THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

VOLUME 15 NUMBER 7
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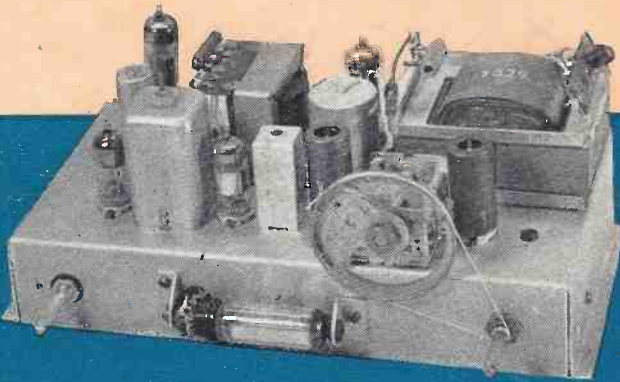
February 1962

Inexpensive VHF Receiver

● Long Cycle Periodic Switch ● Transistorised Tone Control Unit ● Simple Oscilloscope ● Single Transistor C-R Bridge ● Grid Current and Grid Blocking ● An Indoor Workshop ● Simple Transistor Time Switch ● Emitter Follower Circuits, Part 2 ● Radio Astronomy, Part 5 ● Importance of a Good Aerial and Earth ● In Your Workshop ● A Simple Geiger-Müller Counter



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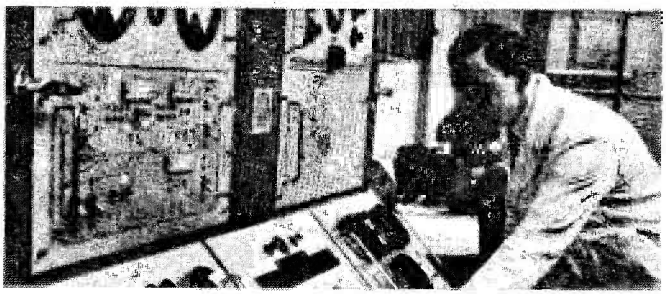

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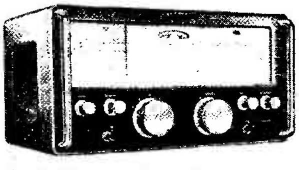

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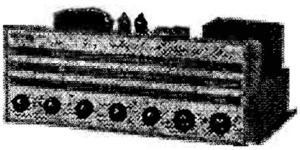

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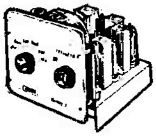

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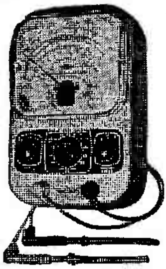

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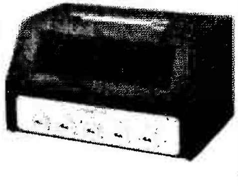

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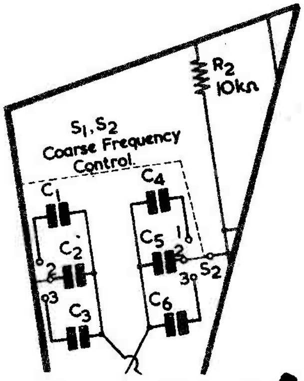

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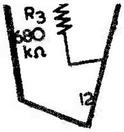
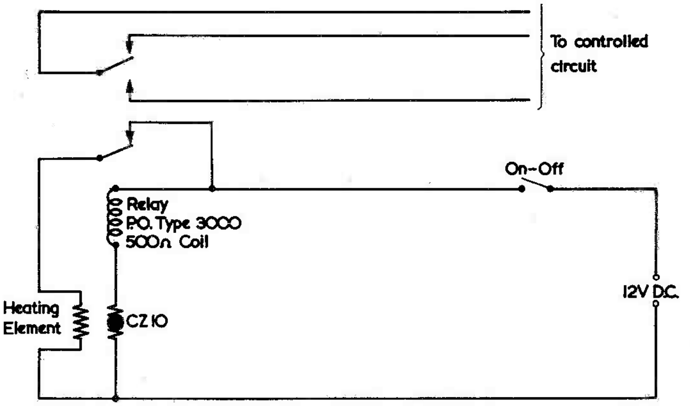


No. 135 A LONG-CYCLE PERIODIC SWITCH

THE WRITER HAS, IN THE PAST, described two periodic switches capable of continuously turning equipment on and off at regular intervals. The first appeared in "Suggested Circuits No. 88" (published in the March 1958 issue of this magazine) and employed a relay with a high resistance coil across which was connected a large electrolytic capacitor. The relay was coupled to a high voltage supply via one of its own contacts and a series resistor. When the supply potential was originally applied the voltage across the relay coil rose slowly as its parallel capacitor charged. After a period the voltage across the relay coil was sufficient to cause it to energise, whereupon its contact broke the connection to the supply. The voltage across the relay coil then fell slowly as the parallel capacitor discharged into it. After a period the relay de-energised, whereupon its contact re-connected the supply voltage and another cycle commenced.

The second periodic switch appeared in "Suggested Circuits No. 121" (published in the December 1960 issue) and this employed the charge and discharge of two capacitors to control a relay. By using a transistor it became possible to employ relatively low value capacitors and to operate the switch from a low voltage supply. This device was exhibited as a working model at the 1960 Radio Hobbies Exhibition, at which it successfully carried out more than 75,000 switching cycles!

Despite (or perhaps because of) the extreme simplicity of their circuit design, these two periodic switches have resulted in considerable comment from readers. In consequence, the writer has no qualms in introducing a third periodic switch. This, also, has very simple circuitry, but it employs completely different time delay components.



CZ10 – Standard Telephones and Cables Ltd.
Heating Element – see text

M218

Fig. 1. The circuit of the periodic switch

The periodic switch described in this article has higher power requirements than the previous circuits, and experiment is needed with regard to one of the components. On the other hand the cost of the timing components (thermistor and heating element) can be a matter of several shillings only.[1] The switch has the considerable advantage of offering long switching cycles. A prototype gave a cycle of some 50 seconds, and this could probably be extended to several minutes, if necessary.

The Circuit

The circuit of the periodic switch is given in Fig. 1. When, in this diagram, the on-off switch is closed, the 12 volt supply is fed, via the lower relay contact, to the heating

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[1] The thermistor, itself, retails at 1s. 6d.

element adjacent to the CZ10 thermister. The heating element warms up and, in so doing, raises the temperature of the thermistor. The latter has a negative temperature coefficient of resistance, its resistance decreasing as its temperature rises. After a period the resistance of the thermistor is sufficiently low to allow the relay to energise. When the relay energises, its lower contact disconnects the supply to the heating element, with the result that the latter, together with the thermistor, commences to cool. The resistance of the thermistor now rises, causing a decrease in relay coil current. When it has cooled sufficiently, the thermistor resistance is such as to allow the relay to de-energise. At once, the lower contact of the relay completes the 12 volt supply to the heating element, with the consequence that the latter starts to warm up again and to raise the temperature of the thermistor. Thus, another cycle commences.

There is a spare set of contacts on the relay which is not employed in the heating element circuit. This spare set of contacts can be used to switch the external circuit controlled by the periodic switch.

In some cases it may be found desirable to employ a separate source of supply for the heating element. In this instance, the circuit shown in Fig. 2 may be used. The operation of the circuit of Fig. 2 is exactly the same as that of Fig. 1, the only change being the introduction of the second source of supply.

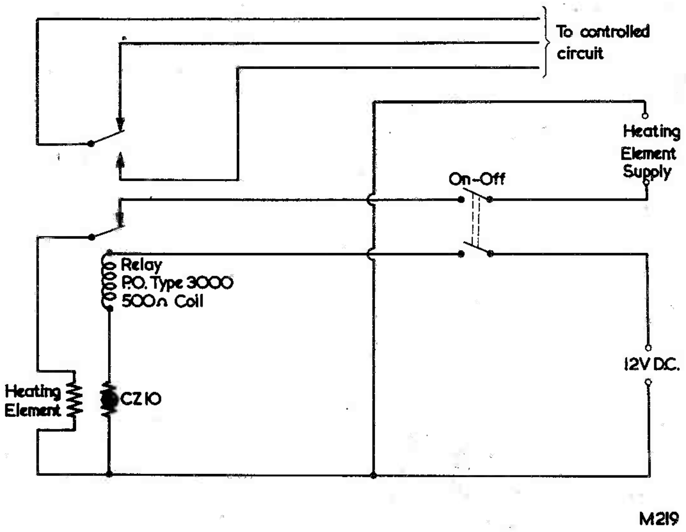

Fig. 2. An alternative circuit employing a separate supply for the heating element

Points of Design

As with the previous periodic switches, the present device functions because the energising current of the relay is higher than the de-energising current. The energising current of a Post Office type 3000 relay with a 500Ω coil and two sets of contacts (the type specified here) is approximately 14mA, whilst the de-energising current is approximately 7mA. These energising and de-energising currents are an essential feature of the design of the present circuit. If alternative relays (or a P.O. type 3000, 500Ω, relay having less or more than two sets of contacts) are employed, the circuit may not function correctly.[2]

Assuming an energising current of 14mA, the specified relay energises (and switches off the supply to the heating element) when a voltage of 7 appears across its coil. In Figs. 1 and 2 this corresponds to a voltage of 5 across the CZ10 thermistor, together with a resistance in it of some 360Ω. The manufacturer's figure for resistance at maximum operating current for the CZ10 is 148Ω and it may, in consequence, be stated that the thermistor is run comfortably below its maximum operating temperature in the present application. The relay supply potential corresponding to 148Ω thermistor resistance and 14mA energising current is 9.1, and this would be the minimum safe voltage which could be employed in the present circuit without the risk of over-heating the thermistor. In practice it would be safe to ensure that the relay supply voltage did not fall below some 10.5 to 11 volts. Supply voltages above 12 volts may alter the length and characteristics of the switching cycle but will not incur the risk of over-heating the thermistor.

The heating element is completely experimental in nature and is not specified here. In order to prove the working of the circuit, the writer employed in the prototype the arrangement shown in Fig. 3. In this diagram the thermistor, together with two pieces of mica, is illustrated as being held loosely to the barrel of an Adamin type A6C, 6 volt, 6 watt miniature soldering iron,[3] the replaceable bit of the latter having been removed to reduce thermal inertia. By employing the circuit of Fig. 2 and a heating element supply voltage of 5, this set-up gave approximately 50:50 timing cycles of 50 seconds duration (i.e. approximately 25 seconds "on" and 25 seconds "off").

It will be noted that the degree of thermal coupling between the soldering iron barrel and the thermistor in Fig. 3 is relatively low. At its reduced voltage the power consumed by the soldering iron was approximately 5 watts; and it would appear possible, with tighter thermal coupling, to achieve equivalent results with a heating element dissipation of two watts or so.

The question of over-heating the thermistor has already been mentioned. The risk of over-heating is greater with the circuit of Fig. 2 because, should the 12 volt relay supply fail, the heating element will

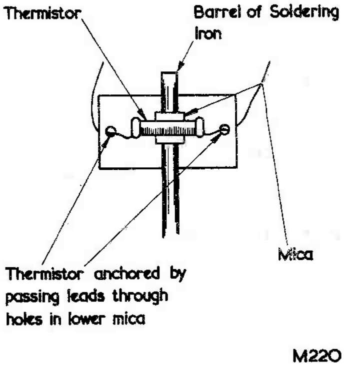

Fig. 3. The experimental heating element and thermistor assembly employed in the prototype

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[2] A suitable relay, fitted with two sets of changeover contacts, is available from H. L. Smith & Co. Ltd., 287 Edgware Road, London, W.2.

[3] Manufactured by Light Soldering Developments, Ltd., Croydon.

remain continually switched on via the lower contact of the relay. The circuit of Fig. 1 ensures that the heating element is automatically disabled if the 12 volt supply fails.

Timing Periods

The length of timing cycles can be adjusted, within limits, by varying the warming-up and cooling-off periods of the thermistor. With the prototype, in which the thermistor was in free air, it was found that the cooling-off period, between relay energising and de-energising, remained reasonably constant at 25 seconds. The length of this cooling-off period could be increased by enclosing the thermistor (and the heating element) in suitable thermal insulation. Reducing the cooling-off period may be a little more difficult. A suggested approach here could consist of fitting radiating heat sinks to the soldered connections at either end of the thermistor.

Unlike the cooling-off period, variations in the warming-up period (from relay de-energise to energise) are extremely simple to carry out. Initial adjustments may consist of varying the thermal coupling between the heating element and the thermistor. If desired, further adjustments can then be made by varying the current flowing through the heating element. It would, indeed, be possible to fit a panel control for varying the length of the complete switching cycle, this control consisting of a variable resistor in series with the heating element. With such an arrangement the cooling-off period would necessarily be constant, and the panel control would vary the length of the warming-up period only.

Practical Points

A few practical points need to be mentioned.

It would be advisable before embarking on the circuit, to ensure that relay energising coil currents (or voltages) are reasonably close to those mentioned above. (The 14mA energising current corresponds to a voltage of 7 across the 500Ω relay coil, and the 7mA de-energising current to a voltage of 3.5.)

It may be found helpful, whilst setting up the thermistor and heating element, to monitor relay coil current (or voltage). Since the switching periods are long it is quicker, during initial experiments, to observe the rate of change of meter reading than to time the operation. The thermistor has a small amount of inertia, and this may cause relay current to increase slightly for a second or so after the supply to the heating element has been cut off.

It was found, with the prototype, that the first two or three cycles of operation immediately after switching on were slightly non-standard; after this, the switch settled down to a constant cycle.

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

Panoramic Radio Adaptor Model RCX.—R. S. Hodgson, 4 Westmoors Road, Three Cross, Wimborne, Dorset, requires information or the handbook of this American equipment particularly with regard to the setting up procedure.

* * *

Bendix Radio Control Box BC602B.—G. Powell, Weald Rise, Litmarsh, Morden, Herefordshire, urgently requires any information on this unit.

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Valradio TP20P Tuner Unit.—W. P. Jenkin, 16 Trelawney Road, Camborne, Cornwall, urgently requires information on where to acquire this unit, it now being out of production. Required for conversion of Magnaview TV to multi-channel operation.

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Concentric Trimmers.—K. E. Le Masurier, "Aqir", Feugre, Cobo, Guernsey, requires information on where he can obtain concentric trimmers having a minimum capacitance of 1pF and a maximum of 10pF.

* * *

Indicator Unit CRT type 1 and Loran Indicator Unit.—R. H. Barnard, 33 Wallis Road, Basingstoke, Hants, requires information on the above especially power supplies, plug details and circuit diagrams and also details of the CRT type VCRX–263.

* * *

R107A Receiver.—R. Ramsley, 14 Blomfield Court, Maida Vale, London, W.9, would be very grateful for a chance to buy or borrow manual, circuit data or any information on this receiver.

* * *

1224B Receiver.—T. R. Smith, 2 Morris Cottages, Ladymead, Guildford, Surrey, requires information on the coverage and circuit of this 5 valve 3 waveband receiver.

* * *

National HRO Receiver.—I. R. Stevens, 3 Market Street, Floriana, Malta, G.C., has obtained some damaged or incomplete coil units (J, H, G, F and E) and would much appreciate some information on these coils. Regular correspondence with other readers welcomed.

* * *

No. 11 A.A. Predictor Mk1.—N. Alcock, 22 Rose Street, Florida, Transvaal, Republic of South Africa, would like to receive any information on converting this radarscope into an oscilloscope. The tube employed is an ACR10.

Transistorised Tone Control Unit

By S. VIPHARATANA

THE UNIT DESCRIBED IN THIS ARTICLE WAS designed for use with the Mullard "3-3" main amplifier.[1] The main purpose of the unit was to give a reasonably wide range of control over bass and treble independently as well as serving as a selector for various input sources (tuner, record player, etc.). This last point is quite important if there are various sources, each giving different output levels. The performance of the unit should match that of the "3-3" amplifier, and to go beyond this would be uneconomical. In fact, the original unit was constructed from "bits and pieces" lying around, with the exception of the aluminium case.

Circuit

Only two transistors were used and the overall gain is not very high, since the tone correction network offers considerable attenuation. The gain

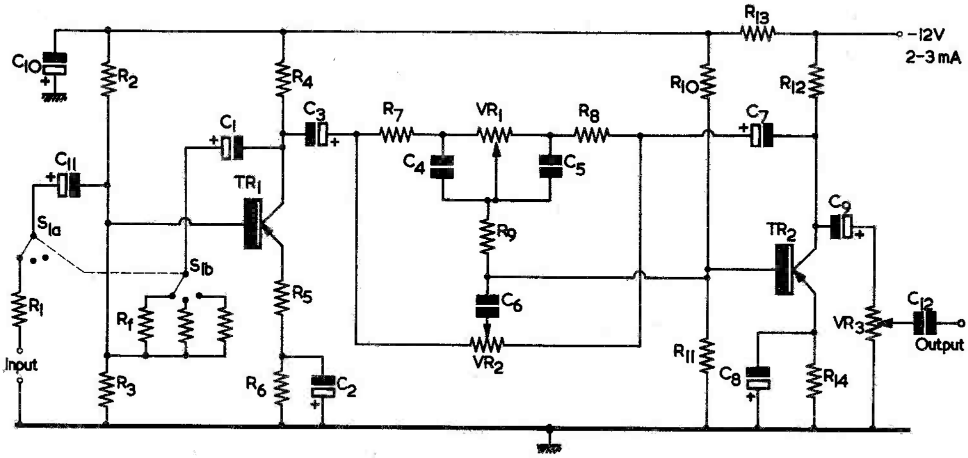

Fig. 1. The circuit of the tone control unit

M225

Components List

Resistors

R_1	See text
R_f	See text
R_2	39kΩ 10% ¼W Hi-stab
R_3	10kΩ 10% ¼W Hi-stab
R_4	15kΩ 10% ¼W Hi-stab
R_5	150Ω 10% ¼W Hi-stab
R_6	2.2kΩ 10% ¼W Hi-stab
R_7	4.7kΩ 10% ¼W
R_8	4.7kΩ 10% ¼W
R_9	22kΩ 10% ¼W
R_{10}	18kΩ 10% ¼W
R_{11}	6.8kΩ 10% ¼W
R_{12}	3.3kΩ 10% ¼W
R_{13}	560Ω 10% ¼W
R_{14}	1.5kΩ 10% ¼W
VR_1	25kΩ lin (Bass)
VR_2	25kΩ lin (Treble)
VR_3	10kΩ log. (Volume) with switch

Capacitors

C_1	8μF WV electrolytic
C_2	100μF 6WV electrolytic
C_3	8μF 6WV electrolytic
C_4	0.1μF 125WV paper
C_5	0.1μF 125WV paper
C_6	2,200pF silver mica
C_7	8μF 15WV
C_8	100μF 6WV
C_9	25μF 15WV
C_{10}	50μF 15WV
C_{11}	16μF 6WV
C_{12}	0.05μF (for high impedance main amplifier inputs)

Transistors

TR_1	OC71
TR_2	OC71

Switch

S_1	2 pole 3-way (Input selection)

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[1] 3-3 *Quality Amplifier Circuit*, Mullard publication TP352. Also *Circuits for Audio Amplifiers*, Mullard publication TP372.

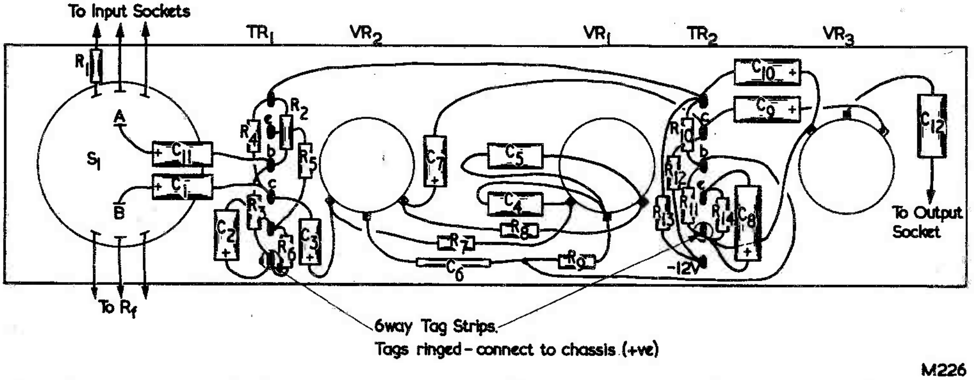

Fig. 2. A practical layout. Series input resistors or equalising networks connecting to S_{1a} are omitted as, also, are the feedback resistors R_f. C_{12} may not be required if the main amplifier input is already isolated. Transistor connections are shown by the letters e, b and c

is, nevertheless, more than enough to overcome the attenuation in the network and therefore some amplification takes place.

The first stage is a straightforward common emitter amplifier. There is negative feedback from the collector to the base via C_1 and R_f, this feedback reducing the gain of the stage according to the value of R_f. Obviously, for a larger input signal more feedback can be applied and the gain reduced; if the input signal is small, feedback is lessened and the gain made consequently greater. Different resistors are switched into the circuit by $S_{1(b)}$ so that the output from the control unit is more or less equal for every input source. The values for R_f were chosen experimentally. A part of the emitter resistor (R_5) is left unbypassed, and this increases the maximum input level which can be applied before overloading results. The output from TR_1 is fed into a Baxandall tone control network[2] which provides a continuously variable bass and treble control. TR_2 gives further amplification, as well as providing feedback for the tone correction network. Output is taken from the 10kΩ potentiometer VR_3 and the output impedance is therefore comparatively low.

The input impedance of the preamplifier is not very high, certainly not high enough for it to be used with a tuner unless the latter has a cathode-follower output. For this reason a high value resistor will be needed in series with the tuner input, and the value of this will have to be determined experimentally. As a rough guide, something of the order of 470kΩ will be required. (When the unit was fed from the Jason Mercury II the value was 220kΩ paralleled by a 560pF capacitor.) The feedback resistor R_f will, of course, depend on the output of the tuner concerned.

The sensitivity of the unit is such that most crystal types of cartridge can be used via a suitable equalising network. At the time of construction there was no need for higher sensitivity such as would be required for a magnetic pick-up, since a two transistor preamplifier was already in use between the pick-up and the control unit. There is no reason, however, why an extra stage could not be added so that a direct connection so such a pick-up could be made.

Fig. 1 illustrates a single input, that required for a tuner unit, connected to $S_{1(a)}$. Alternative inputs would be connected to the remaining contacts of $S_{1(a)}$ via the appropriate series resistors (if required) or equalising networks.

