a minor modification and details will be given later.



J20

FIG. 20 JTL Stereo Tape Link for any Deck which can be fitted with three Heads.

jason

Fig. 20. Circuit diagram of the JTL Stereo tape link for use with any deck fitted with three heads

Components List

(Set out for easy reference to Fig. 20)

Playback Channel,
2 off required of each value

Resistors

R_1	1kΩ ±20%
R_2	47kΩ ±5%
R_3	2.7kΩ ±5%
R_5	100kΩ ±5%
R_7	150kΩ ±5%
R_8	470kΩ ±5%
R_9	100kΩ ±5%
R_{10}	250kΩ+250kΩ pot.
R_{11}	1kΩ
R_{12}	470kΩ ±5%
R_{13}	1.2kΩ ±5%
R_{14}	1.2kΩ ±5%
R_{15}	33kΩ ±5%
R_{16}	1kΩ ±5%
R_{17}	470kΩ ±20%

Capacitors

C_2	1,000pF 5%
C_3	0.05μF paper
C_4	0.05μF paper
C_5	1,000pF 5%
C_6	0.05μF paper
C_7	0.005μF paper
C_8	0.22 or 0.25μF paper
C_9	0.22 or 0.25μF paper

Record Channel,
2 off required of each value

Resistors

R_{41}	47kΩ ±5%
R_{42}	100kΩ ±5%
R_{43}	3.3MΩ ±20%
R_{44}	220kΩ ±20%
R_{45}	15kΩ ±5%
R_{46}	15kΩ ±5%
R_{47}	47kΩ ±5%
R_{48}	1kΩ ±20%
R_{49}	470kΩ ±20%
R_{50}	1.2kΩ ±5%
R_{51}	2.2kΩ ±5%
R_{52}	1.2kΩ ±5%
R_{53}	2.2kΩ ±5%
R_{54}	470kΩ ±20%
R_{55}	1kΩ
R_{56}	250kΩ+250kΩ pot.
R_{57}	680kΩ ±20%

Capacitors

C_{10}	0.22 or 0.25μF paper
C_{11}	0.01μF paper
C_{12}	0.05μF paper
C_{13}	0.005μF paper (see text)
C_{14}	0.005μF paper (see text)
C_{15}	0.05μF paper
C_{16}	Given by lead capacitance (see text)

The following components are common to both channels so that only one of each is required

Resistors

R_{21}	22kΩ ±5%
R_{22}	1kΩ ±20%
R_{23}	1kΩ ±5%
R_{24}	1kΩ ±5%
R_{25}	1kΩ ±20%
R_{26}	22kΩ ±20%
R_{27}	10kΩ ±5%
R_{28}	2.2kΩ ±5%
R_{29}	470Ω ±20%
R_{30}	25kΩ w. wound potentiometer
R_{31}	22kΩ w. wound ±20%
R_{32}	10kΩ ±20%
R_{33}	10kΩ ±20%
R_{34}	10kΩ preset pot.
R_{35}	3.3kΩ ±20%
R_{36}	2.2kΩ w. wound ±20%
R_{37}	2 x 33Ω or 15Ω 1W ±20%

Capacitors

C_{21}	0.04μF paper
C_{22}	0.04μF paper
C_{23}	4,700 or 5,000pF polystyrene
C_{24}	4,700 or 5,000pF polystyrene
C_{25}	4,700 or 5,000pF polystyrene
C_{26a}	50μF 275VW
C_{26b}	50μF 275VW
C_{27a}	50μF 275VW
C_{27b}	50μF 275VW
C_{28a}	32μF 350VW
C_{28b}	32μF 350VW
C_{29}	250μF 18VW
C_{30}	1,000μF 25VW

Switches

S_1	Stereo/Upper/Lower recording switch
S_2	Off/Playback/Record
S_3	7½/3¾in correction
S_4	Upper/Lower track Playback switch
S_5	Monitor switch
S_6	Bias/Signal switch