Performance

When a battery was used to power the unit there was no trace of hum (even with the case open) and the noise was low enough to be inaudible at normal volume settings; it was in any case too low to be irritating. Ordinary carbon resistors were found to give rise to noise and for this reason high stability types are recommended. As regards frequency

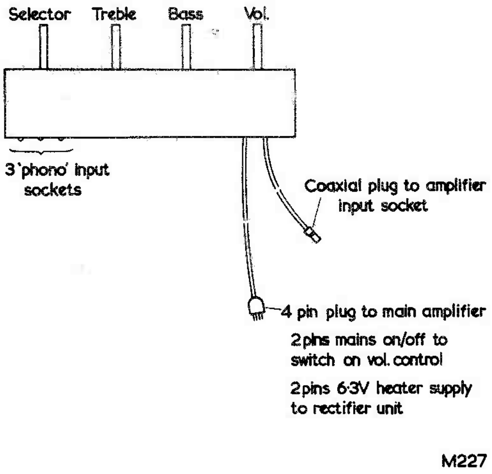

Fig. 3. Outside view of unit, showing suggested external connections

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[2] "Negative Feedback Control", by P. J. Baxandall, *Wireless World*, October 1952.

response, there was no noticeable difference when the main amplifier was quickly changed from a direct connection to the tuner to that via the control unit (with the controls set to "flat"). When a supply voltage of 6V was used, no marked change in the output was detected, although distortion tended to become noticeable on loud passages. Higher supply voltages than 12 are not advisable since these might exceed the ratings of the OC71 transistors.

The supply may alternatively be derived from a 6.3V heater winding via a voltage doubler rectifier. The power supply components can be small enough to be accommodated within the case and, since the current drain is only 2 to 3mA, smoothing presents a minor problem. This arrangement has the advantage that there is no battery to think about, particularly if the equipment is to be used for very long periods. On the other hand it should be remembered that, with a consumption of 2 to 3mA, any battery will last for quite a long while.

Construction

The construction of the unit should be quite clear from Fig. 2 but, since the layout is not at all critical, other methods of construction will be equally acceptable. It might be pointed out that the use of a printed circuit is not justifiable here since the unit can be made just as compact (or even more so) in the manner shown. All the components can be tucked away neatly around the potentiometers and the switch leaving no unused space. The components shown in Fig. 2 are laid out in a single plane for clarity; but it will, in practice, be possible to stack one component on top of another should that be necessary.

The case itself is made from 16 s.w.g. aluminium and is approximately 10 x 2½ x 1½in in size. It need not be fully enclosed since hum pick up will be small. If a mains power supply is to be used, there is sufficient room for the rectifiers around potentiometer VR$_3$, and also around VR$_1$ and VR$_2$ for the smoothing capacitors.

Fig. 3 shows an outside view of the unit with suggested external connections.

Rectifier Unit

A rectifier unit is shown in Fig. 4, and this consists simply of two OA81 diodes connected in a voltage doubler circuit, giving approximately 13V. This arrangement is preferred not only because it offers the required voltage easily but also because the frequency of the ripple voltage is 100 c/s and this makes smoothing less critical. It is important to ensure that a separate heater winding is used for supplying the main amplifier since that feeding the voltage doubler must be completely "floating". The 680Ω resistor provides smoothing and limits the initial charging current of the 500μF capacitor. If hum is present additional smoothing may be required in the form of a further R and a large C. A further R and C (or an increase in value in the existing 680Ω resistor) may also be required to bring the output voltage down to a suitable level if (as may be quite likely) the heater winding gives a higher voltage than its nominal 6.3.

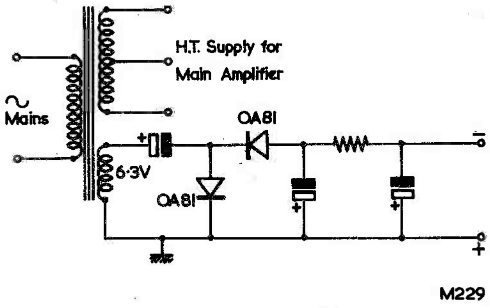


Fig. 5. An alternative voltage doubler circuit which enables one side of the 6.3 volt winding to be connected to chassis

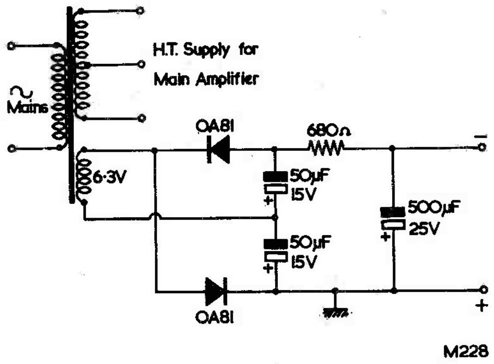


Fig. 4. A rectifier circuit capable of supplying the control unit. The 6.3 volt heater winding should be "floating".

An alternative voltage doubling rectifier circuit which enables one side of the 6.3 volt heater winding to be connected to chassis is illustrated in Fig. 5. This circuit has not been used by the writer and suitable values for the smoothing resistor and electrolytic capacitors required are not specified. These values may be determined experimentally to give the correct output voltages free of hum. The two rectifiers may be OA81 diodes, as with Fig. 4.

Testing

All connections should be checked prior to switching on. Having done that, the control unit may be connected to the 12V supply via a meter. With the meter set to 10mA a current of 2–3mA should be observed; if this is so it is most likely that everything is in order.

The following voltages and current readings were given by the prototype, voltage readings being obtained with a 10,000Ω per volt meter switched to read 10 volts f.s.d. The figures given are intended only as a guide, and may vary slightly due to transistor performance spread and resistor tolerance.

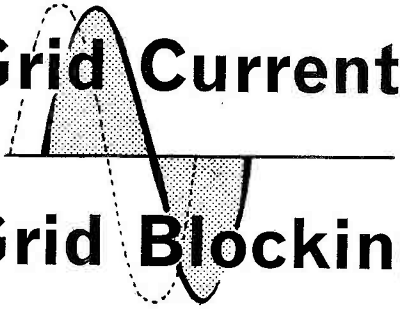
TR$_1$ base—1.8V
emitter—1.7V
collector—3.7V

TR$_2$ base—1.9V
emitter—1.8V
collector—6.0V

All voltage readings are with respect to chassis (+ve).

Note: Frequency Response

Frequency response will be found to be adequate, but it can be improved further by using OC45 transistors. It should not be necessary to alter component values for these transistors.



Grid Current and Grid Blocking

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

THE DATA PROVIDED BY VALVE MANUFACTURERS states that valves must not be operated under such conditions that the resistance between the control grid and cathode exceeds a certain specified maximum value which varies from valve to valve. This implies that valve grids must never be left unconnected, but they can, of course, be connected to earth (either directly or through a coil) when cathode bias is employed.

It is often desirable to use a very large value of grid resistor (R_g) in order to avoid loading the previous stage. If the maximum value quoted in the valve data for R_g is used, the resulting loading of the previous stage may be enough to cause appreciable loss of gain.

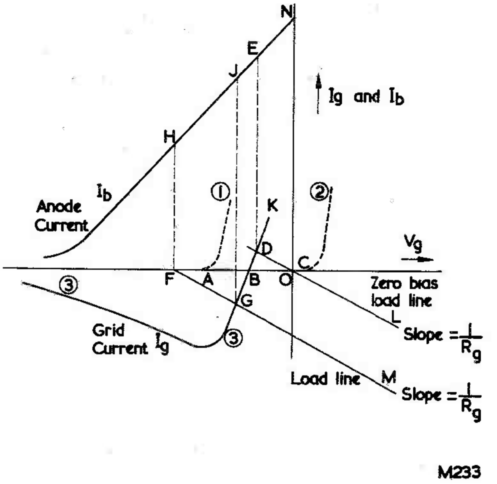


Fig. 1. Grid characteristics plotted with the mutual characteristic I_b

It is often stated in elementary text-books that if the control grid of a valve is biased so that it is negative with respect to the cathode, then no current whatsoever will flow in the grid circuit. If this is true no direct current will flow through R_g, no steady voltage will be developed across it and this resistor will merely allow the valuable signal to be attenuated. What possible reason can there be, then, for not using a much larger value for R_g to prevent this attenuation? In order to answer this question we must abandon the idea that no current flows in the grid circuit and take notice of currents of fractions of a microamp.

Grid Characteristics

As the grid of a valve becomes less negative, a point is reached (A in Fig. 1) where the grid acts as an anode and electrons flow to it from the cathode. This grid current increases rapidly as the grid becomes more positive (curve 1). In a practical circuit the electrons flow from the grid through R_g and back to the cathode. The cathode resistor is normally much smaller than R_g and therefore this flow of grid current causes the grid to become more negative by an amount which is approximately i_gR_g volts. Leaky grid detectors and most oscillators are biased by a voltage developed in this way. Grid current flowing in this direction is said to be positive grid current.

Curve 1, for a typical indirectly heated valve without the slightest trace of gas in it, shows that positive grid current commences to flow whilst the grid is still negative by the amount OA (of the order of 1 volt). In the case of perfectly hard directly heated battery valves, however, the positive grid current may not commence until the grid is slightly positive, at point C on curve 2. Such valves are therefore sometimes operated at zero bias.

Reverse Grid Current

Grid current can flow in the opposite direction from that just described and is then known as reverse or negative grid current. There are three possible reasons for negative grid current tending to flow, namely:

(1) If the valve contains an extremely small amount of gas (as is usually the case), a gas ionization current will flow.
(2) The grid voltage will normally be negative with respect to that of all other valve electrodes. Any leakage path, including that across the base, will therefore lead to reverse grid current.
(3) If some of the electron emissive oxide coating from the surface of the cathode passes to the grid, the grid itself will emit electrons when warmed by the heat radiated from the cathode.

The gas current is usually the largest of these three effects, which all tend to make the grid less negative by an amount i_gR_g volts where i_g is the sum of the grid currents due to the three effects.

Total Grid Current

The effects of positive and reverse grid current thus oppose each other, but they cancel out at one particular value of grid voltage. The total net grid current can be represented by curve 3 of Fig. 1 for a typical indirectly heated valve. At grid voltages more negative than point B the negative grid current predominates over the positive grid current, and vice versa to the right of B. For obvious reasons B is known as the grid current cross-over point and no grid current flows when the grid is at the voltage represented by this point. It usually occurs at $V_g = -\frac{1}{2}$ to -1 volt for indirectly heated valves. If the valve is operated without any grid connection, no grid current flows and the grid operating point will be at B. There is another possibility, which shall be considered shortly, if the grid characteristic has the shape shown in Fig. 2.

Anode Current

It is useful to plot the mutual characteristic (i.e. anode current/grid voltage) on the same graph as the grid characteristic; the anode current is then easily determined from the grid operating point. The mutual characteristic is marked I_b in Fig. 1, but as the anode current is measured in milliamps and the grid current in microamps, the scale used for I_b is different from that used for i_g.

Operating Points

If the valve is operated with the grid resistor returned to cathode (i.e. at zero bias), the operating point will be at D. The grid load line passes through 0 when the bias is zero and has a slope of $1/R_g$; it cuts the grid characteristic at D. The anode current which flows at zero bias can be found from point E which is vertically above D. Thus the flow of grid current reduces the anode current from point N to point E.

If the valve is biased by a voltage OF so that the anode current would be represented by point H in Fig. 1, the effect of the grid current flow can again be found. The grid load line FGM should be drawn through F to intercept the grid characteristic at G. It can now be seen that the anode current will be increased to point J because of the voltage developed across R_g.

The operating point can thus be moved one way or the other by the grid current flowing through R_g. This change of grid voltage is proportional to the value of R_g. In order to keep the operating point reasonably close to the desired value, an upper limit must be imposed on the value of R_g. This limit depends on the probable grid current (measurement of which is not easy, as its magnitude is of the order of a microamp), as well as on a number of other valve characteristics and on the circuit in which the valve is to be used. It is therefore wise to follow the advice of the valve manufacturers and limit R_g to the recommended value.

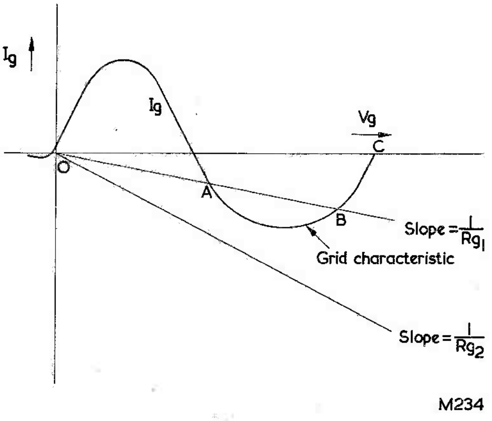


Fig. 2. Grid characteristic of a valve in which grid blocking can occur

The maximum permissible value of the grid resistor must be reduced in proportion if it is common to two or more valves so that their combined grid current flows through it. This situation will usually occur in a.g.c. controlled r.f. and i.f. stages where the a.g.c. time constant must also be kept in mind when choosing grid resistor values.

Grid Blocking

When the grid voltage becomes positive, electrons are attracted to it and, under this electron bombardment, the grid may itself emit secondary electrons. This secondary electron current is in the opposite direction to the electron stream from cathode to grid. In some valves it may merely result in a slight change of slope in the positive region of the grid characteristic, but in other valves the net grid current may become negative as shown in Fig. 2. In such a case "grid blocking" can occur.

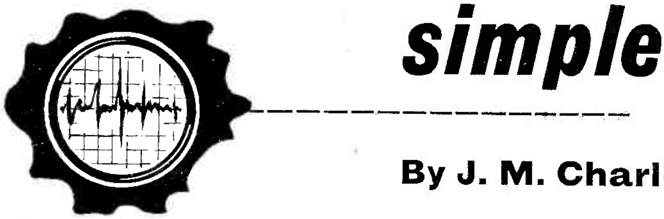
Fig. 2 is merely a continuation of the grid characteristic curve from the point K in Fig. 1 into the positive region of grid voltage. Both scales in Fig. 2 are much more compressed than those of Fig. 1. The distance OC represents about 100 volts and the two peaks represent currents of the order of 1 milliamp.

The grid load line representing the grid resistor R_{g1} cuts the characteristic at A and B in Fig. 2. If the grid voltage (bias plus signal peak) is at any time sufficient to reach A, the operating point will automatically jump to B, as A is unstable. The operating point will then remain at B until the grid resistor is reduced in value or the apparatus is switched off. The grid voltage at B will be of the order of +100 volts; a correspondingly high anode current will tend to flow and the valve is likely to be permanently damaged.

Prevention

Grid blocking can only occur when the load line representing the grid resistor cuts the negative loop of the grid characteristic. Grid blocking cannot occur if the grid resistor is represented by a load line such as the one in Fig. 2 which has a slope of $1/R_{g2}$ and which does not cut the curve. R_{g2} is of lower value than R_{g1}.

If a valve is used which has the type of grid characteristic shown in Fig. 2, care should be taken to ensure that the grid resistor is low enough in value for the load line not to cut the grid characteristic.



simple oscilloscope

By J. M. Charles

This oscilloscope has the considerable advantages of employing simple circuitry and a tube and valves which may be obtained from ex-Government sources. In consequence, the unit may be constructed with little trouble and at relatively low cost

THE TUBE CIRCUIT (SEE FIG. 1) IS CONVENTIONAL except that the tube h.t. is above earth since the same supply is employed for both valves and tube. The tube used is the three inch VCR138A. R_5 is the focus control and R_6 the brilliance control. R_1 and R_2 are the Y and X shift controls respectively.

The power pack gives 410 volts d.c. at 40mA, 5 volts at 2A, 4 volts at 1A and 6.3 volts at 1.2A.

Timebase

The timebase is a version of the Miller oscillator and has four coarse frequency ranges selected by S_2, these covering from 15 to 200,000 c/s. R_{10} is the fine frequency control. The timebase also incorporates a simple type of beam blanking taken from the screen grid of the oscillator through S_3 to the grid of the tube. The depth of blanking is selected by S_3, position 1 giving no blanking, 2

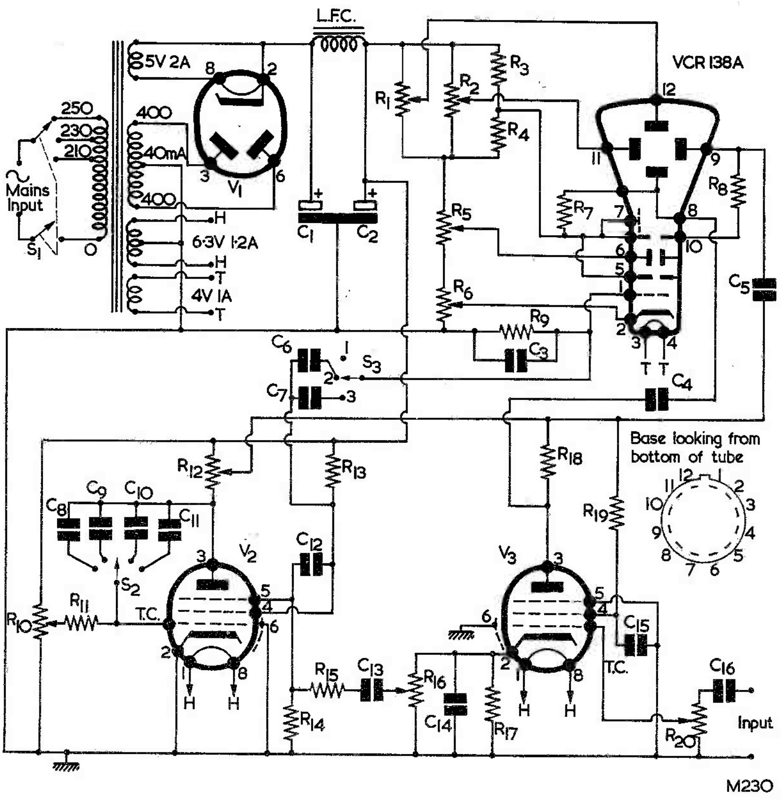


Fig. 1. The circuit of the oscilloscope

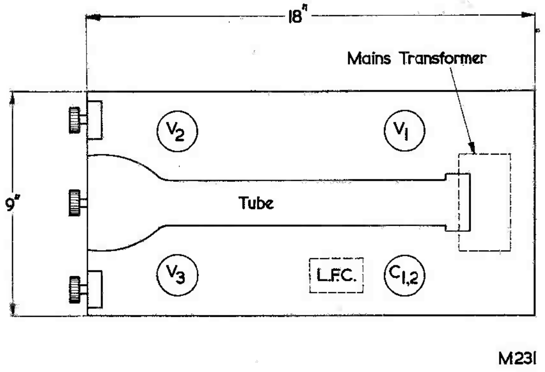


Fig. 2. A suggested chassis layout as seen from the top

Components List

Resistors
R_1 1MΩ potentiometer
R_2 1MΩ potentiometer
R_3 100kΩ $\frac{1}{2}$ watt
R_4 100kΩ $\frac{1}{2}$ watt
R_5 1MΩ potentiometer
R_6 100kΩ potentiometer
R_7 2.2MΩ $\frac{1}{2}$ watt
R_8 2.2MΩ $\frac{1}{2}$ watt
R_9 220kΩ $\frac{1}{2}$ watt
R_{10} 1MΩ potentiometer
R_{11} 2.2MΩ $\frac{1}{2}$ watt
R_{12} 100kΩ potentiometer
R_{13} 3.3kΩ $\frac{1}{2}$ watt
R_{14} 3.3kΩ $\frac{1}{2}$ watt
R_{15} 470kΩ $\frac{1}{2}$ watt
R_{16} 250kΩ potentiometer
R_{17} 3.9kΩ $\frac{1}{2}$ watt
R_{18} 47kΩ $\frac{1}{2}$ watt
R_{19} 150kΩ $\frac{1}{2}$ watt
R_{20} 1MΩ potentiometer

L.F. Choke
20H, 40mA

Switches
S_1 2 pole on/off
S_2 1 pole 4-way
S_3 1 pole 3-way

Capacitors (all 350WV unless otherwise stated)
C_1 8μF 600WV electrolytic
C_2 8μF 600WV electrolytic
C_3 0.001μF mica
C_4 0.1μF 600WV paper
C_5 0.1μF 600WV paper
C_6 50pF ceramic or mica
C_7 500pF mica
C_8 0.01μF paper
[1]C_9 0.001μF

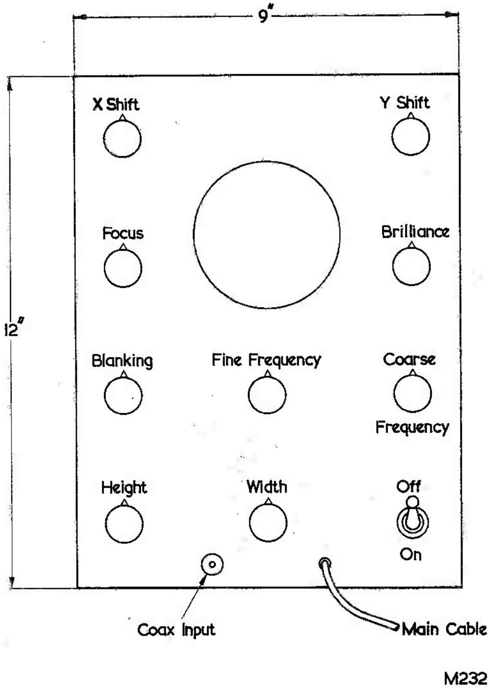


Fig. 3. The front panel layout employed by the author

C_{10} 150pF mica
C_{11} 20pF ceramic or mica
C_{12} 0.01μF 500WV paper
C_{13} 0.01μF
C_{14} 0.005μF mica
C_{15} 0.1μF 500WV paper
C_{16} 0.25μF 600WV paper

Valves
V_1 5Z4
V_1, V_3 SP61 (VR65, CV1065)
Tube VCR138A

Mains Transformer
Primary 210, 230, 250V
Secondaries 6.3V at 1.2A; 5V at 2A; 4V at 1A; 400–0–400V at 40mA minimum. (If h.t. secondary resistance is less than 320Ω per half, insert 2 watt limiting resistors in series with each rectifier anode to make up to this figure.)

medium blanking and 3 full blanking. R_{12} acts as an X gain control or width control.

The Y amplifier employs a simple pentode circuit which is linear up to nearly 200,000 c/s. R_{20} is the variable attenuator control on the input to the amplifier. Also incorporated into the amplifier is a sync control provided by R_{16}.

To assist in simplifying the design, neither the X nor the Y plates have been brought out to the front panel. The original unit was built into an ex-Government Indicator Unit, but any layout could

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[1] C^9 may require a small experimental change in value to give good continuity from range to range. The prototype used 0.001μF capacitor shunted by a 150pF capacitor.

be employed so long as magnetic fields from transformers and the like are kept away from the tube. The best place to mount the mains transformer is directly behind the tube or, if this is not possible, a mu-metal screen should be put round the tube. When connecting the circuit up, capacitors with high insulation properties must be used to couple the tube to other parts of the circuit.

When the tube mentioned is used the case is liable to be rather on the large size. If a shorter tube is used and some of the controls placed inside (for example the X shift, the Y shift, and the width control) the unit can be made very much smaller. To finish off the appearance Panel Signs transfers could be used and these give a simple but professional looking oscilloscope.