Valves

V_1	ECC83
V_2	ECC83
V_3	ECC81
V_4	ECC81
V_5	ECC81
V_6	ECC82
V_7	EM84
V_8	EM84
V_9	EZ80

Miscellaneous

Oscillator Coil L58
Bridge Rectifier Z153
Mains transformer MT58

If a modification to the main amplifier is not practical, then it would be necessary to use a preamplifier with the tape unit. This preamplifier would have to have an input selector switch covering the normal input requirements, such as pick-ups, microphone and radio, together with any necessary correction circuits. These inputs could then be left permanently connected to the preamplifier. If radio input only were required to the tape recorder, this could be left permanently connected to the "A" Recording Input.

The Recording Amplifier

On the circuit diagram V_4 is the recording amplifier valve. The head is fed through the series resistor R_{41}, which helps to keep the current in the head constant independent of frequency. The value of this resistor is chosen to be that suitable to damp any possible oscillations in the record head. The impedance of a tape head is, of course, mainly an inductance and this, together with the bias feed capacitor, C_{16}, will resonate. Although the performance of this resonant circuit (whose Q is about 5) is not very good, it can still cause bad behaviour on transients, and therefore the series resistor R_{41} also acts as the damping resistor and must not be too high in value. The resistor R_{42} merely serves to keep the potential on C_{10} at earth, otherwise when only one channel is in operation there would be no d.c. potential across C_{10}. When this channel is switched into use C_{10} would be charged through the recording head and would very thoroughly magnetise it.

Because the Magic Eye is less sensitive than the head, the output for the head is taken from a tapping on the load of V_{4a}, whilst the full signal voltage is applied to the Magic Eye. Resistor R_{44} serves to prevent Magic Eye grid current from causing distortion of the recording signal. The necessary h.f. boost of the recording signal is achieved by decoupling the cathodes of V_4 with the small value capacitors C_{13} and C_{14}. The values given in the Components List for these two capacitors are suitable for the Bogen and Miniflux heads. Suitable values for other heads will be given later.

There are two methods of feeding a recording head. Normally when one head is used for both recording and playback switching can be simplified by having one end of the head winding connected to chassis. In this case, both signal and bias must be fed into the other end of the head winding. This is the least efficient way of working because it means that the bias voltage has also to be applied across the series resistor, with the result that a relatively high proportion of the bias voltage can get back to the anode of the recording amplifier where it may cause intermodulation troubles. When longer leads to the heads are required there is the further disadvantage that the lead capacitance would shunt the bias signal and thus require a larger value of feed capacitor to maintain the bias voltage. This increased capacitance plus the lead capacitance would shunt the audio frequencies as shown in Fig. 19.

By feeding the bias voltage at one end of the head and the signal voltage at the other, all these difficulties are minimised. The audio signal has to travel through the oscillator coil but since this has a very low impedance, no difficulties arise.

Two leads are required to the head, but the effect of the unavoidable capacitance of these leads is now very different. C_{16} is necessary to provide a path for the bias frequency without being large enough to affect the higher audio frequencies, and it carries out exactly the same function as in the previous circuit. This capacitance (C_{16}) may be replaced by the capacitance of the lead to the head, which does not therefore affect the performance. When a 0.5 Henry head is used, C_{16} is provided by the lead capacitance, the latter having a length of 3 to 4ft. A physical component in the C_{16} position is not then required. The capacitance of the other lead to the head appears directly across the oscillator coil secondary where it does no harm at all. It can be seen that the head switching would be more complicated if this same head had also to reproduce. In our case, however, the "series" feed to the head is the better choice.

Despite the precautions just mentioned, it is still very necessary not to employ undue lengths of screened cable and, also, to use t.v. coaxial cable, which has a much lower capacitance than conventional screened lead.

(To be continued)

NEWS AND COMMENT

(continued from page 194)

an illustrated talk "Twenty-five years of B.B.C. Recording".

● The National Film Archive which, in the national interest preserves films of historic and artistic value, has selected five Mullard films for preservation.