When the sync control is employed care must be taken not to distort the trace by using too much sync. This is caused by too much of the signal being fed into the timebase.

Performance

Despite the low e.h.t. voltage the trace is reasonably bright and fine and can easily be seen in all light except direct sunlight.

An approximate figure for sensitivity is 200mV/cm.

THE SPANNING OF THE ATLANTIC BY WIRELESS TELEGRAPHY

Just over sixty years ago—on the 12th December 1901—Guglielmo Marconi became the first to send a wireless signal across the Atlantic. This remarkable achievement with such primitive equipment marked the birth of world-wide communication.

During the spring of 1900, Marconi had succeeded in sending reliable signals from St. Catherine's in the Isle of Wight to The Lizard in Cornwall, a distance of 186 miles. This encouraged his belief that by using larger aerials and far more powerful transmitters he would be able to achieve transatlantic distances. Scientists were highly sceptical, many said it was impossible because of the curvature of the earth.

Marconi determined to make the attempt. A transmitting station nearly one hundred times more powerful than any previously constructed was built at Poldhu near Mullion in Cornwall. Enormous aerials were erected at Poldhu and at Cape Cod in Massachusetts but both were wrecked in severe gales. Another, less ambitious in design, was put up at Poldhu while Marconi and his two assistants sailed to Newfoundland where, from the top of Signal Hill, a receiving aerial was hoisted, at the third attempt, by means of a kite.

At 12.30 p.m. (Newfoundland time) on 12th December, 1901, Marconi and his assistant G. S. Kemp, using one of the primitive receivers of the period with a telephone earpiece heard a faint succession of S's in Morse code. Signals from Poldhu, 2,200 miles away, had crossed the Atlantic.

To commemorate this historic achievement, a Special Exhibition was held at the Science Museum from 13th December–25th January. Among the many historic exhibits and original photographs, a notable feature was a recording of Marconi's voice telling in his own words of how success was achieved.

During the early 1890s, many of the leading physicists were closely interested in the properties of "Hertzian waves" but none expressed a thought that these waves would be of the slightest value for the purpose of communication.

In 1895, Guglielmo Marconi, working at his parents' residence at Pontecchio in Italy, discovered the great increase in range which could be obtained by the use of an elevated aerial. It was this discovery which paved the way for the use of Hertzian waves in a practicable system of wireless telegraphy.

Early in the following year—1896—Marconi arrived in England and applied for the world's first patent for wireless telegraphy. He had chosen to come to England partly because this country was then the most powerful maritime nation in the world and it seemed likely that wireless telegraphy would be of value to shipping, and partly because of a national affinity, his mother being Irish.

In 1897 he founded the Wireless Telegraph & Signal Company (which in 1900 became Marconi's Wireless Telegraph Company Limited), and this provided him with the money and technical resources necessary for his future developments.

Marconi spent the next four years in an almost continual round of experiment, development and demonstration, his object being continually to improve the reliability and range of his apparatus. At first only covering a mile or so on Salisbury Plain, he was soon communicating regularly from Alum Bay near the Needles in the Isle of Wight to Bournemouth and then to Sandbanks at the entrance to Poole Harbour, a distance of 18 miles. In March 1899 he spanned the English Channel and early in the following year he set up reliable communication from the Isle of Wight to The Lizard in Cornwall, a distance of 186 miles.

The shipping companies had shown mild interest but very little enthusiasm to install wireless equipment on their ships. It seemed, in fact, that far greater ranges and a chain of land stations would be required before wireless telegraphy would have a wide appeal. The scientists of the day, however, were almost united in believing that wireless waves, like light waves, would not follow the curvature of the earth. Therefore, they said, really long ranges were impossible.

Marconi thought otherwise. Experiments had led him to believe that the key to longer ranges lay in the employment of larger aerials and higher transmitter powers. He therefore determined to build two super-power transmitting stations, one on each side of the Atlantic, and to attempt two-way communication. Accordingly, a site was selected at Poldhu in Cornwall and the other at Cape Cod in Massachusetts.

It is difficult to visualise the stupendous problems which confronted him. The aerial system, at both Poldhu and Cape Cod, was of a size and complexity which had never been attempted before, for it consisted of twenty 200ft masts in a circle with an inverted cone of about 400 wires leading down to the transmitter. As to the transmitter itself, it was to be 100 times more powerful than any hitherto built, and no precedents whatever existed for the design. Marconi delegated the responsibility for this to his scientific adviser, Professor J. A. (later Sir Ambrose) Fleming, and Fleming carried it out brilliantly.

Some details of the transmitter may be of interest. The prime mover for the generation of power was a Hornsby-Ackroyd oil engine which drove a Mather and Platt 2,000V 50 c/s alternator. This was capable of delivering 25kW, although from a paper read by Fleming to the Royal Society of Arts in December 1921 it would appear that the plant was considerably under-run at the time of the transatlantic tests.

The transmitter proper, which embodied a form of the new syntonic tuning with all its advantages, employed two 20kW Berry transformers parallel-connected to step up the input voltage to 20,000 volts. This was fed through r.f. chokes to a closed oscillatory circuit in which a capacitor discharged across a spark gap via the primary of a "jigger" or r.f. transformer. The secondary of this transformer connected to a second spark gap and capacitor and the primary of a second r.f. transformer, the secondary winding of this transformer being in series with the aerial. Keying was effected by the short circuiting of the chokes in the alternator output.

The capacitors were made of 20 glass plates each 16in square, backed on one side with one square foot of tinfoil. The plates were immersed in linseed oil contained in stoneware boxes; each box had a capacity of approximately 0.05μF.

Both the Poldhu and Cape Cod stations were all but ready when a double catastrophe struck; severe gales wrecked the aerial arrays and masts at both stations almost simultaneously.

With £50,000 already spent on the project, Marconi elected not to wait until both stations were repaired. Instead, a new aerial system was erected at Poldhu, consisting of 54 copper wires arranged in a fan-shape and upheld by a triatic slung between two 150ft masts. The current into the bottom of this aerial is stated by Fleming to have been 17 amperes and the radiated frequency is thought to have been between 100–150 kc/s. No one knows for certain, however, as no reliable means of measurement existed at the time and individual estimates made by those on the spot differ considerably.

With the encouraging news that Poldhu's signals were being strongly received at Crookhaven in Ireland, 225 miles away, Marconi, with two assistants—Kemp and Paget—took passage to St. John's, Newfoundland, the nearest landfall in the New World, taking with them large canvas kites and several small balloons with which Marconi proposed to raise the aerial. This latter course of action was decided upon for two reasons; to avoid the public speculation that the erection of tall masts would bring, and to save time.

At St. John's all possible assistance was given them by the Governor of Newfoundland, Sir Cavendish Boyle, and the Prime Minister, Sir Robert Bond. Six hundred feet up on the clifftop of Signal Hill, overlooking St. John's harbour, was the disused Barracks Hospital; a ground-floor room in this building was placed at Marconi's disposal, and here he set up his instruments.

On 9th December a cable was sent to Poldhu instructing the engineers to begin transmissions on the 11th, between 3 p.m. and 7 p.m. GMT. The signals were to consist of repetitions of three dots (the Morse letter "S"). This letter was chosen because—to quote Marconi himself—"the switching arrangements at Poldhu were not constructed at the time to withstand long periods of operation—especially if letters containing dashes were sent—without considerable wear and tear, and if S's were sent an automatic sender could be employed."

Heavy gales were sweeping Newfoundland, however, and the next two days were spent in unsuccessful attempts to keep an aerial aloft. A balloon and a kite were lost in these endeavours.

On 12th December a full gale was still blowing, but despite this a kite was flown carrying an aerial to a height of 400 ft. Marconi began a listening watch, using his latest syntonic receiver, but could receive no signals because the erratic movements of the kite were continually altering the angle of the aerial to earth, and therefore its capacity. He decided, therefore, to revert to the older, untuned receiver, using a telephone earpiece in series with the coherer.

Various types of coherer were tried, one of which was the so-called "Italian Navy" device. This is of particular technical interest in that it is described as consisting of a glass tube with a plug of iron at one end and another of carbon at the other, with a globule of mercury between them. The device was self-restoring and had to be used in conjunction with a telephone earpiece. It would seem, therefore, that what is described as a coherer was in fact a true semi-conductor rectifier with either the dissimilar plugs, or oxide film on the mercury, or possibly other surface impurities, performing the rectification process.

At 12.30 p.m., Newfoundland time, on 12th December, 1901, Marconi heard, faintly but distinctly, the groups of three dots which could only have been emanating from Poldhu, 2,200 miles away. He passed the earpiece to Kemp, who confirmed that he had not been mistaken. Paget, to his lifelong regret, was ill on that day and was not present.

The feat was all the more remarkable when it is remembered that the onus was almost enitrely on the transmitter, for no amplification was possible at the receiver, and so the received signal itself had to be strong enough to operate the earpiece.

The use of a telephone in place of a recording tape and the absence of any unbiased witness had unfortunate consequences for, immediately the news was made public, a stormy controversy arose as to whether Marconi and Kemp had been deceived into misinterpreting the noise of static as Morse signals. In this matter events conspired against Marconi in that the Anglo-American Telegraph Company, which had a message-carrying monopoly covering Newfoundland, threatened legal action if further experiments were carried out, and so there was no opportunity of giving a public demonstration. But two months later tests were carried out between Poldhu and the liner *Philadelphia* en route from Southampton to New York in which S's were received on the ship at a distance of 2,099 miles and these were amply verified by witnesses. Ten months later—in December 1902—two-way communication was effected between Poldhu and a new high-power transmitting station at Glace Bay, Canada—a circumstance made possible by the generous action of the Canadian Government in donating £16,000 towards the cost of the station.

There remained the problem of reconciling the theories of the scientists with the practical results achieved by Marconi. At that time no one knew of the existence in the upper atmosphere of an ionised layer which serves to reflect radio waves and so to make long-distance communication possible. In 1902 Heaviside in England and Kennelly in America independently postulated the existence of such a belt to account for Marconi's achievement, but its actual physical existence remained a matter for controversy until the 1920s.

There were, in fact, many unknowns at the time. Until the tests between Poldhu and the liner *Philadelphia* in February 1902 it had not been realised that much longer ranges were obtainable at night. Indeed, it was only then that it was realised that for the transatlantic experiment a listening watch had been kept at the worst possible time of the day! Again, the very success of the operation led to a universal acceptance of the rule "the lower the frequency, the greater the range", and it was not until 1924 that the value of the short-waves for long distance communication was realised, largely as a result of the pioneering work of amateurs. The inauguration in 1924 of the Marconi-Franklin short-wave beam-radio service ushered in a completely new era in international radio communication. Incidentally, it was at the Poldhu site that much of the experimental work in connection with short-wave beam transmission took place.

In the same way as Marconi by the introduction of the aerial/earth system had taken wireless waves out of the laboratory into the realm of practical communications, so by the 1901 transatlantic experiment did he introduce the concept of high-power radio engineering and world coverage. And although the spark telegraphy of that day was not electronically generated, it did lead directly to the invention of the thermionic valve and through this to the dawn of the electronics age.

Minister of Aviation to open Eleventh Electrical Engineers Exhibition

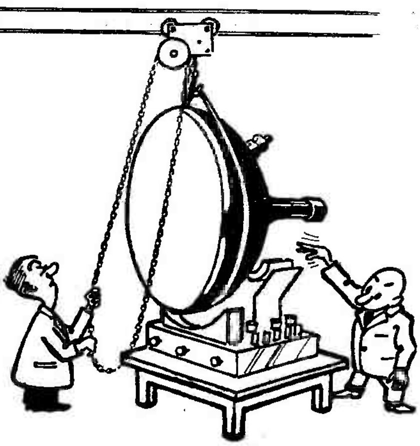
The Minister of Aviation, Rt. Hon. Peter Thorneycroft, will open the eleventh Electrical Engineers (A.S.E.E.) Exhibition at 12 noon on Tuesday 20th March, 1962.

This will be the second time Mr. Thorneycroft has opened this important show; the first time was in 1956. Since then the exhibition has doubled in size and has firmly established itself as Britain's largest "shop window" of electrical equipment and draws engineers and buyers from every part of the world.

Mr. Thorneycroft, who has been Minister of Aviation since July 1960, was educated at Eton and served in the Royal Artillery before he was called to the Bar in 1935. Elected to Parliament in 1938, he became Parliamentary Secretary to the Ministry of War Transport in 1945. From October 1951 to January 1957 Mr. Thorneycroft was President of the Board of Trade, and between January 1957 and January 1958, Chancellor of the Exchequer.

Each year a special section of the exhibition is devoted to a particular aspect of the electrical industry; in 1962 the feature will be "Electricity in Aviation". In a display area covering 5,000 square feet the Royal Air Force and the Ministry of Aviation will be showing a comprehensive range of electrical apparatus, accessories and components used in aircraft and on the ground.

In your Workshop



Refreshed by an uneventful two-day business trip to London, Smithy the Serviceman once more gets down to work, aided by his able assistant Dick. The only snag is Dick's preconceived ideas about behaviour in the Metropolis!

SMITHY UNLOCKED THE WORKSHOP door, entered, switched on the lights, and looked warily at Dick's bench. Much to his surprise it was newly dusted down and tidy. Smithy's eyebrows rose even higher as he noted that his assistant's bench held no chassis in a state of half-repair. When, in the past, he had been away for several days, he had always returned to meet a large number of receivers on whose repair Dick had stuck half-way.

A rush of cold air suddenly blew into the Workshop, heralding the entry of his assistant. Dick breezed in, slammed the door shut behind him, and stamped his feet resoundingly on the floor.

"Hiya Smithy," he called out cheerily, as he took off his overcoat, "and how's the Prodigal Son?"

"Prodigal Son?"

"That's right," confirmed Dick. "After two days in the Big City you're bound to have something to be prodigal about!"

"Nothing of the sort," snapped Smithy. "I would remind you that I went to London on business."

Dick waved a knowing forefinger at the Serviceman.

"You can't tell *me* that," he said, with a confidential wink. "I know what goes on in London. I've never been there, but I've read all about it in the Sunday newspapers!"

Smithy decided to change the conversation.

"I must say that your bench looks nice and tidy," he remarked after a moment's thought. "Don't tell me that you've managed to clear up all the chassis you tackled whilst I was away."

"Not exactly," confessed Dick. "There *are* one or two outstanding. I thought I'd keep them on the racks this time."

Frame Trouble

Smithy heaved a sigh.

"I suppose we'd better clear them out of the way," he remarked resignedly, "before we get down to anything else. Wheel them over!"

Dick walked over to the racks and selected a chassis.

"This one," he called out, as he returned to his bench, "has got low frame height."

"Bung it on, then."

Obediently, Dick placed the receiver on the bench, fitted an aerial, connected the mains lead, and switched on. After some moments the picture came up. It had acceptable line and frame linearity, but its height was one inch shorter than that of the screen.

"Hmm," said Smithy, looking closely at the screen, "focus looks a bit dodgy as well. I suppose you've got the frame height control fully over?"

"The slider's tight up against the end stop."

Smithy rubbed his chin ruminatively for a second.

"As I remember it," he remarked, "this receiver obtains its frame oscillater voltage from the boosted h.t. line. (Fig. 1). Did you check the boosted h.t.?"

"Yes I did," replied Dick proudly, "and on the reservoir capacitor there were a good 600 volts. I checked on the other side of the 470kΩ decoupling resistor and I found about 200 volts only."

"So?"

"So I presumed that the 0.1μF decoupling capacitor to h.t. positive at this point had gone leaky; and I disconnected one end of it."

"Did the voltage then rise?"

"No," said Dick, "It still stayed at 200. I re-soldered the capacitor into circuit again and had another look. This time I thought I'd see if the focus circuit or the height control pot was causing trouble, and I disconnected first the one and then the other."

"Any luck?"

"Not a sausage," replied Dick. "I still got 200 volts. So I carried on to the next step in the proceedings."

"Which was?"

"To return the set to the rack until

you came back from your London orgy!"

"I've already told you that I was up on business," said Smithy testily. "Anyway, let's get on with this set. Up to date we have the following facts. Firstly, we're getting about 600 volts across the boost reservoir capacitor, so we can assume that the line output stage is doing its bit. Secondly, the boosted h.t. drops down to 200 volts on the other side of the 470kΩ decoupling resistor. Something is obviously, therefore, drawing excess current at this point. I presume you measured your voltage with a high resistance meter."

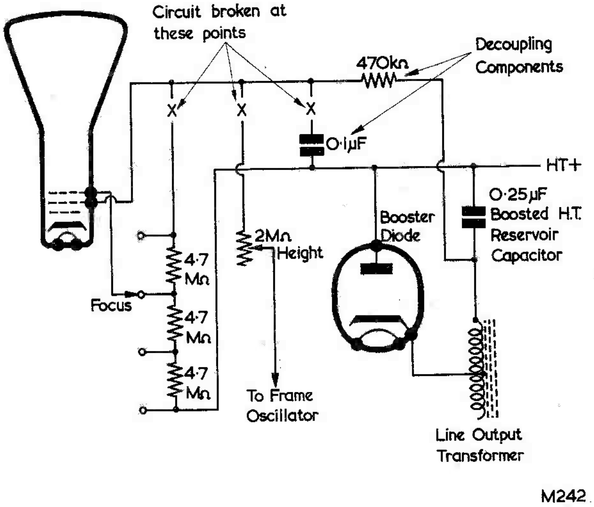


Fig. 1. The boosted h.t. circuit in the receiver serviced by Dick. In an attempt to locate the leakage causing low voltage across the 0.1μF decoupling capacitor, the circuit was broken at the points indicated by crosses.

"10,000 ohms a volt," confirmed Dick.

"Fair enough," said Smithy thoughtfully. "We know that the leak isn't occurring in the focus circuit, the frame height control circuit, or in the decoupling capacitor. Have you looked for leakage in the insulating material around terminal points?"

"I gave a pretty thorough visual check here," said Dick, "but I couldn't find anything."

"Then there's pretty well only one thing left," said Smithy, "and that's the tube."

"The *tube*?"

"That's right," grinned Smithy. "It won't take a second to check it. First of all, I'll pop the meter between the decoupled boost line and chassis. Like you did, I'm getting a reading of some 200 volts. After this I'll switch off the receiver and remove the base from the tube. I next short out the heater sockets on the base with a croc clip lead."

"What are you doing that for?"

"To maintain continuity in the heater chain," explained Smithy. "Whereupon I switch on again and let the set warm up. What's the meter reading now?"

"Well I'm dashed," said Dick, "it's gone up to 500 volts!"

"Which means," said Smithy, "that the leakage on the boost line is in the tube itself. You'll have to pop a new tube into this set, Dick my lad."

Dick scratched his head.

"This is the first time," he remarked, "that I've ever heard of curing low frame height by fitting a new tube!"

"There's a first time for everything," Smithy reminded him. "And leakage in c.r.t.'s is not all that uncommon, you know."

"I suppose not," said Dick, thoughtfully. "Incidentally, that croc clip lead proved useful didn't it?"

"Crocodile clip leads," pronounced Smithy, "are something which should be in every service workshop. You need them in about half a dozen lengths ranging from some 3ins to 3ft in length (Fig. 2 (*a*)) and they are best terminated in narrow pin-grip clips, such as the Bulgin C.R.40 type. Narrow clips get into awkward corners with less chance of shorts. And, of course, you can always hang the leads up out of the way by means of the clips themselves." (Fig. 2 (*b*).)

"They're certainly useful," agreed Dick. "Shall I change the tube on this set now, or carry on to the next?"

"We'll tackle the next," said Smithy decisively.

Another Frame Fault

Obediently, Dick walked over to

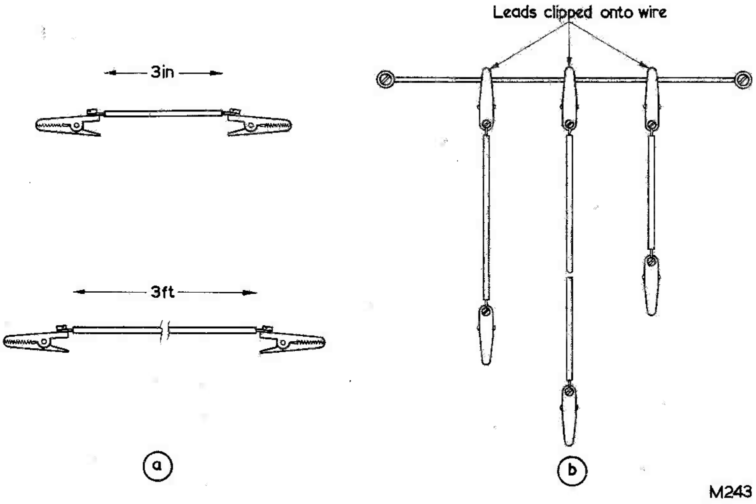


Fig. 2 (a). A selection of crocodile clip leads ranging from some 3ins to 3ft in length can be especially useful in the Workshop. Narrow-jaw clips such as the Bulgin type C.R.40 meet most servicing requirements.
(b). The leads can be conveniently stored by clipping them to a wire, as shown here.

the rack and selected another receiver.

"This one's got a frame fault as well," he called out. "The picture rolls like billy-oh and it just won't lock."

"Is the frame oscillator getting sync?"

"I don't think it *is* a sync fault," said Dick, putting the chassis on the bench and connecting it up. "Because what seems to be wrong here is that the frame oscillator is just miles off frequency. Even if we weren't getting sync we should still be able to adjust the frame oscillator to run near to correct frequency, shouldn't we?"

"That's a fair assessment," commented Smithy.

The receiver warmed up and Smithy noted that the picture rolled continually despite adjustments to the frame hold control.

"That hold control seems to be having hardly any effect at all," commented the Serviceman, after some moments. "I suppose you've checked it for open circuit connections to the track and so on."

"I've checked it thoroughly," said Dick, "as well as the circuit around it. Indeed, I got the service manual out and went right through the whole oscillator. (Fig. 3)."

"It must have been a baffling fault," remarked Smithy drily, "for *you* to get the service manual out! Anyway, let's have a look at the circuit. I note that there are two triodes in a multivibrator, one of these being in the same envelope as the frame output pentode. Have you checked the multivibrator capacitors which cross over from each triode anode to the opposite grid? These could cause trouble, either by leakage or by shifts in capacitance."

"I've changed them."

"And the grid anode resistors?"

"I measured those."

"Fair enough," said Smithy. "The only trouble the resistors would contribute would be changes in value, whereupon the time to start changing them would be when you're getting *really* desperate. Did you check the cathode bias resistor and capacitor for the triode-pentode?"

"Why, no," said Dick, surprised, "they'd only affect the frame output circuit, wouldn't they?"

"If you look again," said Smithy, "you'll note that the triode-pentode has a single cathode. With the result that the cathode bias components could affect one of the multivibrator triodes as well. Anyway, we've got the set running now so let's quickly see what voltage that cathode does actually have."