● The French State electricity authority has placed an order with Wayne Kerr Laboratories for a computer that can solve electric power line problems.

● As a consequence of the decision made by A.E.I. (Woolwich), formerly Siemens Edison Swan, to cease all activity in connection with the manufacture and sale of transisitors and semi-conductor devices, their factory at High Road, Tottenham has been put up for sale.

● The General Electric Co., has been awarded a three million dollar contract to supply radio and multiplexing equipment for a microwave network linking important towns in Peru.

● The records of the state graduated pension scheme are to be kept by the largest electronic computer system in this country.

Britain's second computer exhibition is to be held at Olympia from 3rd to 12th October.

● Home Telerentals Ltd., the very

successful northern firm of radio and television dealers, also operate a chain of dry-cleaning shops which are being substantially increased in number as the result of a share acquisition.

● The chairman of the Dubilier Condenser Co. (1925) Ltd., referred in his annual statement to the recession in the television industry and the adverse effect on his company as suppliers of large quantities of mass produced components. Notwithstanding, the company's total turnover was well maintained but the pattern of sales changed

Despite the name of the firm it was interesting to observe that references were always made, quite correctly, to capacitors.

● The Pye Transhailer, a hand held transistorised megaphone with a range of 400 yards or more, has been selected for exhibition at the Design Centre, London, and in future will carry the Council's special Design label.

The Council of Industrial Design was set up "to promote by all practical means the improvement of design of British industry".

A Constructor Visits the 1961 National Radio Show and G.E.C. Exhibition

THE 1961 NATIONAL RADIO SHOW at Earls Court was especially intended to mark the Silver Jubilee of British high definition television, since it was at the 1936 Exhibition that visitors were first able to see high definition transmissions from Alexandra Palace. To mark the occasion the 1961 Radio Show demonstrated colour transmissions for the first time.

It is very probable, however, that this year's Show will go down into history not because it marks the 25th anniversary of the emergence of television nor, even, because it was the first in which colour television was staged. Instead, it will be remembered because it set the scene for an unhappy controversy between set-makers on the question of whether this country should retain its present 405 line system or commence the change-over to 625 lines. As readers will be aware, the question of the introduction of colour must wait until a Government decision on line standards is forthcoming. This decision has not, at the time of writing, been made and is not, indeed, expected until the Pilkington Committee makes its report in 1962.

A minor complication this year was that the General Electric Company (together with McMichael and Sobell) did not appear at Earls Court, but exhibited separately at the New Horticultural Hall, Westminster. This report will, nevertheless, deal with the separate G.E.C. Exhibition in the same context as the main Radio Show at Earls Court.

Controversy

The controversial aspect of the 1961 Radio Show was evident right from the start in the opening speech by Lord Boothby. Lord Boothby stated: "The question of 405 or 625 lines must be resolved one way or another before colour can be added —and colour must be added. And we cannot wait another two years for a decision.

"If I were the Postmaster-General, and I often think what a pity it is that I am not, I would decide the future of television in this country and the number of lines. And in no long time either."

Fortified with this statement, which was widely reported in the national Press, what did the visitor to the Earls Court Show find? He might first have noticed a number of receivers reproducing 625 line pictures dotted around the various stands in positions which ranged from the relatively inconspicuous to the blatantly obvious. For example, Ferguson showed a modified "Senator" model 705 19in receiver displaying a 625 line picture all on its own at one corner of the stand. Dynatron showed a receiver which was continually switched from 405 to 625 lines so that a comparison could be made of the two pictures. Unfortunately, the switching arrangements necessitated a slight pause with a blanked-out screen whilst the circuits were switched, and it was difficult to make a direct comparison between the two pictures. Stella showed a 625 line receiver alongside a model of the same type displaying a 405 line picture, and it was very easy here to compare the resolution offered by the two systems. It must be pointed out that the two receivers were not showing the same scene, the 625 line picture being a standard programme (of fish swimming in a glass tank) which was piped to all stands displaying 625 line receivers, whilst the 405 line picture was taken from one of the studios at the Exhibition. The writer's opinion of the two pictures was that there was a very obvious reduction of "lininess" in the 625 line picture, and that horizontal definition was noticeably better.