Smithy switched the testmeter to a suitable range and applied its test prods between the triode-pentode cathode and chassis.

"Well, there's ten volts here," he remarked. "Which seems the sort of thing we would expect."

"Just a minute, Smithy," broke in Dick, excitedly. "I don't know whether it's my imagination or not, but it looks to me as though that meter needle's got a tremble on it."

"So it has," said Smithy, looking closely. "And that may well offer a clue towards our fault. Could you hustle me up a new 100μF, Dick? 25 working volts?"

Dick rummaged in the spares cupboard, produced a new capacitor and handed it over to the Serviceman. Smithy opened out the leads of the component and, carefully ensuring correct polarity, tentatively applied it across the cathode bias resistor. The rapid rolling of the picture reproduced by the receiver stopped at once, and the Serviceman and his assistant found themselves watching a scene which floated slowly downwards, attempting to lock each time it was properly positioned on the screen. Whilst Smithy held the capacitor in position Dick adjusted the frame hold control, whereupon the picture locked in perfectly. With a gleam of satisfaction in his eye, Smithy took away the temporary capacitor and switched off the receiver.

"That's another job done," he remarked cheerfully, "the 100μF cathode bypass capacitor in this set has gone open. This must have caused the output pentode to enter the frame multivibrator circuit and pull it off frequency. Quite an interesting fault, that."

"It's the tremble on the needle that intrigues me," confessed Dick. "I suppose that was because, with an open-circuit bypass capacitor, the cathode of the frame output pentode was drawing pulses at oscillator frequency."

"That would be it," said Smithy. "It would tremble in the same way as when a voltmeter is coupled to the output of an a.c. rectifier circuit without a reservoir capacitor. Anyway, that's got another of your sets cleared!"

Picture Shape Distortion

However, Dick was not in the mood to discuss matters electronic for the moment.

"Talking about trembles," he remarked experimentally, "I must say that you seem remarkable steady in your actions this morning."

"Why shouldn't I be?" asked Smithy, puzzled.

Dick plunged in.

"Well," he continued. "You certainly look pretty fit, despite your two days in London."

"Dash it all," said the exasperated Serviceman, "I've already told you that I went up on business. All that happened was that I passed two perfectly blameless, peaceful, and quiet days."

"That's what *you* say."

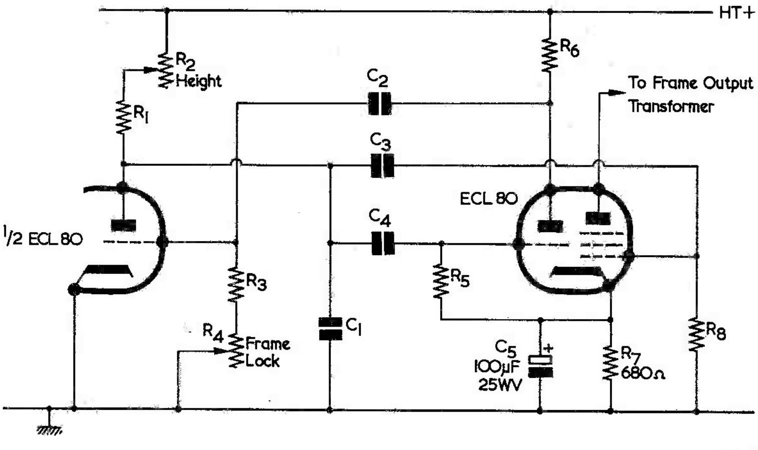


Fig. 3. A common frame oscillator and frame output circuit shown in basic form. The two triodes form a multivibrator, the cross-coupling capacitors being C_2 and C_4. C_1 shapes the waveform on the anode of the left-hand triode, and C_3 couples this waveform to the grid of the pentode, which functions as frame output valve.

"But that's what *happened*," protested Smithy. "I was fairly busy on the first day and when I finished, I just went back to my hotel and got into bed."

"That's only the first day," continued Dick inexorably. "What about the second day?"

"I went on business again."

"All day?"

"Well, no, not exactly," admitted Smithy. "I managed to get things cleared up by lunch-time, and I had the rest of the day to myself."

"Ah," said Dick, in a tone fraught with meaning.

"You carry on," protested Smithy irritably, "as though I've been wallowing in the Casbah or something."

But Dick was not to be put off so easily.

"You can at least tell me what you had for lunch," he persisted.

"If you *must* know," said Smithy testily, "I had barbecued chicken. And very nice it was, too."

Dick looked horrified.

"Barbecued chicken?" he exclaimed. "But you can get that down here!"

"Of course you can," snapped Smithy, "and you can get it in London, too. Now let's get on with the next set, *please*."

Wearing a look of utter disbelief, Dick walked over to the rack and selected another set.

"This one's baffled me," he remarked, as he connected up the chassis and switched it on. "The picture changes shape as you turn up the brilliance."

Smithy experimentally adjusted the controls of the receiver.

"Well, the picture shape looks pretty reasonable at low brilliance," he remarked. "But the bottom bends over to the left quite noticeably as you increase the brilliance. The effect is certainly conspicuous enough to be annoying because, apart from anything else, it will give you different degrees of bending according to the brightness of the scene being reproduced. Has this set got flywheel sync?"

"It has," said Dick.

Smithy groaned.

"Just our luck," he complained.

"Why's that?"

"What we have here," said Smithy, "is line displacement at the bottom of the picture when the brilliance goes up. An increase in brilliance corresponds to an increase in final anode current for the tube, together with an increase in loading on the line output stage. Since flywheel sync circuits are not directly locked to the transmitted sync pulses we may well be having a queer phase shift effect somewhere in this section. Let's hope I'm wrong anyway!"

"I thought there might be a horrible fault like that," confessed Dick, "so I haven't done anything to the set but check the valves in the sync separator, line oscillator and line output stages. And *they* were all O.K."

Smithy brightened visibly at this news.

"If that's all you've done," he remarked, "there may well be a simple fault causing the trouble after all. Now, by increasing brightness we're increasing the effective current of the electron beam as it travels down the tube. This *could* mean that we are getting a strange effect with any stray magnetic field that happens to be lying around. Do the picture shape correction magnets look O.K.?"

"Do you mean the little rod-shaped magnets fitted to the deflection yoke?"

"That's right," confirmed Smithy. "If there *are* any, they'll most probably be mounted on thin brass holders you can bend around, or they may be stuck into grooves in the yoke housing."

"We've got the brass holder type here," said Dick. "And the magnets look O.K. to me. At least they're there!"

"We'll take them as read for the time being then," said Smithy. "Sometimes they drop out, whereupon they can cause trouble elsewhere, either on account of their magnetic field or because they may short things out."

"I thought that most of those magnets were made of ferrite," protested Dick. "Surely, ferrite can't cause a short-circuit—it's an insulator!"

"I shouldn't be too sure of that," replied Smithy, guardedly. "Anyway, I *do* know that if you apply an ohmmeter to two ground faces on a piece of Ferroxcube you can get quite a low resistance reading. However, we're digressing. For the time being, we'll take the picture connection magnets as being O.K. The next thing on the list is the deflector yoke itself. I suppose something here *could* cause this fault, although I wouldn't like to commit myself on just exactly what it might be! I think I'll look upon changing the deflector yoke as a sort of Custer's Last Stand type of repair. Now, next to the yoke is the picture shift magnet."

Smithy experimentally adjusted the picture shift assembly, and watched the picture as it moved across the screen.

"You're doing something to the picture shape distortion," said Dick, suddenly. "The bending seems to vary as you move the picture around."

"There *is* an effect of that nature," agreed Smithy, "although I can't quite put my finger on it. The ion-trap magnet is the next thing on the tube neck, so let's try adjusting that."

Smithy set the picture shift assembly to its previous position and adjusted the ion-trap magnet.

"The bending's gone," exclaimed Dick excitedly. "Look, the picture's got it's proper shape now!"

Smithy looked closely at the screen. As Dick had said, the picture shape distortion was now completely cleared. Experimentally, Smithy adjusted the brilliance control, to find that the picture retained its correct shape at both high and low settings.

"Well," he remarked, "we certainly seem to have cured the fault. I've set the ion-trap magnet now for maximum brilliance, although it wasn't far off that position before. The picture needs a small amount of re-centring so I'd better tackle that next."

Smithy made a slight re-adjustment to the picture shift assembly and noted with satisfaction that this did not cause the picture shape distortion to re-appear.

"I wonder why the picture shift assembly changed the distortion," said Dick thoughtfully.

"I wouldn't like to be too dogmatic about this particular fault," confessed Smithy, "but I would venture a guess that the real trouble lies in the ion-trap in the tube itself. Unless the beam goes straight through the trap, as it does with the magnet correctly adjusted, I would guess that it tends to veer slightly at different beam currents. Anyway, we've cleared the snag very easily, and that's the main thing! The fact that the picture shift assembly changed the distortion is probably incidental. The assembly is pretty close to the ion-trap magnet anyway, and there appears to be some interaction between the two. Not an unusual state of affairs."

F.M. Detector

Smithy paused and lit a cigarette.

"Well," he remarked with satisfaction. "That's got three sets cleared up already. You know, Dick, it's good to be back in the old groove again."

Dick looked suspiciously at the Serviceman.

"What did you do," he asked, "after lunch?"

"After lunch where?"

"In London, of course."

Smithy reflected for a moment.

"Why, I went down to Lisle Street."

A light gleamed in Dick's eye.

"I thought as much," he said, darkly. "What you mean is you went prowling through Soho!"

"I most certainly do *not* mean I went prowling through Soho," replied Smithy hotly. "I've got no reason to prowl, as you call it; and, anyway, Lisle Street isn't in Soho. At least," he finished weakly, "I don't think it is."

"You must have gone there for some reason," persisted Dick.

"I went to have a look at the radio components shops," said Smithy. "I like looking in the windows of components shops."

"How long did you stay there?"

"Oh, I don't know," replied Smithy, irritably. "About an hour or so, I suppose."

"Which would make the time you left," pronounced Dick, "about half past two in the afternoon."

"Well?"

"Just nice time to pop into one of those theatre clubs," said Dick triumphantly. "*I've* heard about them!"

Smithy sighed.

"Since it is quite impossible," he said resignedly, "to convince you of the innocence of my recent sojourn in the Smoke, I would suggest we change the topic. Let's talk about something else."

Dick thought for a moment.

"What about ratio detectors?" he said suddenly. "You promised me we'd have a final session on these."

"If you like," said Smithy wearily. "Anything for peace!"

Dick moved away and returned with a service manual.

"Here we are," he said, putting the manual on the bench. "This is the circuit that puzzled me the last time we had a rag-chew about f.m. receivers. You said you'd give me the gen on the detector itself."

Smithy examined the circuit carefully, (Fig. 4); after which he drew a pad of paper towards him and took out a pencil.

"You've got a fairly conventional ratio detector here," he explained, "although it may not appear so at first sight. Let's get down to basic. Now, a conventional balanced ratio detector looks like this (Fig. 5 (*a*)), whilst the unbalanced version is like this (Fig. 5 (*b*)). The major difference between the two is that, with the balanced version, the chassis connection after the diodes is made into a centre-tap in the stabilising capacitor circuit. With the unbalanced circuit the chassis connection is at one end of the stabilising capacitor. The circuit in your service manual is that of an unbalanced detector, as you can see if you trace out the secondary diode circuit. Incidentally, that particular circuit *has* to be of the unbalanced type because one of the diode cathodes is shared by the triode, and so must be at chassis potential."

"How does the ratio detector provide amplitude limiting?"

"By reason of the stabilising capacitor," replied Smithy. "Let's look at the detectors I've just sketched out. (Figs. 5 (*a*) and (*b*).) Now, when an i.f. input is applied to the tuned primary of the ratio detector transformer, an i.f. voltage appears across the tuned secondary winding, as in the normal course of events. This i.f. voltage is rectified by the two diodes and causes the stabilising capacitor to charge up. The result is that, when there is an i.f. input of constant amplitude, the stabilising capacitor charges up to a steady voltage. Also in the circuit is a relatively low value of resistance across the stabilising capacitor, and this causes a certain amount of damping on the transformer. Now, let's imagine that the i.f. input to the primary changes in level. If the input amplitude goes up, further current flows into the stabilising capacitor because the latter now tries to charge up to the increased voltage. This additional current causes extra damping on the transformer. On the other hand, if input level goes down less charging current is required by the stabilising capacitor, and transformer damping is reduced. Summing it up, you can say that the transformer suffers a constant amount of damping when a signal of constant amplitude is applied. This damping increases if signal amplitude increases, and it decreases if signal amplitude decreases."

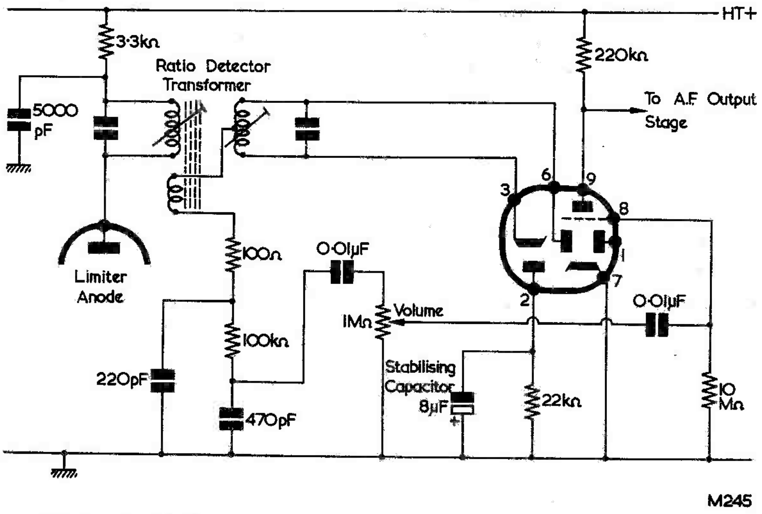


Fig. 4. A typical commercial ratio detector stage with representative component values. This is part of the f.m. receiver circuit published last month.

"I get it," said Dick. "Obviously output goes down if damping is increased, with the result that increases in input level are cancelled out by increased damping of the transformer. At the same time, drops in input level are cancelled out by decreased damping of the transformer. Dead easy, isn't it?"

"Well, it's not all *that* easy," interjected Smithy, "because in practice the ratio detector circuit must be planned very carefully if a.m. limiting is to be really efficient. The transformer itself has, of course, to be correctly designed and manufactured, as it would be in the case of a commercial receiver such as we are considering here. It frequently happens, also, that additional components are added to the basic detector circuit to modify the effect of the stabilising capacitor. A typical dodge is to insert resistors in series with the diodes and the stabilising capacitor (Fig. 5 (*c*)). As you can see, these alter the degree of damping imposed by the stabilising capacitor. The values of such resistors would normally be around 1kΩ, and they would be selected to offer optimum rejection at the average input level at which the ratio detector is intended to work. For final adjustment, one of these resistors could be made variable."

"Why do you say 'average input level'?" asked Dick. "Won't the ratio detector work for any input level?"

"It will *detect* over a very wide range of input levels," replied Smithy, "but, for a given set of component values, it may give really efficient a.m. limiting over a relatively small range only. Probably the most important reason for this is non-linearity in the diodes. In practical receivers you ensure that the input to a ratio detector is pretty constant in amplitude by putting a limiter stage in front of it."

"I see," said Dick. "This limiter stage not only provides limiting on its own, but it also assists the limiting given by the ratio detector."

"That's about it," confirmed Smithy. "I should add the further point that the ratio detector normally gives optimum limiting at one *frequency*. This effect is quite noticeable with some f.m. receivers. If you tune in a signal whilst there's heavy background interference caused by, say, a motor, you can find one particular spot where the interference shows a marked null. Incidentally, the frequency at which optimum limiting is given may not always coincide with that at which optimum detection occurs, although the two frequencies should be close enough in practice to cause no trouble."

"Are there any other ways of modifying the limiting action of the ratio detector?"

"A very common practice," said Smithy, "consists of inserting a low value resistor between the end of the tertiary winding and its bypass capacitor (Fig. 5 (*d*)). This resistor may have a value lying between some 20 to 200Ω, and it may even be made a pre-set variable in some cases. In the circuit in your service manual (Fig. 4) a 100Ω resistor has been fitted at this point."

"So it has," said Dick, re-examing the circuit. "Tell me, Smithy, why do they call it the 'tertiary' winding?"

"All that 'tertiary' means," replied Smithy, "is 'third in order'. The tertiary is the next winding, in order, after the secondary."

"I'm dashed," exclaimed Dick. "I always thought that 'tertiary' was an egg-head word which described what the winding *did*!"

"Well, now you know," chuckled Smithy. "Getting back to the detector circuit, the a.f. output appears at the tertiary winding terminal, proceeds through the de-emphasis filter and then passes via the 0.01μF blocking capacitor on to the volume control. After this. . . ."

"Whoa!" interrupted Dick. "You're half a dozen lengths ahead of me! For instance, what's the de-emphasis circuit for?"

"To counteract the pre-emphasis on the transmitted signal, of course."

"All right then, what's the *pre*-emphasis for?"

"To improve signal-noise ratio."

Dick groaned.

"Look Smithy," he said, "I know I'm dim, but could you just *explain* that this de-emphasis and pre-emphasis business is."

"As you like," said Smithy equably. "It's all quite simple. Now, it happens that conventional f.m. receivers tend to offer more noise at the high frequency end of the a.f. spectrum than they do at the low frequency end. An obvious way of reducing this noise would consist of applying a little top-cut in the receiver a.f. circuits, and that is, basically, what the de-emphasis circuit does.

"In order to maintain a flat frequency response over the complete system, the higher frequencies are then accentuated by a corresponding amount at the transmitter, this latter process being known as pre-emphasis."

"I think I'm with it," said Dick doubtfully. "Although I can't see any obvious top-cut components in the service manual circuit."

"They're there if you look hard enough," grinned Smithy, taking up his pencil again. "The simplest method of obtaining de-emphasis in the receiver is to put in a low-pass filter after the tertiary winding terminal. Like this, (Fig. 5 (*e*)). To correspond to the pre-emphasis transmitted by the B.B.C. in this country, the resistor and capacitor in the filter has to have a time constant of 50μS."

"Then, the 100kΩ resistor and 470pF capacitor in the service manual circuit must be the de-emphasis filter," said Dick excitedly. "I thought they were just there to assist in stopping i.f. getting into the a.f. stages!"

"They do that as well," said Smithy, "which makes for a nice convenient arrangement all round."

"You said," continued Dick, frowning, "that the time constant had to be 50μS. Well, we've got a 100kΩ resistor and a 470pF capacitor in the service manual circuit. Megohms times picafarads equals microseconds, so we've got 0.1 multiplied by 470. And that is 47μS."

"Near enough," commented Smithy, "to 50μS for the likes of us. And I'm glad to see that you've benefitted from the little mental arithmetic exercises we had during our last session! I must point out that many commercial receivers don't use de-emphasis circuits which are equal to 50μS. They may alter the time constant slightly to make up for response variations in the a.f. stages."

"What's the 0.01μF capacitor which follows the de-emphasis circuit for?"

"To keep d.c. off the volume control," explained Smithy, adding a blocking capacitor and volume to his previous sketch (Fig. 5 (*f*)). "You see, quite a high d.c. potential relative to chassis can appear on the tertiary winding terminal, and if this is applied across the volume control the latter will sound scratchy

Fig. 5 (a). A balanced ratio detector circuit. Fairly typical component values would be: C_1, *100pF;* C_2, C_3, *200pF;* C_4, *5μF;* R_1, R_2, *10kΩ.*

(b). The unbalanced ratio detector. The chassis connection is, in this instance, made to one end of the stabilising capacitor, with a consequent saving in components. Fairly typical values are: C_1, *100pF;* C_2, *5μF;* R_1, *20kΩ.*

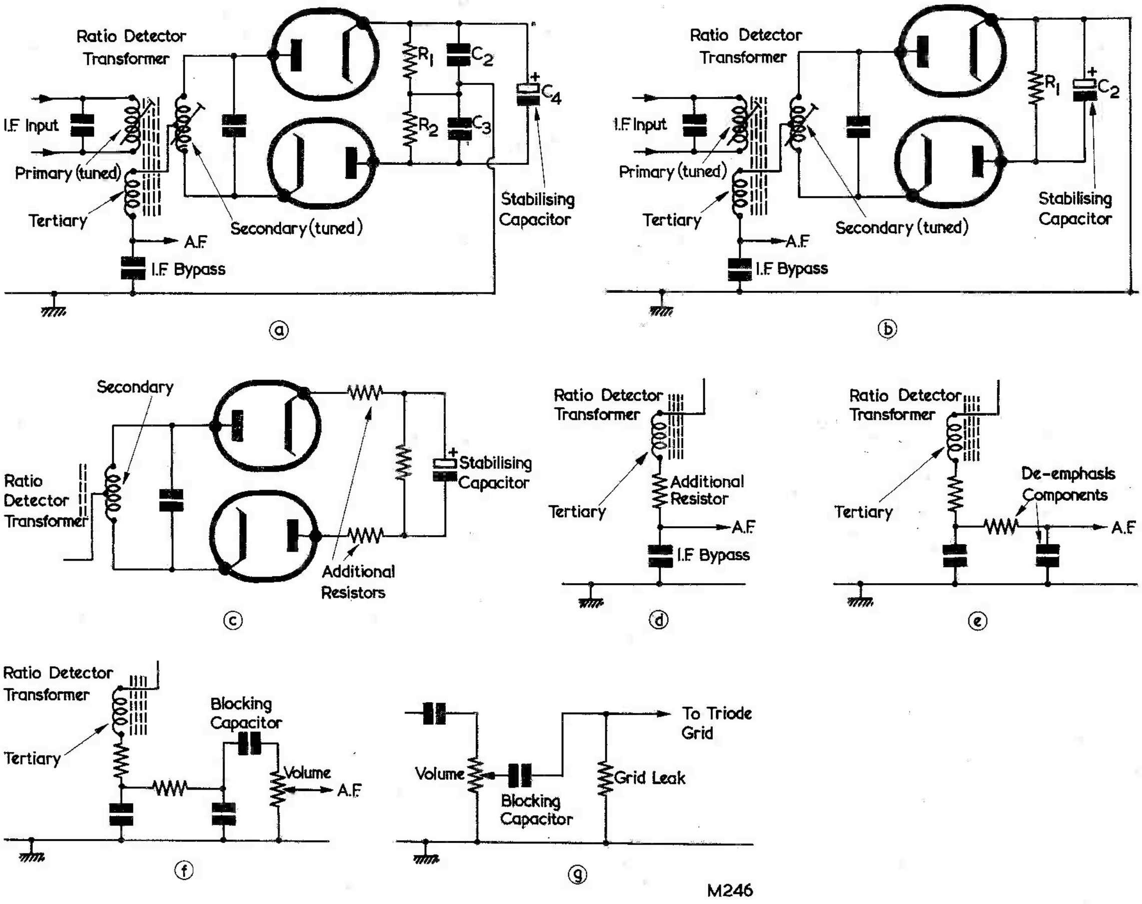
(c). The a.m. limiting properties of the ratio detector may be modified by inserting resistors between the diodes and the stabilising capacitor.

(d). Another method of modifying the a.m. limiting properties of the ratio detector.

(e). A very convenient method of applying de-emphasis in an f.m. receiver.

(f). A d.c. voltage may be present on the tertiary winding terminal and this must be blocked from the volume control, or the latter will be noisy in operation.

(g). A further blocking capacitor may be needed to isolate the grid of the following a.f. amplifier from the relatively low resistance given by the volume control.



as you adjust it."

"There's *another* 0.01μF capacitor following the volume control," Dick pointed out.

Smithy added this to his sketch (Fig. 5 (*g*)).

"That provides d.c. blocking as well," said Smithy. "The triode has no cathode bias, and its grid is coupled to chassis via the usual high value resistor. If you didn't have the second 0.01μF capacitor, that high value resistor would be shunted by whatever resistance lay between the slider of the volume control and chassis."

Persistence

Smithy stopped and looked up at the clock.

"There I go again," he said in annoyance. "Gassing away the working day! Are there any more queries before we get back to work?"

"There's just one thing that puzzles me."

"Fire away!"

Dick settled himself comfortably.

"Tell me what you did after you left Lisle Street."

British Equipment to Detect Worldwide Nuclear Explosions

British scientists are studying methods of detecting, identifying and locating nuclear explosions in other countries. They are now proceeding with the development of very advanced detection equipment.

There is a great deal more to this than merely measuring "fall out"—the degree of radioactivity in the atmosphere—since it is now possible to carry out tests which do not produce fall out.

One way of exploding a nuclear device without producing detectable fall out is to bury the weapon. But an explosion under these conditions produces effects similar to those of an earthquake, so scientists using seismic detection apparatus can record the disturbances in the earth's structure. EMIDATA magnetic tape instrumentation equipment, manufactured by EMI Electronics Ltd., is used to record these data accurately by employing advanced frequency modulation techniques.

An array of recording stations can be set up and left unattended for two weeks, after which the tape recordings can be collected and replayed into a computer for analysis. One feature of the EMIDATA instrumentation equipment is that the recorded tapes may be replayed at over 100 times faster than the recording speeds. So data recorded over a period of two weeks can be played back in three and a half hours. The analysis methods used can significantly improve the signal-to-noise ratio and help in the determination of the location and depth of the source of seismic signals.

It is possible to "muffle" a nuclear explosion—greatly reducing the seismic effect—by firing it in a very large chamber deep underground. The British scientists are exploring methods of sensing such a decoupled nuclear explosion by measuring its effects on the earth's magnetic field and by the generation of earth currents. Again, EMIDATA instrumentation equipment makes this a practical proposition.

It is clear that considerable progress is being made in solving the problems of nuclear detection. EMIDATA equipment could supply the means for a world-wide network of recording stations to provide an international monitoring service of nuclear explosions.

The Importance of a Good Aerial and Earth

By Gordon J. King, Assoc.Brit.I.R.E.

Despite the introduction of v.h.f. frequency modulation broadcasts, a considerable amount of domestic listening is still carried out on the Medium and Long wave bands. This article discusses the installation of efficient aerial and earth systems, with particular emphasis on a.m. receivers or tuners having transformer-isolated power supply circuits

Many medium-frequency reception difficulties are caused by insufficient attention being paid to the aerial and earth installation. Indeed, a large proportion of cases of interference investigated by the Post Office are directly attributable to poor or inadequate aerial and earth arrangements.

In days gone by reception troubles due to inefficiency of installation were remote, mainly because medium range reception then demanded a lofty long-wire aerial and a good earth. The situation today is vastly different for three primary reasons.

Firstly, because modern sets are far more sensitive than their early counterparts one is tempted to use just an odd bit of wire for the aerial and conveniently forget all about the earth. Secondly, electrical interference is far more concentrated now than in the past owing to the extended use of domestic electrical appliances, including television sets which produce their own brand of interference. Thirdly, the cramped medium-frequency spectrums now carry many more transmissions than in the days of long aerials.

VHF-FM broadcasting solves most of these problems, but a good aerial is required to operate such a set satisfactorily, anyway! There are, nevertheless, millions of sets operating on the medium-frequency a.m. bands, and while Radio Luxembourg continues to use the medium wave band it is unlikely that the demand for a.m. sets will decline.

Signal Coupling

Unlike a v.h.f. or television aerial an ordinary medium-frequency aerial is tuned to no specific frequency, and it is, therefore, responsive to all signals in the LW, MW and SW bands. It does, however, work best at one particular frequency which is sometimes called the aerial's natural frequency or wavelength. This frequency is governed by the inductive and capacitive distributed elements and hence on the length of the aerial, including the downlead.

As an example, an aerial of 100 ft. has a natural frequency of about 2.5 Mc/s (120 metres), and the natural wavelength is approximately 4.5 times the length of the wire. The tuning of a long-wire aerial is very flat and for this reason it operates satisfactorily over a very wide range of frequencies.

The signal induced into a long-wire aerial is relative to the earth, which means that signals cannot be coupled to a set from the aerial alone—there must also be an earth connection. It is shown in Fig. 1 how the signal is coupled to the set, and the set operates only because a signal is induced across the coupling coil.

Very sensitive sets will operate without an aerial or with a very short length of wire and no earth. This is because there is always a certain amount of signal pick-up on the aerial circuit wiring and also on the coils themselves.* From the r.f. point of view, the set is always earthed to some degree or other by the capacitance between the chassis and earth or between the chassis and the mains supply circuit. However, such "earths" are highly inefficient and this can be proved by removing the earth connection from a battery set which has no connection to the mains supply circuit. When this is done the signal pick-up drops considerably. With a mains set, the effect is not so bad owing to the relatively high capacitance to the mains circuit, which itself has a relatively low impedance to earth.

As the strength of the signals fed to the set are proportional to the strength of the signals induced in the coupling coil, it follows that the earth lead must itself have very little loss for maximum signal transfer. If the earth lead is long it can be represented by a resistor as shown by R in Fig. 2 (*a*), and from this it can be clearly seen that the available signal between aerial and earth now has to be proportioned between the resistance and the coupling coil. If the value of the resistance is such that it develops across it half of the available signal, then there is only half left for the coupling coil and only half the available signal is fed to the set.

There is a further point, and that is that the earth lead may well pick up signal itself and thus cancel out a certain amount of the signal that the aerial has picked up. Moreover, since the earth lead is at fairly low level it tends to pick up more interference than signal and thus injects interference into the set.

Mains Interference

If there is no earth or if the earth connection is highly inefficient, much of the signal transfer from the aerial to the coupling coil may depend on the capacitive coupling between the chassis and the mains supply circuit. This is shown as a "lumped" capacitance, C, in Fig. 2 (*b*) and

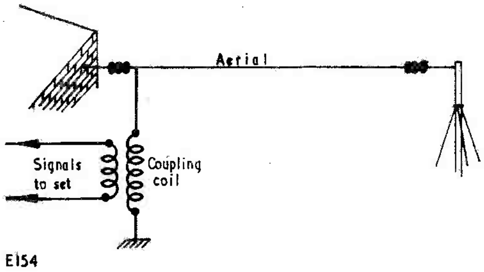


Fig. 1. A signal picked up by an aerial is relative to earth, which means that the coupling coil cannot receive a signal without an earth

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* If the receiver has a ferrite rod aerial, the aerial coil is, of course, intended to pick up signals.—Editor.

comprises the capacitance between the primary winding of the mains transformer and other similar strays, including the mains circuit capacitance to true earth.

There are always developed across this capacitance large interference voltages resulting from interfering currents injected into the mains supply circuits from such things as electric motors in domestic appliances, fluorescent and neon lights, electric switches and the hundred-and-one other electrical devices which are now in mode, including television sets.

This causes two things to happen: one, the signal transfer from the aerial is impaired and two, interference currents are injected straight into the aerial circuit. The set not only works below peak, therefore, but reception is also likely to be severely marred by buzzes and crackles. This is, indeed, a very common complaint and, although there are now certain regulations about interference, the Post Office can hardly be expected to do much about such disturbances if one allows the set to pick them up in this way.

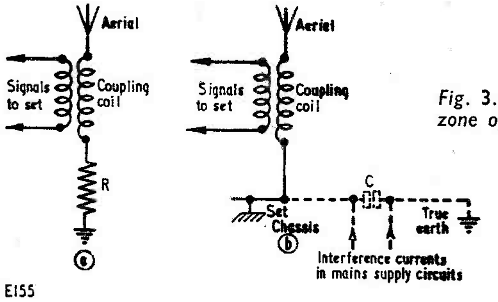


Fig. 2. At (a) is shown how the aerial signal is divided between the resistance of the earth lead R and the coupling coil, while (b) shows how interference currents are injected into the aerial circuit of a mains receiver operating without an earth

There is no doubt that a very good earth goes a long way in reducing interference and improving reception. There is a lot in favour of the old-fashioned earth consisting of a well-watered copper plate or rod buried directly below the window and connected to the set through a short, stout copper wire.

Screened Downlead

No matter how good the earth is, the set will still not operate properly without an aerial. A good earth will go a long way in masking the shortcomings of a poor aerial, but if a quiet background is to be enjoyed, then a good aerial and earth are essential requirements.

If an ordinary aerial picks up a lot of interference, even with a good earth, it is often rewarding to mount the aerial as high as possible outside the interference zone and direct the signal to the set through screened cable. An unscreened downlead picks up signal and interference because it acts as part of the aerial, but a screened downlead has an appreciable immunity to signal pick-up and is ideal for getting the signal to the set through a zone of interference.

Screened cable has quite a capacitance between its inner conductor or conductors and outer braid, which means that, if it is connected direct to the aerial and the outer braid is earthed as it should be, much of the signal is lost across the capacitance. If the aerial is picking up really strong signals then a signal loss may be tolerable to provide an improvement in signal-to-interference ratio. In this event, the inner conductor of a suitable length of coaxial cable should be connected to the aerial and the inner conductor at the other end to the aerial socket of the set, while the outer braiding should be connected to the earth socket which should be connected also to an efficient earth.

On a number of occasions this arrangement has been known to alleviate the disturbing whistle that television line timebases radiate on the medium-frequency bands, especially on the Light Programme of the B.B.C.

If a signal loss cannot be tolerated a more scientific approach to the problem is necessary. The loss can be considerably reduced by the use of two transformers as shown in Fig. 3. The transformer at the aerial has a step-down ratio from the aerial to the cable, while that at the set has a step-up ratio from the cable to the set. In effect, the aerial transformer steps down the high impedance of the aerial to a value equal to the characteristic impedance of the cable, while the transformer at the set does exactly the reverse.

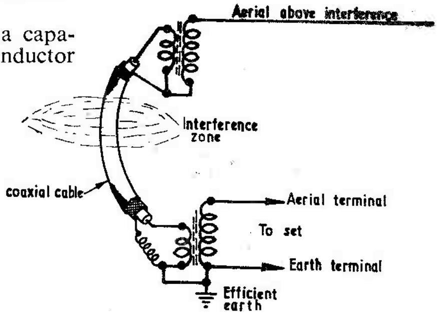


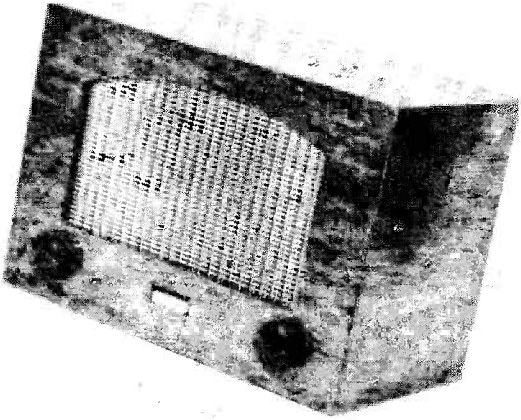
Fig. 3. Showing how the aerial signal may be directed through a zone of interference via screened cable. The transformers match the aerial to the cable and the cable to the set

Transformers of a similar nature are available commercially from one of the well-known aerial manufacturers, but the experimenter may feel inclined to make a pair up himself. While the efficiency may be below those of commercial design, quite reasonable signal transfer has been obtained on home-made units. The transformers should have a turns ratio of about 10-to-1, and the high impedance winding should contain approximately the same number of turns as a Long wave aerial coil, and the same diameter wire. Thicker wire should be used for the low impedance winding.

To preserve the wideband characteristics of a long-wire or rod aerial the transformer should be wound on one of the new low-loss cores, preferably with a closed magnetic circuit; but ordinary open-ended coils work quite well.

In conclusion, it is hoped that this article has revealed that, although an odd bit of wire plugged into the aerial socket may provide indifferent reception of the local station, much more is required for an a.m. set or tuner to give its best performance in face of the steadily growing interference. It is truly surprising how a.m. reception can be improved by paying a little extra attention to the most important part of the installation —the aerial and earth.

Cover Feature



INEXPENSIVE VHF RECEIVER

By V. E. Holley

THIS IS A COMPACT LOW COST RECEIVER FOR USE within the service areas of the B.B.C. v.h.f. transmitters. With a suitable aerial and average reception conditions, it will perform satisfactorily up to a range of about 30 miles. Only seven valves are used, including the tuning indicator, and the power rectifier, and the number of other components have been reduced to the minimum necessary for adequate performance. For the benefit of listeners not so favourably situated, a simple and inexpensive modification will be described by means of which the receiver can be made to give a good account of itself in fringe or difficult reception areas.

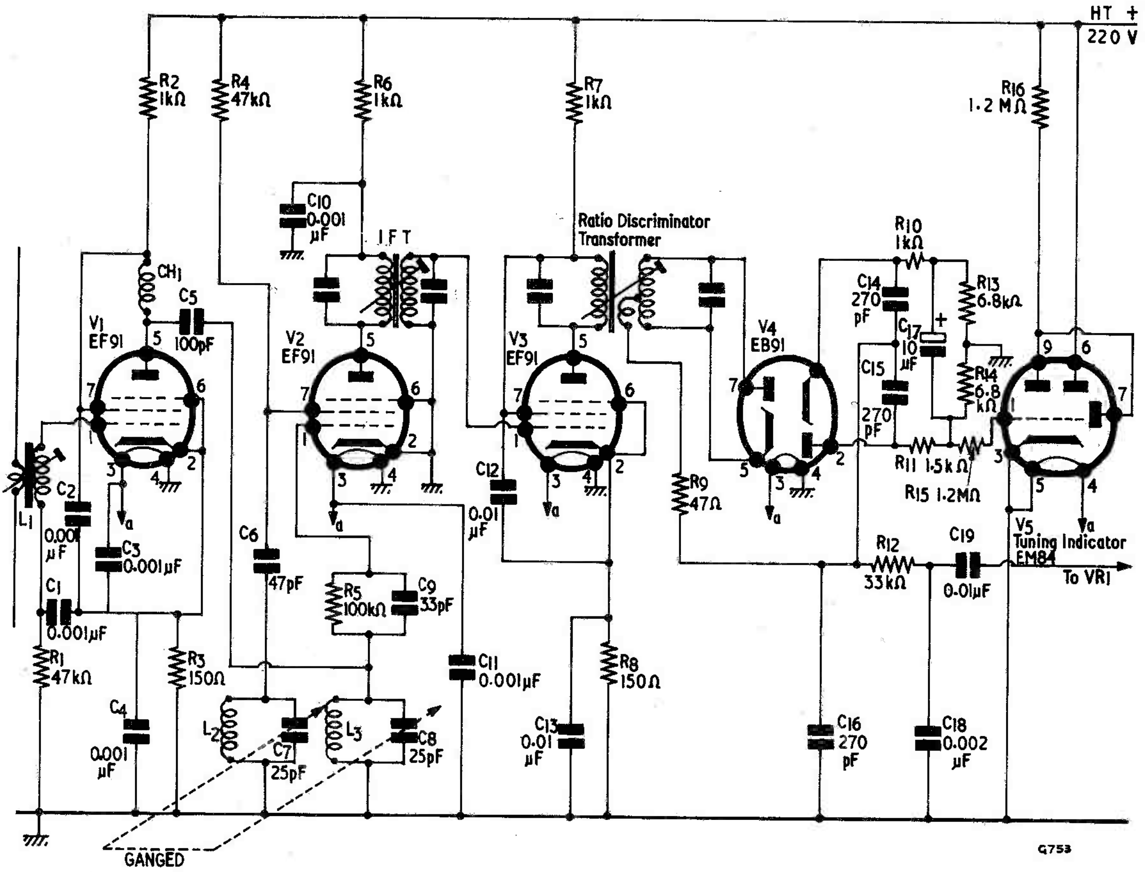


Fig. 1. Circuit of the r.f. section

Components List

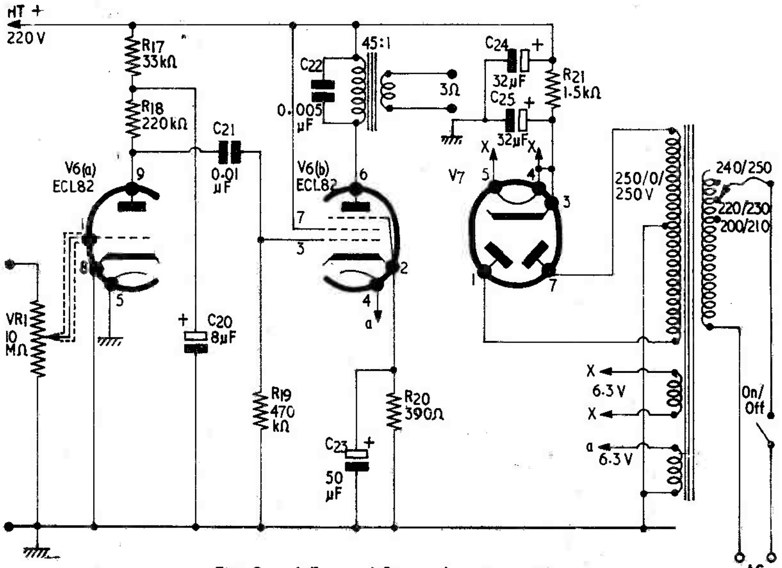


Fig. 2. A.F. amplifier and power supply

Resistors ($\frac{1}{4}$ watt unless otherwise stated)

R_1	47kΩ
R_2	1kΩ
R_3	150Ω
R_4	47kΩ
R_5	100kΩ
R_6	1kΩ
R_7	1kΩ
R_8	150Ω
R_9	47Ω
R_{10}	1kΩ (5%)
R_{11}	1.5kΩ (5%)
R_{12}	33kΩ
R_{13}	6.8kΩ } Balanced or 5% tol.
R_{14}	6.8kΩ } Balanced or 5% tol.
R_{15}	1.2MΩ
R_{16}	1.2MΩ
R_{17}	33kΩ
R_{18}	220kΩ
R_{19}	470kΩ
R_{20}	390Ω 1 watt
R_{21}	1.5kΩ 10 watt
R_{22}	47kΩ[1]
R_{23}	47kΩ[1] $\frac{1}{2}$ watt
VR_1	10MΩ log. with switch (see text)

Capacitors (350V wkg unless otherwise stated. Ceramic capacitors preferred in r.f. circuits unless otherwise stated)

C_1	0.001μF
C_2	0.001μF
C_3	0.001μF
C_4	0.001μF
C_5	100pF
C_6	47pF silver mica
C_7	} Air spaced variable ganged. Max values 25 to 30pF
C_8	} Air spaced variable ganged. Max values 25 to 30pF
C_9	33pF silver mica
C_{10}	0.001μF
C_{11}	0.001 disc ceramic
C_{12}	0.01μF
C_{13}	0.01μF
C_{14}	270pF silver mica
C_{15}	270pF silver mica
C_{16}	270pF
C_{17}	10μF 50V electrolytic
C_{18}	0.002μF
C_{19}	0.01μF
C_{20}	8μF electrolytic
C_{21}	0.01μF
C_{22}	0.005μF
C_{23}	50μF 25V electrolytic
C_{24}	32μF electrolytic
C_{25}	32μF electrolytic
C_{26}	47pF silver mica[1]
C_{27}	0.01μF[1]

Speaker
3Ω, 7 x 4in elliptical

Valves

V_1	EF91, B7G base[2] and screen
V_2	EF91, B7G base[2] and screen
V_3	EF91, B7G base[2]
V_{3A}	EF91, B7G base[1,2]
V_4	EB91, B7G base[2]
V_5	EM84, B9A base[2]
V_6	ECL82, B9A base
V_7	EZ80, B9A base

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[1] These components are required when the extra i.f. stage is fitted.
[2] Base fitted with centre spigot.

Coils

L_1	Neosid former $\frac{3}{16}$in, black core. Lengths of 20 s.w.g. tinned copper wire and 24 s.w.g. enamelled.
L_2	} Length 16 s.w.g. tinned copper wire
L_3	} Length 16 s.w.g. tinned copper wire
Ch_1	1 watt resistor, 150kΩ, $\frac{5}{32}$in dia., 36 s.w.g. enamelled copper wire.

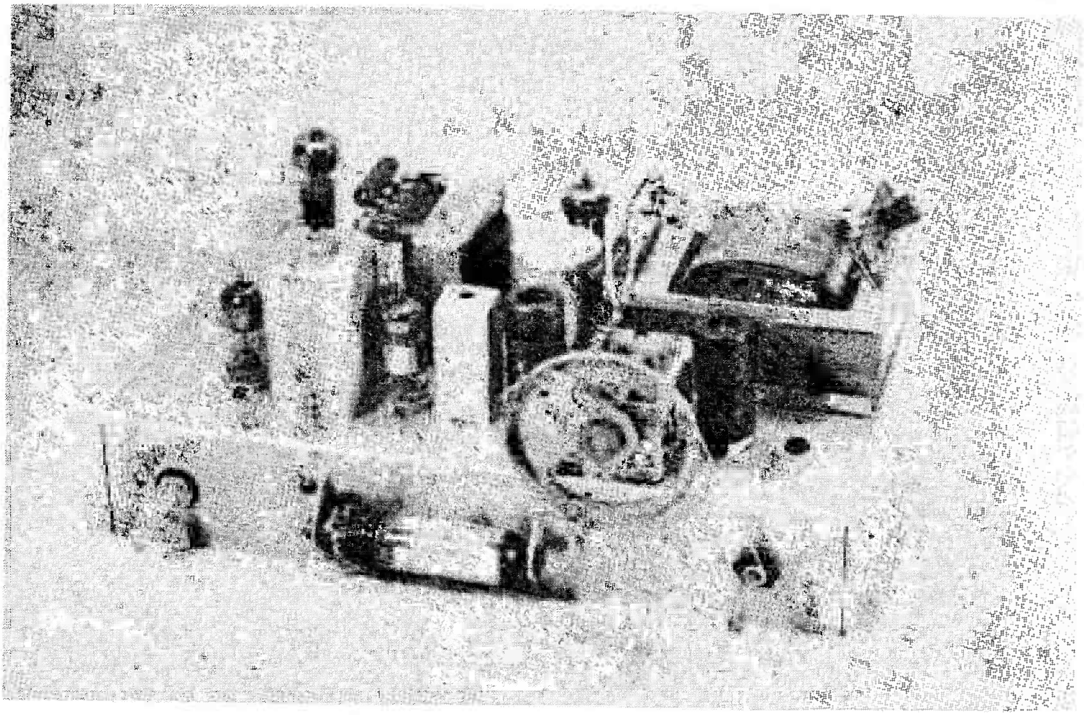
Transformers
Mains: 250–0–250V 70mA, 6.3V 2.5A, 6.3V 0.6A
I.F.: Denco, IFT 11/10.7
Output: 45 : 1
Detector: Denco type RDT

Chassis
Sheet aluminium, 16 s.w.g. $15\frac{3}{4}$ x $9\frac{3}{4}$in

Miscellaneous
Discarded volume control
Drive drum and cord
Two $1\frac{1}{2}$in control knobs
Coaxial socket
Three $\frac{1}{4}$in rubber grommets
Plywood, hardboard, panel pins, glue, glasspaper, etc., for cabinet.