It should be pointed out that the manufacturers just referred to stated that some or all of their current models were capable of being converted to 625 lines. So also did other set makers, including Bush, C.W.S., Decca, Ekco, Ferranti, Invicta and Ultra. The Decca announcement carried the somewhat pointed comment: "All Decca receivers displayed can be converted to 625 line reception —should this be necessary."

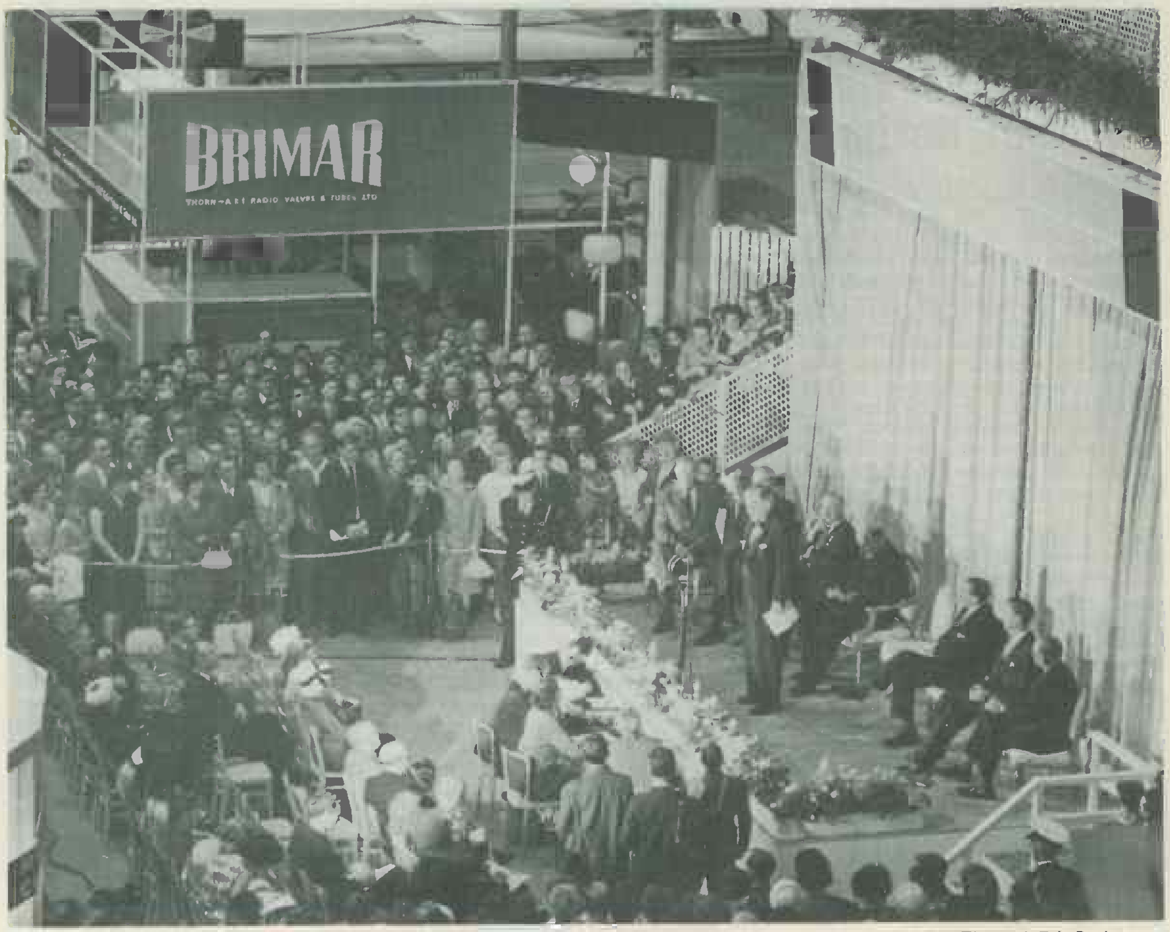
This somewhat cautious approach was not evident with the Pye display, whose main motif consisted of the figures "625" incorporated into the stand design. The centre of attention on this stand was the new Pye 405/625 19in receiver which is already fitted with a changeover switch (but not, as yet, the necessary u.h.f. tuner). The Pye literature states: "The Pye 405/625 t.v. set—which you can buy today—is fitted with the amazing Pye switch enabling you to receive 405 line pictures now . . . and the new high-definition 625 line pictures from the moment they come on the air." A Pye Press Release stated that large quantities of the new model have been mass-produced and supplies are being sent to thousands of dealers. Several Pye 405/625 models were on display, and the writer checked the operation of the line standard switch on one of these. Change-over from one standard to the other was instantaneous.

A number of leaflets explaining the present 405/625 line situation were available to the public, one of these being issued by the British Radio Equipment Manufacturers' Association (and which was reprinted from the Exhibition Catalogue). This gave a sober and carefully outlined picture of the situation up to the present time. More direct was "All you want to know about 625!" issued by Pye, which stated quite definitely that, with 625 lines, "viewers get a better picture". An alternative leaflet issued by Stella, "Questions and Answers on 625 lines", states that 625 lines give a *slightly* (the writer's italics) better picture "because the lines are less visible". Going down the scale a G.E.C. booklet *The Facts about Line-Standards and Colour TV* (available at the New Horticultural Hall exhibition) answers the question "Would the 625 line system give a better picture?" with "Probably not"! The G.E.C. booklet also states that "The general opinion of people who have compared the different systems [in Britain and in countries which use 525 and 625 line systems] is that the average picture quality in Great Britain is a good deal better than the average in other countries."

Colour Television

The writer has devoted rather a lot of space in this report to the 405/625 line argument because this represents an important aspect of conditions currently prevailing in the television industry. Let us now turn to other features shown at the Exhibition.

The colour television demonstrations, both at Earls Court and the New Horticultural Hall attracted considerable attention. The Earls Court demonstration employed signals from a local studio and used the B.B.C. version of the American N.T.S.C. system on 405 lines. In the N.T.S.C. system the transmitter carrier is modulated by a main signal which is equivalent to that given in a black and white system and which occupies the same bandwidth. Colour information modulates a subcarrier removed from the main carrier, and it has a much lower bandwidth. This lower bandwidth is permissible because the eye does not detect colour in small areas; and an overall impression of full colour is given despite the low resolution of the colour information. Two colour signals must be transmitted if three primary colours are to be resolved at the screen of the tube, the third primary colour being extracted at the receiver by comparing the two colour information signals and the main, full definition, signal. In the N.T.S.C. system the two colour signals modulate the subcarrier in quadrature (i.e. at 90° phase difference) and are recovered at the receiver with the aid of an oscillator which not only runs at the same frequency as the subcarrier but also stays locked in phase with it. This oscillator is synchronised by a "colour burst" on the back porch of the transmitted signal, the colour burst consisting of



Lord Boothby making the opening speech at the Radio Show, 1961, with the Brimar Stand of the new Thorn-A.E.I. Radio Valves and Tubes organisation in the background several cycles at subcarrier frequency.

The colour subcarrier is contained within the channel width which would normally be allocated to the transmitter for black and white operation. A colour receiver tuned to the transmission reproduces a colour picture with the aid of the information on the main carrier and the subcarrier. At the same time a black and white receiver only responds to the main carrier, which it handles as a monochrome signal.