Circuit

The circuit of the r.f. section is given in Fig. 1. The signal from the dipole aerial is presented, via the coil L_1, to the grid of the first valve, a pentode r.f. amplifier, EF91. As there is little advantage in having variable tuning here, the coil is tuned by means of its dust core to the centre of the band of frequencies to be received. No separate tuning capacity is necessary, the input capacity of V_1 being sufficient. The amplified signal appears at the anode and is transferred to the grid of V_2 with the aid of the v.h.f. choke (Ch_1) and the capacitor C_5. This stage provides valuable gain and at the same time serves to isolate the oscillator from the aerial. The second harmonic of the local oscillator can fall in television Band III and it is therefore important that radiation should be avoided.



Above—chassis view of the receiver

Oscillator and Mixer

A second r.f. pentode, EF91, is made to perform the dual function of oscillator and mixer. L_2, the oscillator coil, is inductively coupled to L_3, the signal frequency coil, so that both oscillator and signal frequencies are fed additively to grid 1 and combined within the valve to produce the intermediate frequency of 10.7 Mc/s. Because the cold input capacity of a valve is different from the capacity when hot, an oscillator always displays a frequency drift in the first few minutes after switching on, thereafter the effect of the valve itself is small but there is a slow drift, for an hour or more, due to the effect of rising temperature on components and dielectrics in the associated circuits. This drift must be corrected or eliminated. In this receiver it is eliminated by good ventilation and by arranging that there is no capacity across either L_2 or L_3 other than the air spaced variable tuning capacitor, C_7, C_8. The initial drift on switching on cannot be eliminated but it is not sufficient to spoil reception. Once the cathode of V_2 has attained working temperature the receiver will remain accurately in tune indefinitely.

IF Stage

In the anode circuit of V_2 a transformer tuned to the intermediate frequency transfers the signal to the grid of V_3 for further amplification. This stage is quite conventional and requires no comment except to say that the capacitor C_{13} must be completely non-inductive, or there will be instability. Most ceramics are suitable.

Demodulation and De-emphasis

The signal which up to this point is expressed as variations of frequency, must now be converted to variations of amplitude in order that it may be reproduced as sound. This is accomplished by a ratio detector circuit consisting of the ratio discriminator transformer in the anode circuit of V_3, the double-diode valve V_4, and its associated R/C network. The transformer may be regarded as an ordinary i.f. transformer having a third or tertiary winding the purpose of which is to supply a reference for the behaviour of the secondary. The diodes are so connected that they conduct on the same half cycle of applied voltage and, when a signal is present, a rectified current flows around the series circuit R_{10}, R_{13}, R_{14}, R_{11}. This current is "smoothed" by the reservoir action of C_{17} and a steady potential is built up across the diodes. Because C_{17} is large, this potential remains constant at a level related to the average value of the incoming signal, even during the receipt of a large interference pulse. Interference is thus excluded from the output and the steady d.c. potential is available for the operation of the tuning indicator.

While the applied signal remains constant at 10.7 Mc/s, the voltages at the ends of the ratio discriminator transformer secondary are equal and opposite and both diodes conduct equally. When modulation is present, i.e. when the signal deviates from 10.7 Mc/s, the secondary obeys the laws of coupled tuned circuits, the state of balance is upset and one diode receives momentarily a larger voltage and the other a smaller. There is thus a variation at audio frequency in the ratio of division of the steady d.c. potential between the diodes, and an audio frequency signal becomes available at the centre tap of the a.c. shunt load connected across them (C_{14} and C_{15}). The signal thus obtained is passed through the low pass filter R_{12}, C_{18} to remove the emphasis of the higher audio frequencies which is a feature of the B.B.C. transmissions. This filter has a time constant of 60 μS.

The resistors R_{10} and R_{11} have been selected to produce the best balance for the rejection of interference; they should be ±5% or better, as also should R_{13} and R_{14}.

Tuning Indicator

The inclusion of a tuning indicator is well justified. Not only is it an invaluable aid to accurate tuning but, in conjunction with a simple method of programme identification, it enables the customary slow motion drive and tuning scale to be dispensed with and serves also as a panel lamp to indicate that the receiver is switched on. An indicator is necessary because, in the absence of modulation, there is nothing at all to be heard. The valve selected is the EM84; the display consists of two lines, about 5mm in width, extending in length towards the centre of the tube as the control voltage increases. The control grid is connected, as shown, to the negative end of C_{17} through a 1.2MΩ resistor. Modulation is not present here, so no capacitor is required at the grid.

AF and Output Stage

As will be seen from Fig. 2, the signal from the ratio detector is passed to VR_1 and thence to the grid of the triode portion of V_6. The triode receives a measure of bias, by the grid leak method, via VR_1, the cathode being returned direct to chassis. If desired, cathode bias can be provided in the usual manner, using a 2.2kΩ resistor bypassed by a 25 or 50μF electrolytic capacitor and, if this is done, the value of VR_1 should be reduced to 1MΩ. R_{18} is the load resistor and C_{20} and R_{17} provide the additional smoothing which is necessary to exclude hum from the output. The pentode section of V_6 is employed as the output valve in the conventional manner. Its optimum load is 5.6kΩ and the output transformer should have a ratio of 45:1 for a 3Ω speaker. Across its primary is connected the capacitor C_{22} which is necessary to correct response at the higher frequencies, at which both the speaker impedance and the output of the valve rise considerably. The maximum output is 3.5 watts with the usual 10% distortion. As there are no whistles, sideband interference, etc., to contend with, a tone control is not required and none is provided. The mains switch is incorporated with VR_1.

Power Supply

The mains transformer must supply 250–0–250V, 70mA, for the h.t. and 6.3V, 2.5A for the valve heaters; also 6.3V, 0.6A for the rectifier, an EZ80. Alternatively, the rectifier heater may be included with those of the other valves, in which case, the main heater winding must be able to supply 3A- *If this is done, it is most important to omit the connection between pins* 3 *and* 4 *of the rectifier*. Any other rectifier may be used in lieu of the EZ80, the only requirements being that it will pass 70mA and that the appropriate heater voltage is available from the mains transformer. Main smoothing is provided by R_{21} in conjunction with C_{24} and C_{25}. A value of 1.5kΩ will generally be correct for R_{21} but some slight adjustment may be required to provide the correct h.t. rail voltage of 220, depending upon the output from the rectifier. As the smoothing capacitors are large, it should be verified that the transformer secondary winding provides the minimum effective supply impedance required by the rectifier. In the case of the EZ80 this is 125Ω per anode and, if the winding measures less than this, the difference must be made up with resistors in series with the anodes.

Distant Reception

If the receiver is to be used in an area where transmissions are poorly received, it will be necessary to increase the sensitivity. This may be done quite simply by the addition of a second i.f. stage, the circuit of which is given in Fig. 3. It will be seen that the only additional components required are a valve, EF91, an i.f. transformer, two resistors and two capacitors. This stage not only increases the sensitivity considerably but also provides the additional protection against intereference which is desirable under conditions of less favourable signal/noise ratio. The valve is employed as a limiter; the anode and screen voltages are low so that amplitude changes at the grid are reproduced in the anode circuit only to a limited and pre-determined extent. The network R_{22} C_{26} in the grid circuit generates bias and reduces the anode current to a very low value, so assisting the limiting action. The limiter, in conjunction with the balanced form of ratio detector, provides a very high degree of protection against impulsive interference and very little, if any, noise will be heard even under the most adverse conditions.

If the constructor is uncertain whether the second stage will be required the receiver can be completed without it; there is no difficulty about adding it later.

Construction

The receiver is built on a chassis of 16 s.w.g. aluminium sheet measuring 11 x 6 x 2in as shown in the plan. (Fig. 4.) Note that the rear runner is only 1¾in deep, leaving a space of ¼in at the bottom for ventilation. Valveholder orientation is given in Fig. 6. The fixing holes for the mains and output transformers have been omitted, since their positions and size will vary according to the components used. For the same reason, the positions of the holes for the i.f. and detector transformers are not indicated by measurement. The tuning indicator is fitted horizontally on the front runner of the chassis, being held in position by two aluminium brackets. The left hand bracket is fitted with a 2BA bolt which engages in the centre spigot of the valveholder and the other with a ¼in rubber grommet in which the glass pinch at the top of the valve is located. Fig. 5 shows the detail. The indicator should be positioned so that the centre of the display is on the centre line of the chassis, and the hole in the front runner through which the wiring passes can then be marked and cut immediately behind the valveholder. The

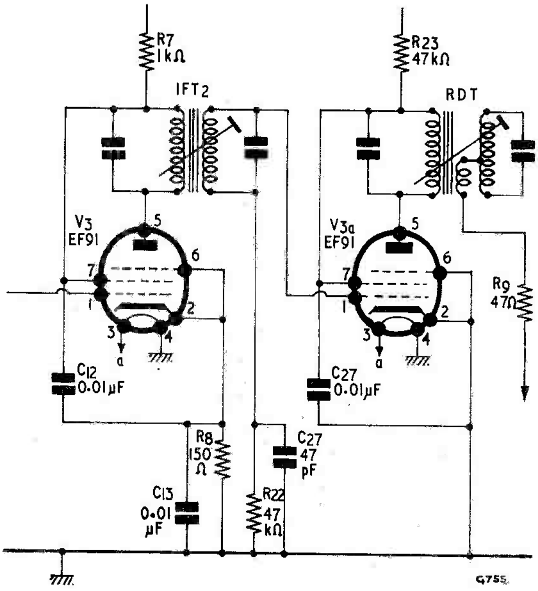


Fig. 3. *Additional i.f. stage for distant reception*

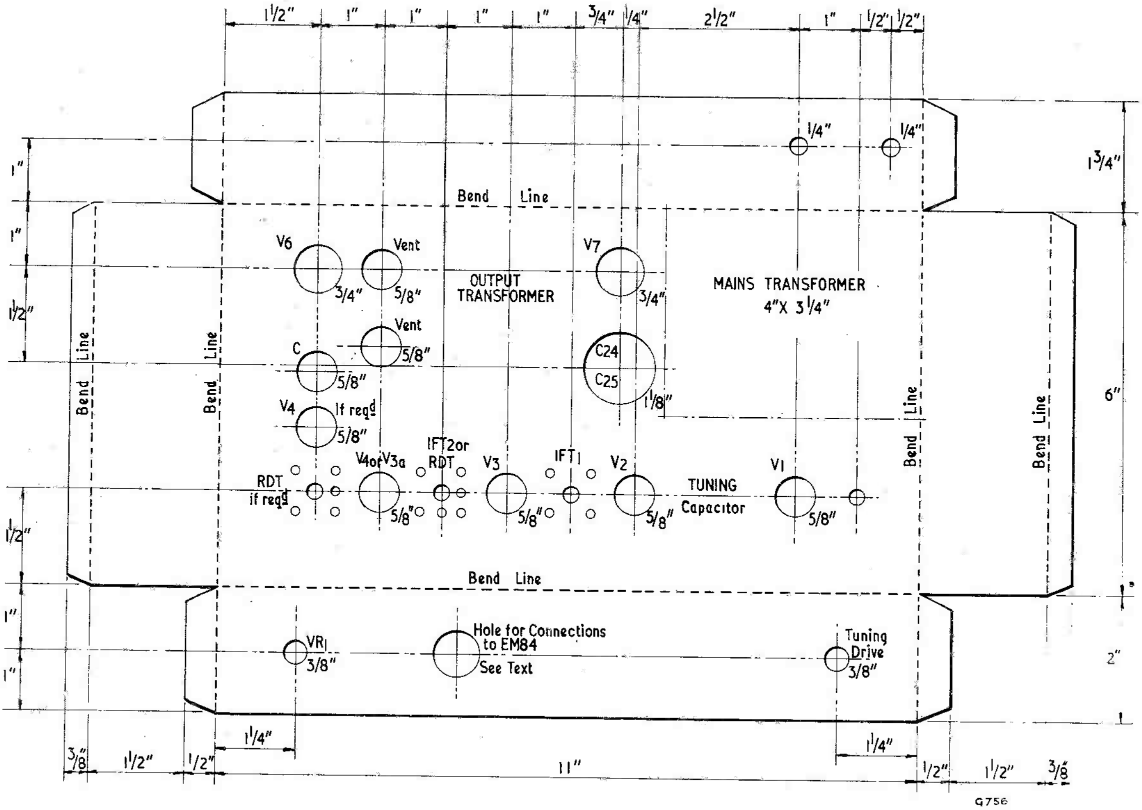


Fig. 4. *Plan of chassis*

holder should be of the moulded type and the outer metal surround should be removed.

The construction of the receiver is simple and straightforward and, subject to what follows, may be attempted with confidence by any constructor who has successfully built a mains operated set of any kind. It is convenient to fit the valveholders first, followed by the transformers and tuning capacitor; construction can then proceed stage by stage from aerial to output. Dropping and decoupling resistors in each stage should be mounted vertically so that when all else is done, the h.t. rail can be run around to each in turn. The main smoothing resistor, R$_{21}$, must be mounted in some convenient position above the chassis where its heat is easily dissipated. In the prototype, it is carried on a tagstrip fitted to the top of the mains transformer.

Wiring

It must be appreciated that, at very high frequencies, the physical form of a circuit has a great deal to do with its performance. Even a short length of wire has a high self-inductance. In some cases this may merely add to the inductance of the circuit of which it is a part, but in others it can lead to trouble, particularly in the case of bypass and decoupling components. So, unless the constructor is familiar with the liberties which may be taken with v.h.f. construction, he should follow the specified layout exactly in the v.h.f. section of the receiver, making all connections as short and direct as possible without regard to appearance. This is a primary requirement. Regeneration must be avoided at all costs since, although it may be insufficient to affect stability, it produces an asymmetric response curve leading to distortion in the detector stage. A small soldering iron of the instrument type is necessary and a certain amount of manual dexterity is required in the placing and soldering of small components.

In the wiring diagrams, Figs. 6 and 7, the wiring and components have been opened out for clarity; this latitude is not permissible in the actual wiring. P.V.C. flex is recommended for the heaters and 22 s.w.g. tinned copper for the rest of the wiring. Short connections make sleeving unnecessary and very little will be required.

Components

It is recommended that only the specified valves, EF91, be used in the v.h.f. section. They are specially suitable and can be obtained very cheaply. The tuning capacitor may be any two-gang component with a maximum capacity of 25 to 30pF in each section and with the rotor efficiently earthed. Few of the other components are critical. Ceramic capacitors should be used generally because of their small size, but where another type is specified in the components list it is advisable to use it.

The tuning drive is made from an old volume control. Remove the back and also one of the internal stops so that the spindle with the contact arm attached is free to rotate about 350° against the remaining stop. It will be appreciated that, as the tuning capacitor provides the only capacity across the tuned circuits, only a small part of its total range will be required to cover the reception frequencies. Therefore, if it is fitted with a drive drum of appropriate diameter, driven by the ¼in tuning spindle, the three required transmissions will be accommodated within the 350° rotation of the latter. Programme identification can then be arranged by engraving lettering on the tuning knob and arranging matters so that each station is received when its identification letter is brought to the 12 o'clock position, final adjustment being made, of course, with the aid of the tuning indicator; or more simply, a ⅛in depression can be drilled on the perimeter of the knob and filled with white paint, the Home programme being received with the marker at say, 8 o'clock, the Third at 12 and the Light at 4 o'clock. If the transmissions are spaced 2.2 Mc/s as is usually the case, a 2½in drive drum will generally suffice, but if the spacing is greater—as in the case of Wenvoe—a smaller one will be required. The drive cord should be well waxed and should have three turns around the drive spindle.

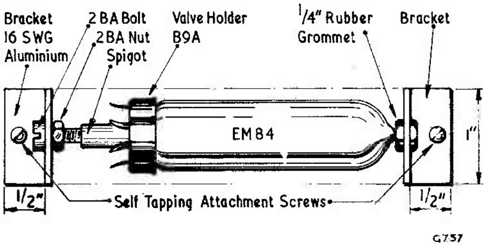


Fig. 5. *How to fit the tuning indicator*

Coils

The coil L$_1$ consists of 4½ turns of 20 s.w.g. tinned copper wire on a Neosid former $\frac{3}{16}$in in diameter, having a core coded black. The turns should be spaced one wire diameter. The wire should first be stretched slightly to make it quite straight, then close wound on a ¼in former, putting on an extra turn. It can then be removed and slipped over the proper former where it will be a tight spring fit, the turns being adjusted for number and spacing. The aerial coupling is one complete turn of 24 s.w.g. enamelled wire located at the bottom of the grid winding as shown in Fig. 8. When this has been fitted, both windings should be secured with cellulose cement. The r.f. and oscillator coils are of 16 s.w.g. tinned copper. They are wound as a self supporting unit with a space of ¼in between them, in a clockwise direction on a $\frac{5}{16}$in former. Five turns are required for L$_2$ and four for L$_3$. Withdraw the former and adjust the coils to the measurements given in Fig. 8. The ends should, of course, be made long enough to pass through holes in the chassis to connect to the tuning capacitor and the coils should be mounted so that there is a space of about ⅜in between them and the chassis. C$_6$ is located in this space.

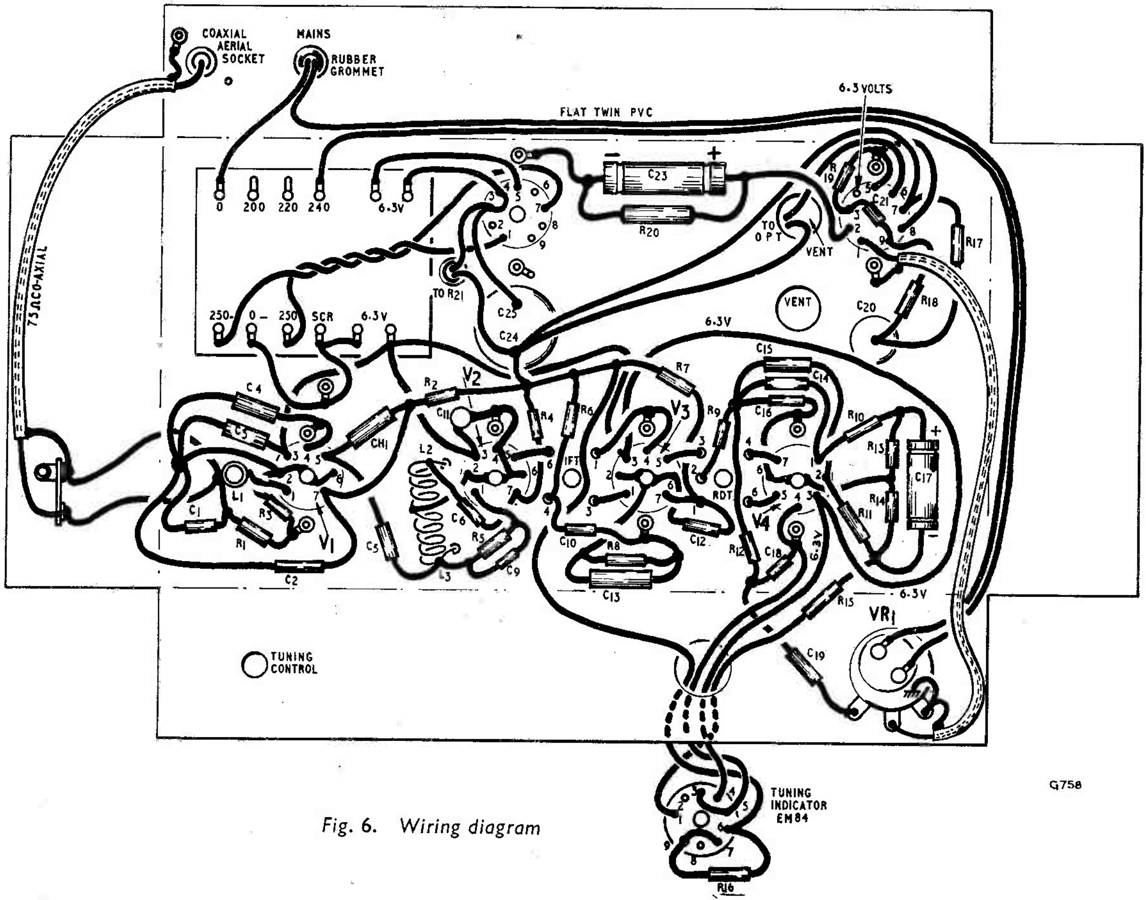


Fig. 6. Wiring diagram

The v.h.f. choke, Ch$_1$ is made from a 1 watt resistor of 150kΩ (the value is not critical), diameter $\frac{5}{32}$in, on which is close wound 50 or 60 turns of 36 s.w.g. enamelled copper wire. It should be mounted horizontally in the chassis to avoid possible inter-action with L$_1$.

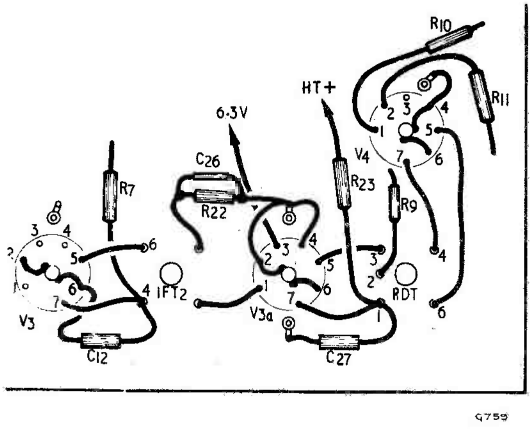


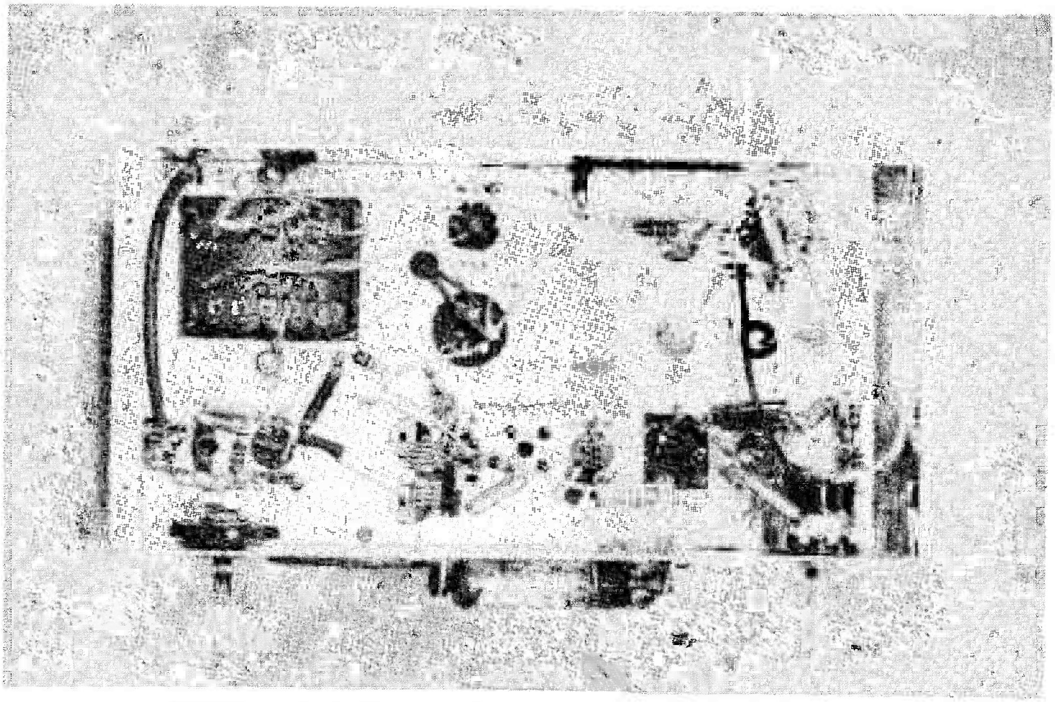
Fig. 7. Wiring diagram for second i.f. stage

Testing and Alignment

When construction is complete and the wiring has been checked against the diagrams, test with a meter between C$_{25}$ and chassis in order to ascertain that there are no short-circuits in the h.t. wiring. If all is well, the power can be connected and the h.t. rail voltage measured. It should be 220 ± 10V and if not, it should be brought within this range by altering the value of R$_{21}$. Check also that voltage is present at the anodes and screen-grids of all the valves. Alignment requires a signal generator and a high resistance d.c. voltmeter, the procedure being as follows.

IF Alignment

Connect the meter, on the 10 volt range, across C$_{17}$, observing polarity, and inject at the grid of V$_2$ an unmodulated signal of 10.7 Mc/s. Adjust both cores of the i.f. transformer and the top (primary) core of the detector transformer for maximum reading on the meter, reducing the amplitude of the signal progressively as the circuits come into line so that the meter reading does not exceed about 5 volts. If there are two i.f. stages, signal injection should commence at the grid of V$_3$, the generator afterwards being transferred to V$_2$ for alignment of the 1st i.f. transformer.



Below-chassis view. Compare with the point-to-point drawing on opposite page

Now connect the meter between the chassis and the junction of R_9 and C_{16}, adjusting the secondary (bottom) core of the detector transformer for zero reading. This will affect the primary, the core of which must therefore be readjusted for maximum reading as previously described. Repeat all the adjustments and make sure that all cores are adjusted for optimum results and that the output between R_9 and chassis is zero. Care is necessary in manipulating the bottom core of the detector transformer. As it engages in the former, it will be found that the meter reading will rise to a maximum, then fall through zero to a reverse maximum and back to zero, after which further core movement will have no effect. The correct position is the zero between the two maxima.

The acceptance bandwidth should now be checked. With the meter between chassis and R_9/C_{16}, move the generator slowly over the range 10.5 to 11 Mc/s. If the alignment is symmetrical, a maximum reading will be observed at 10.6 Mc/s, zero at 10.7 and a reverse maximum at 10.8 Mc/s. The two maxima should be of equal magnitude and equidistant from zero.

RF Circuits

Connect the meter across C_{17} and inject at the aerial a signal of the frequency of the centre one of the three transmissions it is intended to receive. Adjust the tuning near the maximum capacity end of its range, for maximum indication in the meter. Adjust the core of L_1 for maximum response. The inductance of L_3 can also now be checked by opening or closing the turns slightly with an insulated tool and observing the result on the meter but, if the coil is of the correct dimensions, not much improvement is likely to be obtained. If there are two i.f. stages, the limiting action of the second will tend to obscure improvements in signal strength obtained by r.f. adjustments and it is therefore necessary to keep the injected signal to the minimum required to give a reasonable indication on the meter.

An aerial can now be connected and transmissions should be received somewhere in the first 90° of rotation of the tuning capacitor. Reception will also probably be obtained with the capacitor near the fully open position but this should be disregarded as the circuit is designed to use the lower oscillator frequency.

Alignment Without Instruments

The receiver can be aligned without instruments provided pre-tuned i.f. and detector transformers

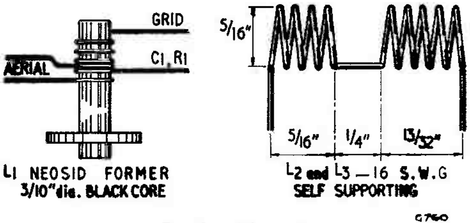


Fig. 8. The coils

are used. Connect the best available aerial and advance the volume control fully. There should be a subdued "rushing" noise in the speaker, indicating that V_2 is oscillating. If it is not, the fault must be found and rectified before proceeding further. Search for a transmission and having found it, adjust the i.f. and detector transformer cores for maximum response as shown on the tuning indicator. Do not judge the adjustments aurally as the loudest sound does not coincide with resonance in an f.m. receiver. If there are two i.f. stages, it will be necessary to reduce the signal strength as the circuits come into line, either by detuning L_1 or connecting a less efficient aerial. If a high resistance voltmeter is available, use it to adjust the bottom core of the ratio discriminator transformer as previously described; otherwise, this core must be adjusted for optimum results as judged aurally. As the core position is varied either side of the correct position, points will be found at which the reproduction begins to sound distorted. These correspond roughly to the two maxima already referred to and the proper position of the core is midway between them. Adjust L_1 as previously described, using a transmission in lieu of the signal generator. If there is a second i.f. stage, it will tend to mask the adjustments but there will be a detectable result in the tuning indicator.

This method of alignment is not to be recommended where instruments can possibly be used, but with care it will give satisfactory results. The adjustments required to the i.f. and detector cores will be limited to those necessary to accommodate stray capacitances and will be small. Do not make large adjustments or the original pre-alignment will be lost.

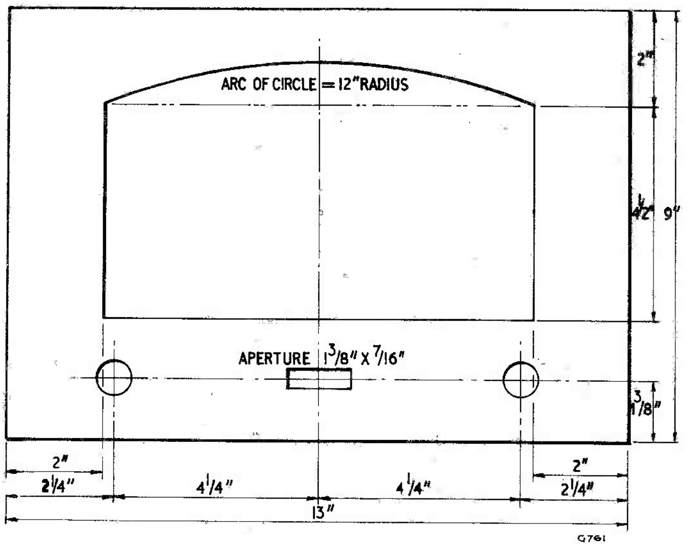


Fig. 9. The front of the cabinet

Operation

The aerial required will vary according to reception conditions and the number of i.f. stages in the receiver. Under favourable conditions, a length of flat twin p.v.c. flex will serve, the conductors being parted at one end over a length of 30in and extended horizontally along a picture rail, etc., to form a rudimentary dipole in a direction perpendicular to the direction of the transmission. If this is not satisfactory, a loft mounted dipole with reflector is recommended, with a down lead of 75 ohm coaxial cable. The strength of the signal obtained varies with the height of the dipole above the ground and, if the down lead is long, low loss cable is an advantage. The minimum desirable signal for first class reception is that which produces 8 volts across C_{17}, though worthwhile results can be obtained with less. If, when the receiver has been aligned, this voltage is less than 6, it will be advisable to improve the aerial or add a second i.f. stage or both.

Cabinet

The best home built receiver will not be viewed with favour about the house unless it is made to look attractive. A cabinet of professional appearance is easily made and requires only simple tools and the expenditure of a few shillings. Suitable material is ⅜in plywood having a facing of oak, walnut, etc., and the best source of supply is an old television cabinet or something similar because, although the old polish will have to be removed, the wood will require much less treatment before repolishing than if it were new.

The front should be cut first, 13 x 9in, and apertures made as in Fig. 9 for the controls, tuning indicator and speaker. The speaker aperture is best dealt with by making a 1in hole with a brace and bit at each corner and cutting away the unwanted wood with a coarse hacksaw blade held in a pad handle. Do not throw away the cut out portion as it will be needed later. A rebate as shown in Fig. 10

must now be formed all the way round the front on the unfaced surface. This can, of course, be done with a rebating plane but if this tool is not available an equally good result can be obtained by other means. First draw a line all round, very slightly more than ⅜in from the edge and cut along it with a tenon saw to a depth of ¼in, leaving two layers of ply uncut. The layers which have been cut through can then be removed with a chisel or penknife, finishing off with No. 2 glasspaper. If the constructor is not confident of his ability with the tenon saw, a wooden straight-edge can be fixed temporarily along the line of cut as a guide. Keep the saw close against the guide and perpendicular to the surface of the ply. Now sand off the edges of the speaker aperture, apply a coat of matt-black paint and set aside to dry.

The sides of the cabinet should be cut next, each 9 x 7½in and similar rebates formed on the unfaced surfaces at top and bottom. When this has been done, assemble the front and sides temporarily, using two or three 1in panel pins driven half way home through each side into the rebated portion of the front. The top and bottom can then be cut, each 7½in wide and of a length to fit exactly into the top and bottom rebates of the cabinet. Fit them in position temporarily with panel pins, mark all joints for subsequent identification and dismantle. About eight ½in holes should be made in the bottom of the cabinet for under-chassis ventilation and some wood must be removed from the unfaced surface of the front in order to allow the tuning indicator to come within ⅛in of the outer surface. Fit the front and bottom together and stand the receiver in position. Mark on the front a rectangular area sufficient to contain the EM84, its base and the supporting brackets and, with a chisel, remove layers of ply within the marked area to a depth of ¼in.

The cabinet can now be finally assembled. Coat the mating surfaces of all joints with glue, fit them together and fix with panel pins driven right home. Three pins along each joint will be sufficient and it is not necessary to drive any through the front.

Finishing

When the glue is hard, the panel pins should be driven slightly below the surface. A small wire nail with the point sawn off makes a good punch for this. Fill in the resulting indentations and any other blemishes with plastic wood of colour similar to that in which the cabinet is to be finished and, when this is hard, sand off thoroughly with No. 2 glasspaper, squaring off the corners and removing any old polish from the wood. The outside edges of the viewing aperture for the tuning indicator should be faired away so that the display will be easily visible from above or from an angle. Finish off with No. 0 paper to make all surfaces as smooth as possible; the final result depends greatly on the preparation at this stage. Wood dye of the desired colour can now be rubbed on with a rag wad.

Polishing

The best final finish is french polish. Contrary to popular belief, this is not difficult with one of the polishes specially compounded for amateur use. Follow the manufacturer's instructions supplied with the polish. Another method, which gives quite a passable finish, is to rub in one of the several floor sealing compounds now on the market, such as Ronseal. Three or four coats will be required with a light rub down between each.

Speaker

Fix a piece of Tygan material over the speaker aperture. This material does not stretch and some care is necessary to get a good taut fit. Place the cabinet face down on a flat surface and fit into the speaker aperture the piece of wood which was cut out of it. The Tygan will not then sag in the middle while the adhesive is hardening.

An elliptical speaker about 7 x 4in is very suitable and can be obtained quite cheaply "ex-equipment". It should first be mounted on a piece of ⅛in hardboard about 11 x 6½in in which a suitable aperture has been cut, and secured at the two lower points by 4BA countersunk bolts, nuts to the rear. Place this assembly in the cabinet and secure with ½in wood screws through the upper fixing holes of the speaker and through the hardboard at intervals around the edge of the cabinet aperture. It should be arranged that the speaker is located at the top of this aperture where it will be well clear of the receiver.

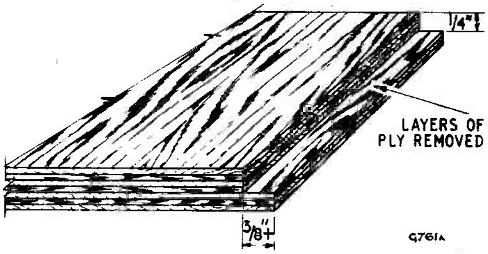


Fig. 10. How to form a rebate

Fitting the Receiver

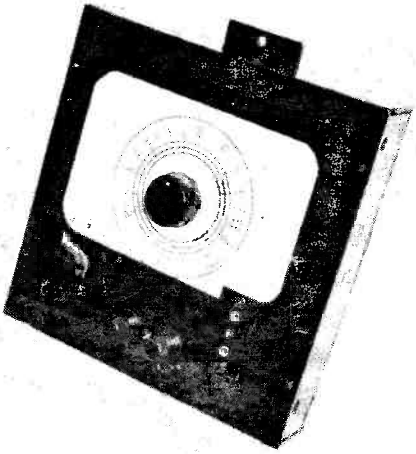
Place the set in position and with a small twist drill make holes through the bottom of the cabinet and into the flanges at the ends of the chassis; two at the mains transformer end and one at the other will be sufficient. Enlarge and countersink the holes in the wood only. If wood screws of suitable diameter are now inserted, they will have a self-tapping action as they enter the aluminium and the receiver will be firmly secured. Connect the speaker to the secondary terminals of the output transformer; 12 or 15in of twin flex should be used for this purpose so that it will be possible to remove the receiver for attention without disconnecting the speaker. Four small rubber buffers secured to the bottom of the cabinet will permit under-chassis ventilation and prevent damage to any polished surface upon which the receiver may stand.

Single Transistor C-R Bridge

By A. S. CARPENTER

A self-contained apparatus that will check

Capacitors—10pF–0.1μF *Resistors*—100Ω–1MΩ



It can be extremely annoying to the experimenter to find himself the possessor of a large number of capacitors whose value he does not know with any degree of certainty. Values specified on some of the waxed types soon become obliterated, whilst others may carry ex-Service or other coding that is not immediately intelligible. Capacitors are not inexpensive items, so it is generally desirable to make the fullest use of those already to hand.

Before trying out a new circuit or constructing from a published design it is usual to sort out all required components beforehand, since many of the items needed will already be available. In selecting resistors the ohmmeter is frequently used for approximate checks, but for capacitor checks and selection a bridge is needed. A bridge is also needed when resistors must be matched for use in phase splitting circuits, etc.

A C-R bridge is therefore very necessary in the workshop. Fortunately, a simple bridge is comparatively inexpensive to construct and a suitable circuit is shown in Fig. 1, this being that of a unit constructed by the writer. Briefly, it consists of the C-R bridge proper together with a transistor a.f. tone generator, the two sections being shown to the left and right of the broken line respectively in the diagram.

The control knob of VR$_1$ works in conjunction with a pointer and a scale graduated in values of capacity from 10pF–0.1μF. The switching afforded by S$_1$ and S$_2$ in conjunction with the values assigned to C$_1$ and R$_1$ permits the same scale to be used for resistance readings, the latter being mentally multiplied by 10. For example, should the pointer indicate "100" when a capacitor was being measured, this would indicate 100pF, whilst in the case of resistance it would mean 1,000Ω (1kΩ). The range of resistance readings is thus 100Ω–1MΩ. These ranges are sufficient for general use but should alternative ranges be required it merely becomes necessary to choose alternative values for C$_1$ or R$_1$. Reducing R$_1$ to 1kΩ, for example, would still allow the same scale to be used for both types of reading although resistance readings of 10Ω–100kΩ would now be indicated. If desired such additional ranges can

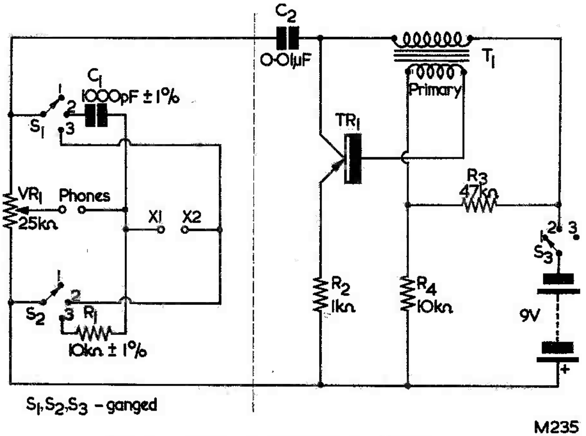


Fig. 1. The circuit of the C-R Bridge

Components List

Capacitors
C$_1$ 1,000pF 1%
C$_2$ 0.01μF paper

Resistors
R$_1$ 10kΩ 1%
R$_2$ 1kΩ $\frac{1}{4}$ watt 10%
R$_3$ 47kΩ $\frac{1}{4}$ watt 10%
R$_4$ 10kΩ $\frac{1}{4}$ watt 10%

Miscellaneous
TR$_1$ Surplus transistor, red spot or similar
T$_1$ Miniature inter-valve transformer, ratio 3:1
VR$_1$ 25kΩ wirewound
Phone sockets or phone jack
Panel mounting screw terminals (X$_1$, X$_2$)
9V battery—EverReady PP6, or similar
Control knobs
S$_1$, S$_2$, S$_3$ 3-pole, 3-way rotary switch (4-pole, 3-way miniature may be used)
Pointer, scale material, wood, nuts, bolts, etc.

be incorporated by using a selector switch with more positions. Components used for R_1 and C_1 must have a tolerance of ±1% if accuracy of readings is required.

Using the Bridge

To use the bridge, high impedance phones are plugged in at the sockets provided (discarded aerial-earth sockets were used in the original) whereupon the note provided by the audio generator will be heard. A capacitor or resistor, depending on the setting of the selector switch, is connected across the terminals X_1, X_2, and VR_1 rotated until the audio note disappears. The exact point of extinction is very precise, a slight movement of VR_1 slider being sufficient to restore it. The value of capacitance or resistance may then be read from the scale fitted to VR_1.

Capacitors, especially tubular types, may develop leaks, and such components should be unhesitatingly discarded in case they cause trouble later. Since leaky capacitors may cause incorrect bridge readings, they should, preferably, be tested for leakage before being measured.

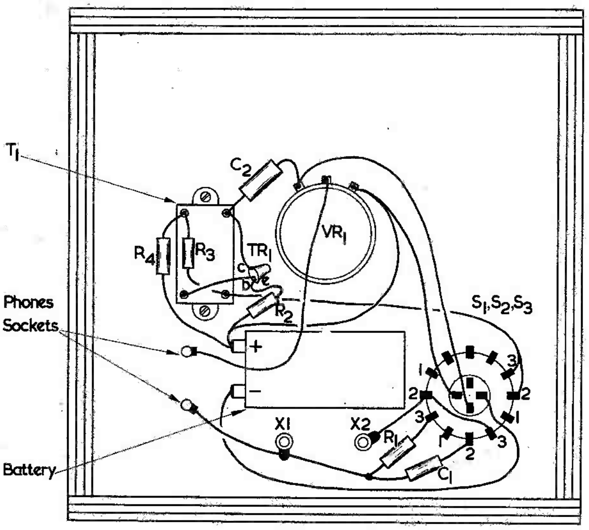


Fig. 2. The internal layout of the unit. The transformer and switch tags shown here apply to the components employed in the prototype; alternative components may have a different tag layout

Energising the Bridge

Although the bridge may be energised by the audio note from a signal generator it is simpler to fit a self-contained section and thus render external hook-ups unnecessary. The expense entailed is negligible as a surplus transistor will perform well enough here. The transformer may be a miniature inter-valve type, of ratio 3:1. In some cases it might be beneficial to fit a 33kΩ resistor in series with C_2 and the bridge. A capacitor having an experimental value between 0.001 and 0.01μF can also be connected across the secondary winding of T_1 to vary the audio note, if desired.

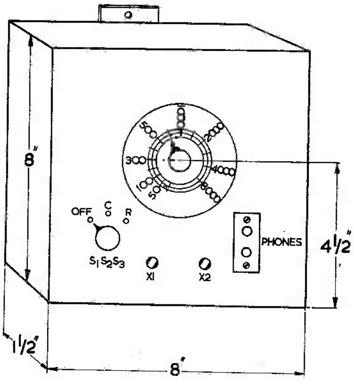


Fig. 3. Front view of the completed bridge

Layout and Constructional Details

The positions assigned to the various components, and the general dimensions, can be seen in Figs. 2 and 3. The battery used was an EverReady type PP6, this being retained to the rear of the front panel with adhesive. All components are fixed to the front panel, this being made of wood and screwed to ⅜in side pieces. The back, made from hardboard, is cut to give an extension at the top (see Fig. 3) in which a hole is drilled so that the apparatus may be hung at a convenient point.

Calibration

By connecting capacitors and resistors of known value to the X_1 X_2 terminals major null points can be established on the scale. The latter may be made from stiff card on which circles are drawn in indian ink using a bow pen. The scale should initially be secured at its corners by small pieces of Sellotape and the control knob and pointer (which can also be made from stiff card glued to the base of the knob) adjusted to traverse the scale symmetrically, as shown in Fig. 3. By using single, series, parallel and series-parallel combinations of the test components as many null points as possible should be found and marked lightly on the scale in pencil. It should be found that the reading "1000" will occur at the centre of the scale, viz., at 12 o'clock. The control knob and scale can then be removed and the numerals inked in. It will be found convenient to let these radiate from the centre as shown in Fig. 3. When dry the scale can be glued firmly in position and the pointer reset, care being taken to ensure that it cannot slip.