In the Earls Court set-up a number of colour television receivers were positioned at intervals along the first floor, each receiver having alongside it a black and white set reproducing the same programme. This was a most effective method, to the writer's mind, of demonstrating the added life which colour can give to a television programme. Colour reproduction was very acceptable, especially with regard to tonal values. Flesh colour, which is notoriously difficult to reproduce, was particularly good in the cases seen. Colour presentation appeared to be somewhat "soft", as opposed to the "hard" brilliance of, say, early Technicolor, and the writer had the impression of very slight "fringing" in so far that some colours did not appear to be entirely contained within their proper outlines. He would add that this last criticism is a subjective impression only, and that it was in any case very slight in character.

The G.E.C. demonstrations included both the N.T.S.C. system and the recently developed SECAM system. The latter, proposed by a French engineer, Henri de France, is now being developed by the G.E.C. in collaboration with Compagnie Francaise de Television. The SECAM system differs from the N.T.S.C. system in that the two colour signals are not transmitted at the same time but sequentially, one of the signals being delayed locally at the receiver so that both may be applied to the tube circuits at the same time. A colour burst is transmitted during line retrace with the SECAM system but its function is not that of synchronising a receiver oscillator, as in the N.T.S.C. system. Instead, it merely marks the commencement of the first of the two colour signals so that these may be separated correctly in the receiver. The advantage claimed for the SECAM system is that this obviates the necessity of having a very tightly synchronised oscillator in the receiver, and, therefore, allows a significant improvement in reliability and easing of maintenance problems.

The colour pictures exhibited by G.E.C. consisted of local studio presentations in N.T.S.C. and SECAM together with B.B.C. colour broadcasts on N.T.S.C. All those seen by the writer were of high quality and he would say, since it was impossible to make a direct comparison, that they were similar to those he saw at Earls Court.

Other Exhibits

A noteworthy feature of the Show was the fact that armchair control of t.v. receivers was offered by practically all manufacturers. One receiver, the Ekco "Magic-Ray", changes from B.B.C. to I.T.A. and vice versa when an ordinary pocket torch is flashed three or four times towards the set. A photo-cell in the receiver detects the flashes and causes the set to be switched to the other channel. Three or four flashes are needed so that the control circuit can discriminate between the torch signals and those given by switching room lights off and on. The Philco "Selectaflash" operates in a somewhat different manner. There are two ports over the screen, flashing a torch at one port changes channels, flashing it at the other causes sound to be switched off or returned to its pre-set level.

The Dynatron "Space Director" uses ultrasonic sound waves to control channel or volume. The control unit has a small lever hinged at its centre, either end of which may be pressed according to whether it is intended to change volume or channel. Pressing the lever at the appropriate end causes one of two tuned reeds to vibrate, the ultrasonic note generated thereby being picked up by a microphone built into the receiver. The Murphy "Super-sonar" control offers similar facilities.

An interesting innovation was a stand devoted entirely to transistor radios of all makes. This showed very effectively the range of sizes currently available, the smallest receivers being 2⅞ x 4⅛ x 1⅛in (Perdio) and 3 x 4 x 1⅛in (Pye). Last year Roberts Radio exhibited (on their own stand) a jewel encrusted transistor portable studded with 70 real diamonds and other mixed stones. This year Roberts Radio exhibited a portable fitted in a solid gold case, this selling at 2,000 guineas. The snag about gold cases is, of course, that they tend to offer rather good screening. The writer noticed the top of a telescopic aerial poking out of the corner of this particular model!

Within the first few days of the Show, Multicore Solders Ltd. received what is thought to be the biggest order from the United States for an exhibitor. The order was for £64,000 worth of solder and Multicore factories are now on overtime to complete the order by early next year.

The Mullard Home Constructor Demonstration Room provided, as always, a centre for radio enthusiasts. Featured by Mullard is the new ECL86 triode-pentode which has been developed exclusively for a.f. applications. An input of 50mV at the triode grid can produce 3 watts of audio output at the pentode anode. A new 10 watt stereo amplifier has now been designed using two ECL86's and one EF86 per channel, and the performance of this compares favourably with the Mullard "5–10" circuit. Also shown was the new PC97 triode amplifier for t.v. tuners. This valve, when neutralised, replaces the conventional cascode input stage with considerable simplification of circuit design. The PC97 is already being used in current Ferguson and Marconiphone t.v. receivers. Also introduced is a new rectifier, the PY33, which offers 10 volts more output than comparable existing rectifiers. The secret is a substantial reduction in anode-cathode spacing, this being effected by a new "pressed-powder" cathode having a hard shiny surface. This surface prevents the sputter effect given by overheating of high spots on conventional cathodes.

Daystrom Ltd. introduced several new kits to their already extensive Heathkit range. These new kits include a transistor intercom system (type XI-1U and XIR-1U) which is in the form of a Master Unit with up to five Remote Stations. Comprehensive interconnection facilities are provided and the whole assembly is, of course, battery operated. Also new was the Single Sideband Adaptor Model SB-10U; a transistorised general coverage receiver (550 kc/s to 30 Mc/s) Model GC1U; the "Malvern" high fidelity cabinet unit (for all components of a hi-fi set-up except speakers), and the Sine-Square Wave Generator Model AO-1U (20 c/s to 50 kc/s square, 20 c/s to 150 kc/s sine).

On the first floor there was a separate audio section. Here the writer's eye was suddenly caught by a display of *The Radio Constructor* on the Jason Electronic Designs Ltd., stand. This firm are supplying a kit for the Stereo Tape Recorder Unit described by G. Blundell which is, of course, being currently featured in this magazine. We trust that those of our readers who wished to buy a copy in advance of publication were not disappointed to learn that they were for display purposes only.

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1S5	7/6	ECL80	10/6	PCL83	12/6
3S4	7/6	EF80	8/–	PCL84	12/6
3V4	7/6	EF86	12/6	PL81	12/6
DAF96	9/–	EL84	8/6	PL82	9/6
DF96	9/–	EY51	9/6	PL83	10/6
DK96	9/–	EY86	10/–	PY32	12/6
DL96	9/–	EZ81	7/6	PY81	9/6
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50/50V	2/–	32+32/275V	4/6
100/25V	2/–	50+50/350V	6/6
8/450V	2/3	60+250/275V	12/6
4/350V	2/3		
16+16/450V	5/6	100+200/275V	12/6
32+32/450V	6/6		

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

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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, 15/–	900ft, 19/6	1,200ft, 31/6
5¾"	900ft, 16/6	1,200ft, 22/6	1,800ft, 39/6
7"	1,200ft, 21/–	1,800ft, 32/6	2,400ft, 47/6

Post and Packing, per reel, 1/–, plus 6d. each for additional reels.
SPECIAL OFFER—3" mfrs. surplus tape, 225ft, 5/6. P. & P. per reel 6d.
Plastic Tape Reels, 3" 2/6, 5" 3/–, 5¾" 3/3, 7" 3/6.

Volume Controls—5K–2 Megohms, 3" Spindles Morganite Midget Type. 1½" diam. Guar. 1 year. LOG or LIN ratios less Sw. 3/–. DP. Sw. 4/6. Twin Stereo less Sw. 6/6. D.P. Sw. 8/–.

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

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Auto-Changers	carr. 4/6
Garrard RC210	**£10.10.0**
Collaro "Conquest"	**£7.15.0**
B.S.R. (UA8)	**£6.15.0**
B.S.R. (UA8 Stereo)	**£6.19.6**
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SINGLE SCREENED LEAD—Standard size, **8d.** yd.; Ditto Lightweight for Pick-up, etc., **7d.** yd.; ditto lightweight for PVC sheathed, **9d.** yd.; Twin screened sheathed, **1/–** yd.

VALVEHOLDERS—Paxolin: Int. Oct., **6d. Moulded:** B8G, **9d.** each; **Nylon or Moulded Ceramic:** B7G, B9A unskirted, **9d.** each; B7G, B9A skirted, **1/–** each; B7G with Can, **1/6** each; B9A with Can, **1/9** each; EF50, B7G, **1/–** each; B9A ditto, **1/3** each.

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M. & L.W.	5/9
Midget Driver Trans. 3.5:1	6/9
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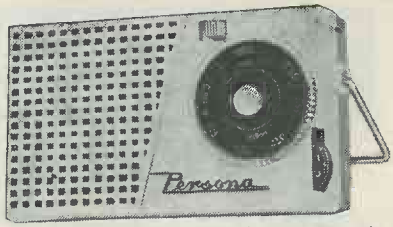

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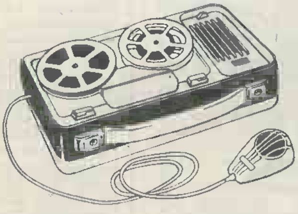

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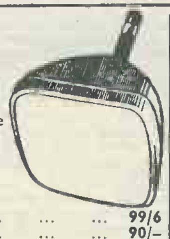

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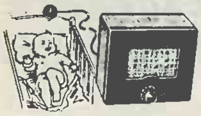

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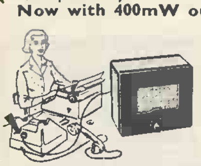

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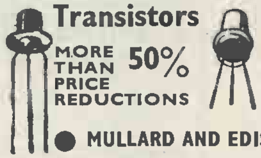

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BOTH TYPES ARE FULLY GUARANTEED

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59/6 P.P. 2/–
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★ Standard Volume Controls, ¼in dia., 3in spindle: 5k, 10k, 25k, 50k, 100k, 250k, 500k, 1 meg, 2 meg, **3/6**, less switch; **4/6** with switch.

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★ Crystal Lapel Microphone, ideal for portable tape recording, **18/6**. P.P. 1/–.

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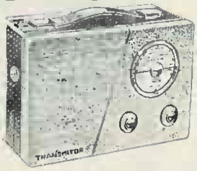

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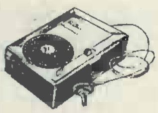
3-TRANSISTOR and 2 DIODES



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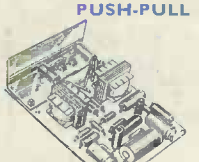

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- Uses OC71/OC8-ID, 2—OC81.
- ±3dB 70 c/s to 12 kc/s.
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UNBEATABLE IN PERFORMANCE AND APPEARANCE

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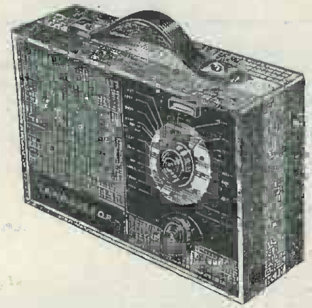

Employs the latest techniques. Double tuned IF'S, AVC and first-grade components are standard features. Excellent tone, sensitivity and selectivity on both wavebands.

- 425mW Push-Pull Output.
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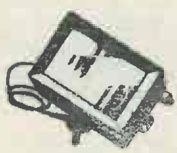

ALL PARTS
37/6 P.P. 1/6
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Size $4\frac{3}{8}$ x 3 x $1\frac{1}{4}$in

Quality output on personal earphone
Three Transistor and Diode.

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"QUINTET"

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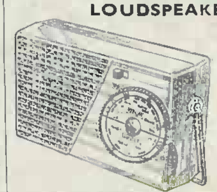

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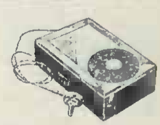
RANGER 2

PERSONAL POCKET RADIO



Two Transistor Two Diode version of "Ranger-3". Ideal pocket receiver.

All Parts **59/6** P.P. 1/6

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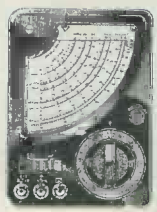
POCKET TESTER

MODEL 200H



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Size $4\frac{1}{2}$ x $3\frac{1}{4}$ x $\frac{1}{16}$in. Over 20 Scales.

20,000 Ohms/Volt!

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