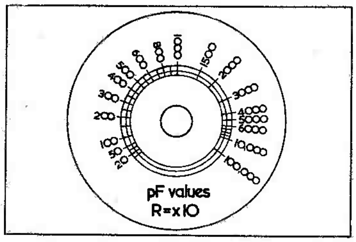


Fig. 4. The scale obtained with the prototype. This is reproduced here as a guide to calibration only in reduced form

The scale obtained with the prototype is illustrated in Fig. 4. This is intended as a guide to calibration only, because different potentiometers in the VR_1 position may alter the distribution of individual values around the scale. Nevertheless, Fig. 4 offers a useful guide to the scale graduation characteristic likely to be encountered.

Part 2

Emitter Follower Circuits

MEDIUM IMPEDANCE PRE-AMPLIFIER

By **PETER WILLIAMS,**
B.Sc.(Hons.), Grad.Inst. P., Grad.I.E.E.

This is the second of a series of four articles, each of which describes a particular application employing emitter follower transistor circuits. A special feature of the series is that a standard set of components may be employed, if desired, to construct all the devices discussed. Despite this, the circuits are extremely non-critical so far as component tolerances are concerned, and alternative values are dealt with fully.

Of particular interest are the d.c. coupling and negative feedback arrangements employed by the writer, these not only reducing the number of components required but also permitting excellent stability to be maintained, together with flexibility in component values.

The devices described can provide a valuable introduction for the newcomer to transistor theory, and have the advantage of being somewhat more sophisticated than the "beginners' circuits" which are normally published.

IN THE FIRST ARTICLE IN THIS SERIES IT WAS SHOWN how two transistors could be directly coupled to produce a low impedance amplifier stabilised by direct current feedback. If, instead of to the emitter, the input is now taken to the base of the first transistor, with its emitter grounded, then this stage now becomes a conventional grounded emitter. It is still, nevertheless, coupled into an emitter follower output as before.

The alternative circuits are shown together in Fig. 1, and it can be seen that the only difference so far as direct currents are concerned is in the emitter of TR_1. Since the d.c. resistance of the microphone is only a few tens of ohms, and the emitter current a fraction of a milliamp, the voltage developed across it in Fig. 1 (*a*) is about 20 millivolts. This opposes the bias voltage derived from the emitter of the second transistor and fractionally reduces the current of the first transistor. Because of the stabilising effect of the d.c. negative feedback the effect of the microphone in the emitter circuit is reduced, and the d.c. operating conditions of the two arrangements will be very little different unless a microphone of high resistance had been used originally.

Thus the previous discussion on the stability of the amplifier with respect to variation in transistor parameters still holds good with the circuit of Fig. 1 (*b*). To summarise the argument briefly, any increase in the collector current of TR_1 reduces its collector voltage and hence that of the second emitter. In turn this reduces the base current supplied to the first transistor, and so returns its collector current closer to the original value. Variations in TR_2 can be shown similarly to be self-compensating via the d.c. loop.

A.C. Operation

On considering the a.c. operation, the fact that the second stage is unchanged simplifies the discussion. As before, its input impedance, as "seen" by the collector of TR_1, is high. It will be approximately equal to the actual value of emitter resistance, in this case 4.7kΩ, multiplied by the current gain of the transistors which will vary widely but should be at least 20. It produces very little loading effect on the first stage which then develops its maximum value of voltage gain, most of which appears at the output.

In the previous article a value of 80Ω was assumed for the input impedance of the grounded base stage and it is not easy to see immediately why the impedance in grounded emitter should be so different, since the input is still being fed between the base and the emitter. Without considering equivalent circuits a practical answer is quite easy to obtain by reference to Fig. 2.

Here the resistance in the emitter is the 80Ω which would be found if the base were earthed and the input taken to the emitter. For any input voltage at the base, say 80mV, this voltage will appear across R_e if we think of it as being an ordinary resistive load external to the transistor. The emitter current produced will then be $\frac{80\text{mV}}{80\Omega}$, i.e. 1mA.

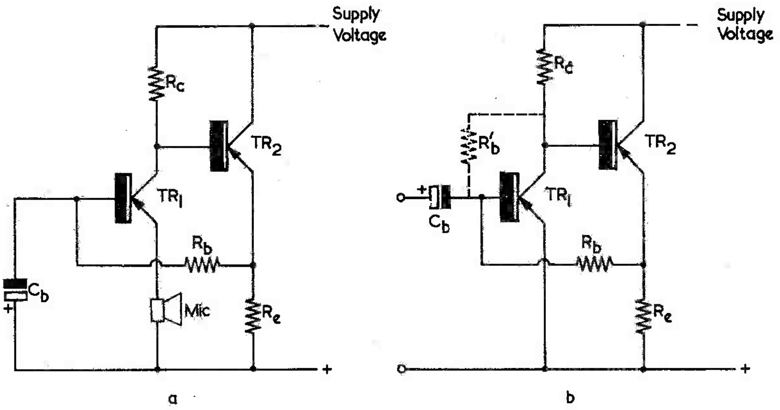


Fig. 1 (a). The pre-amplifier circuit discussed last month (b). The earthed base circuit changed to earth emitter. This circuit is the subject of the present article

	Operating Range	Suggested Values
Supply Voltage	3–20 volts	10 volts
R_c	5–40kΩ	22kΩ
R_e	2–10kΩ	4·7kΩ
R_b	100–1000kΩ	330kΩ
α′	20–100	
C_b	0·5–64μF	16μF

M221

Because of the current gain of the transistor the current taken by the base from the source will be much less than this, depending, of course, on the value of current gain of the particular type in use. Its value should be greater than 20 for almost all transistors currently available and this ensures a maximum base current of $\frac{1}{20}$mA. The input impedance as seen by the source is determined by Ohms Law and is $r_{in}=\frac{V_{in}}{L_{in}}$ which, with appropriate figures suggested above, would be $\frac{80\text{mV}}{\frac{1}{20}\text{mA}}$, i.e. 1.6kΩ

This corresponds with the figures quoted in manufacturers' data for audio transistors and, on comparing it with r_e, we see that, as we should expect, it is the value of r_e multiplied by the current gain of the transistor. Here the internal emitter resistance has taken the place of the emitter load of the emitter follower stage as described in the first article.

Although not exact, this is a very convenient rule for finding the input impedance of any stage where the signal is applied between base and earth. Estimate the total resistance in the emitter, i.e. internal resistance and external resistance, and multiply by the current gain of the transistor. By an exactly similar argument, the output impedance at the emitter involves the source impedance divided by the current gain.

The only remaining problem in calculating the properties of the arrangement of Fig. 1 (*b*) is the presence of the bias resistor R_b. When the tran-

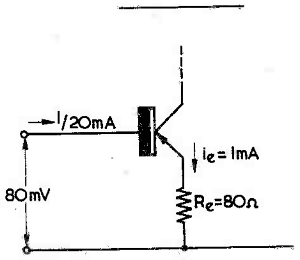


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Fig. 2. Demonstrating how the input impedance of the first transistor may be assessed

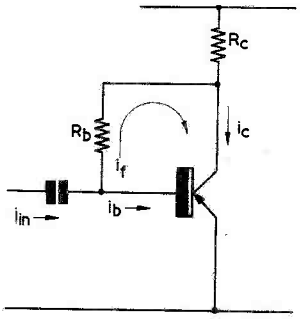

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Fig. 3. The effect of R_b in the earthed emitter circuit

sistor TR_1 was operating in the grounded base configuration, the capacitor prevented any a.c. negative feedback by shunting the fed back signal to earth. Now that the capacitor is being used only to isolate the input from d.c., the negative feedback becomes effective and changes the input impedance. The way in which it does this can best be determined by remembering that, since the second emitter follows the potential of the first collector very closely, then R_b acts as if it were between collector and base of the first transistor. This is shown in dotted line by R_b in Fig. 1 (*b*), and the various currents involved are indicated in Fig. 3. As the base current of the transistor increases, the current amplifying action of the transistor causes the collector to draw a collector current i.e., mostly from the battery via the collector load, but partly from the input signal through R_b.

In practical terms, since R_b is about thirty times R_e, the source has to supply a current through R_b of about $\frac{1}{30}$th of the collector current. This is the approximate value of the signal into the base of the transistor and so the source has to supply double the current to the circuit when the feedback is taken into consideration. With twice the current being drawn at the same input voltage, the input impedance must have been halved and this reduction would be enhanced by increased current gain or a reduced base resistor.

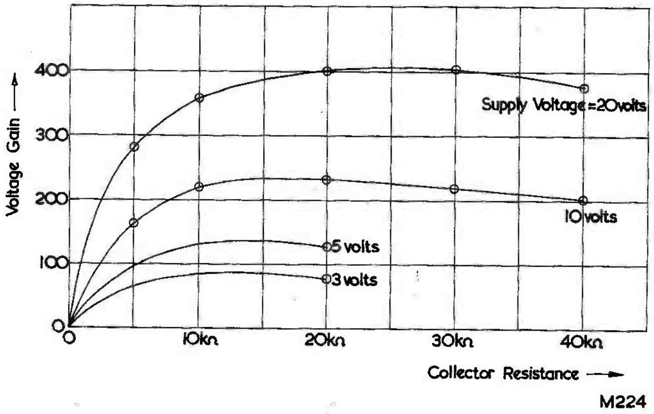


Fig. 4. Curves showing voltage gain for differing values of collector resistance and supply voltage

Another, and advantageous, effect of the feedback is its stabilising of the a.c. gain of the circuit. Should the current gain of the transistor vary through changes in the supply voltage or because of ageing, then a similar change occurs in the negative feedback. If, for example, the current gain were to increase by a factor of five, so also would the portion of the input current flowing through R_b. This would leave the base receiving only one sixth of the input current, as against one half originally, amounting to a threefold reduction in gain. The final increase in gain is thus $\frac{5}{3}$ and the initial drastic change of 400% has been cut to a very respectable 66%.

It is now convenient to summarise the operation of the circuit of Fig. 1 (*b*) before turning to the measured values of gain, etc. Each transistor is biased from the other, forming a d.c. closed loop and providing a good measure of stabilisation against variations in battery supply, temperature and transistors. The first stage is a grounded emitter amplifier, so lightly loaded by the high impedance of the grounded collector output transistor that it delivers its maximum voltage output. A.C. negative feedback reduces both input impedance and gain, and stabilises the latter. It is particularly interesting to note here that resistor R_b assists the stabilisation of gain in two distinct ways. Firstly, it reduces changes in operating conditions which would contribute largely to such gain variations, and secondly, by a.c. feedback it reduces the effect of such variations as may occur.

Operating Conditions

A very wide range of conditions was imposed on this, as on the previous circuit, and, as might be expected, because of their similarity, they continue to perform to the same limits. One surprising fact that emerges on comparing their voltage gains is the comparatively small advantage enjoyed by the grounded emitter version. There are two contributory factors to this, one of which is the negative feedback discussed above and which was inoperative in the grounded base circuit. The second factor is that, under most conditions, the grounded emitter amplifier succeeds in driving most of its output current into the following stage. Since this load is likely to have an impedance equal to that transistor's own input impedance, the total gain is limited to the current gain of the transistor. With a grounded base stage there is no current gain, and amplification is possible only because of the higher load impedance through which the transistor drives this current. So the grounded emitter gain is kept to that of its current gain, well below its theoretical value, and the grounded base stage is able to offer serious competition at least for low source impedances.

The voltage gain under a wide range of collector load and supply voltages is shown in Fig. 4. There is a slight but noticeable fall in gain at high loads. This is because low current operation reduces the current gain of the first transistor, whilst shunting by the second stage becomes more noticeable and prevents the total load "seen" by the first stage from rising.

Facts and Figures

Now for some facts and figures not covered by the graphs. With a collector load of 20kΩ and a 20 volt supply, changing both transistors produced gain variations of less than 30% although the units used had current gains ranging from 20–100. Similarly, changing R_b from 60kΩ to 1MΩ, lowered the voltage gain by about 40%.

The input impedance shows a much wider difference. Collector load and supply voltage were maintained as above at 20kΩ and 20 volts respectively and the value of R_b adjusted. Increasing it to 1MΩ from the suggested value of 330kΩ almost exactly doubled the input impedance (less negative feedback allows impedance to partially revert to its "natural" value). This result holds true at other supply voltages, while reductions in the supply lowered the impedance mainly through the resulting fall in emitter current. These results are shown more fully in the accompanying table.

Flexible though this arrangement clearly is, safety reasons compel care in the choice of operating conditions and it would be unwise to combine the two extremes of high voltage and low resistances without first checking carefully on the ability of the transistors to cope with them. Using the recommended values, all currently available transistors should operate satisfactorily provided that the following point is observed. If the first transistor should have a high value of leakage current it will "bottom" unless the bias resistor R_b is increased, but even this failure would be a perfectly safe one because of the protection offered by the high collector resistance. Over a dozen widely differing units have been tried in both positions in the circuit, and all operated satisfactorily.

TABLE
Variations of Input Impedance

Supply Voltage V_s	Base Resistor R_b	Input Impedance
5 volts	330kΩ	2kΩ
	1MΩ	4kΩ
10 volts	330kΩ	1.28kΩ
	1MΩ	2.5kΩ
20 volts	330kΩ	800Ω
	1MΩ	1.6kΩ

Next Month

In the third article in this series it is hoped to describe a multivibrator offering quite a wide range of frequencies and using the same components as in the first two circuits.

New Semiconductor Developments

The development of semiconductors is so rapid that it has become necessary for the electronic valve and semiconductor manufacturers to produce a new edition of the booklet "The Use of Semiconductor Devices".

The booklet, of 64 pages, is much more complete than the publication it replaces. Its aim is to help equipment designers to make the best use of new devices now coming on to the market. It is also a useful quick-reference manual for teachers and students of electronic engineering, explaining many of the essential design parameters that are required.

The new publication details recent developments such as tunnel diodes, controlled rectifiers, variable capacitance devices and microwave diodes.

Four-layer two-terminal switching devices are dealt with, including broad descriptions of their construction and application.

To users of semiconductors, the booklet indicates the way in which manufacturers approach the evaluation of characteristics, and gives practical advice on how these characteristics should be applied. There is a section dealing with various ratings, indicating where the responsibility of the designer and the device-maker can be divided. For example, the book says that in the case of absolute maximum ratings, the equipment manufacturer is entirely responsible for the combined effects of all variables; whereas in the design-centre rating system, the semiconductor manufacturers hold the responsibility for ensuring that the performance of the device is satisfactory under normal circuit and component variations.

Practical advice is given on the acceptance of temperature ratings and there is a section devoted to the theoretical design of heat sinks. This includes a valuable table of thermal resistivity for various materials. Another section indicates how the designer should approach the problem of air-cooling.

A description is given in a very few hundred words of the working and application of tunnel diodes. This includes formulae for working out the maximum frequency at which a tunnel diode will oscillate and an appreciation of its stability when used as a small-signal amplifier.

The booklet is not intended as a reference manual, but it is a brief and comprehensive generalisation of basic information needed by designers, buyers and students of semiconductor devices.

New sections include those on heat sinks, mechanical standardisation, parametric and microwave diodes and controlled rectifiers.

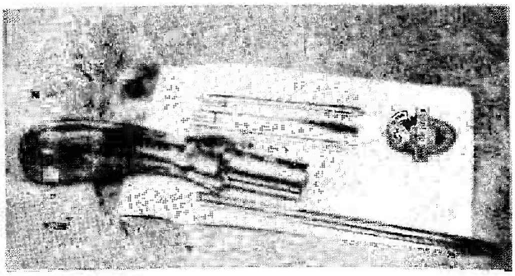
The booklet is being distributed to industry, technical colleges and schools by members of the Electronic Valve & Semiconductor Manufacturers' Association. It can also be obtained from the V.A.S.C.A. headquarters, Mappin House, 156-162 Oxford Street, London, W.1, price 2s. post free in the United Kingdom.

TRADE REVIEW . . .

Steadfast Multiblade Ratchet Screwdriver

A NEW ADDITION TO THE DARWINS TOOL DIVISION range of tools is the Steadfast Multiblade Ratchet Screwdriver. From the illustration shown herewith, it will be seen that the unbreakable amber plastic pistol grip incorporates the ratchet action barrel with positive blade locking device.

Four interchangeable "quick release" blades comprising (*a*) engineers type, 3in long; (*b*) number 1 engineers crosspoint type, 3in long; (*c*) number 2 electricians crosspoint type, 3in long, and (*d*) electricians type, 6in long. The complete set is contained in an attractive and very useful press studded plastic wallet.



The retail price of the complete set is 19s. 6d. and is available from most hardware and tool dealers, replacement or spare blades also being available at 2s. 3d. each, if required.

News and Comment . . .

Rescue

In our September issue we reported on the purchase of SARAH (Search, Rescue and Homing) marine equipment by both the Swedish army and navy. We have recently received a report of the practical use of such equipment.

A Gloster Javelin flying in East Pakistan ran into difficulties. The intercomm had broken down and the first intimation the navigator received that he would have to eject was when he heard the "bang" of the pilot leaving the aircraft; the pilot was unfortunately killed.

The navigator landed safely in the jungle and "was overjoyed to find himself alive". During the day Master Navigator Melton moved about, mainly along streams, as this was less exhausting than trying to break through the dense vegetation. As the area is well known for its ferocious tigers, at night Melton would try to snatch a few hours sleep perched in a tree.

A Shackleton aircraft was searching for him, and when he heard the plane Melton switched on his SARAH and almost immediately the aircraft turned and headed towards him. The aircraft moved away slightly and made several runs to indicate that something had been dropped, and the following day he found Lindholme gear in a stream containing food, cigarettes, another SARAH, with a fresh battery, a Verey pistol, and with these latter he guided the rescuing plane, a civilian owned Grumman Goose, which landed on a narrow stream.

The manufacturers, Ultra Electronics Ltd., give a silver tankard to all survivors whose lives have been saved by SARAH. Mrs. Melton accompanied her husband when he was presented with his memento of a thrilling rescue.

Of Mice and Men

Mice will fight each other only in the dark. This can present a very real problem to biologists, who wish to observe the mouse in all its moods. The problem can, however, be solved by using a closed-circuit television camera, equipped with the infra-red-sensitive vidicon camera tube now being produced by EMI Electronics Ltd. Infra-red lighting, which is not easily detectable by living creatures, is used to "illuminate" the scene.

This camera tube has several other uses. It can observe the reaction of an audience in a darkened cinema to various types of films. Penetration of the outer layers of the skin by infra-red light is sufficient for the tube to be useful in the examination of the superficial veinous system which is valuable in the study of varicose veins and certain heart diseases.

As the EMI infra-red camera tube is of standard vidicon size it can be used in most vidicon television cameras.

Coventry Cathedral

When the new Cathedral Church of St. Michael, Coventry, is consecrated next May, the service will be the subject of a major outside broadcast by B.B.C. TV. This programme—and any others in the future from Coventry Cathedral—will be lit by equipment installed to the specifications of the B.B.C. and paid for by the Corporation. This is the first cathedral to have the requirements of television incorporated into its design.

About a year ago B.B.C. engineers began studying the special problems involved in lighting a television outside broadcast from the new cathedral. Unlike the mediaeval building, with arches, pillars and side chapels all carved ornately in stone, the design at Coventry is austerely modern. The walls rise sheer to a height of eighty feet without ornamentation of any kind. Any temporary installation of television lighting could not be hidden, and would ruin the conception of the whole, and was naturally ruled out by those concerned with the appearance of the completed building.

This then was the problem. How could the lighting installation be made unobtrusive but efficient in a structure which appeared to offer no opportunity to conceal the equipment?

After many discussions with both the architect, Sir Basil Spence, and the cathedral authorities, a scheme was evolved. Visible to members of the congregation is a vaulted ceiling. This is supported from above by a false ceiling and by climbing a circular stone staircase, one can reach a catwalk running between the false ceiling and the concrete roof of the cathedral. The space in which this catwalk is situated is where a series of motorised winches will be used to raise and lower a series of lighting bars, which will be eased over the edges of the vaulting by specially designed skids, so as to avoid any possibility of damage. When television lighting is needed, the lighting bars will be lowered to ground level so that the lamp units can be attached. These will then be raised to a height of about 45 feet. After use, the lamps will be detached and the bars will be raised to their concealed position above the false ceiling.

The installation will cost approximately £7,500. For the first five years after its installation the equipment will be owned and maintained by the B.B.C. Any other organisation wishing to use the equipment will pay a fee to the B.B.C. except on the occasion of the Consecration ceremony. Subsequently ownership and maintenance will pass to the cathedral. The B.B.C. will be able to use the installation without fee.

Short Story

Radial, the monthly magazine of the Bedfast Club, the society for helping physically handicapped radio amateurs, about which we hope to write in a future issue, printed this amusing anecdote in a recent number.

An applicant for a position as a junior clerk in a firm of accountants was asked at an interview about his outside interests. The youth replied: "My avocation is amateur radio." The personnel manager laid down his pen, looked sternly at the young man, and said: "Young man, directors have avocations; department heads have hobbies; what you are doing is simply messing about."

Radio Astronomy

PART 5

by

FRANK W. HYDE

F.R.S.A., F.R.A.S.

THOSE READERS WHO HAVE COMPLETED THEIR radio telescope will be anxious to begin working with it. Having set up the aerial and the receiver, examination of some of the intense radio sources can begin. There are a number of these sources suitable for amateur study.

The nearest and most intense source is the sun, it being a very second-rate star since it is one of the hundred-thousand million making up our galaxy. Our galaxy is similar in shape to that of the Andromeda nebula, and is approximately one hundred thousand light years across and about six hundred light years thick.[1] The position of the solar system is about 25,000 light years in from one edge.

From the optical point of view our galaxy would appear to be like a thin disc. When we look up into the sky we see a concentration of stars along a narrow band which we call the Milky Way. This is the edge of our galaxy which we see from our position near one of the spiral arms, and of course, the density of stars is greater looking in this direction, so that they appear much more intense. When we look through the thickness of our galaxy the number of stars is much more scarce.

The radio galaxy, however, is very much larger than that which we see optically and in the case of the Andromeda nebula would appear to have a halo or corona more or less evenly scattered in all directions around it. We must assume, therefore, that our own galaxy presents a somewhat similar picture. This indeed explains why the intense sources of radio waves are not confined to the edge of the galaxy. Some of the intense sources are within the galaxy itself, and some are outside. We will, however, begin with a brief study of the sun.

This star, which gives us life on earth, is a spherical ball of highly compressed gas in an elementary state. Near the centre the temperature is of the order of 20 million degrees Kelvin. In astronomy we use the Kelvin absolute scale, which is the Centigrade scale plus 273 degrees. (Absolute zero is Centigrade 0 minus 273 degrees.) This high temperature within the Sun is hot enough to cause hydrogen to combine, forming helium. This results in a thermo-nuclear reaction, which releases enough energy to maintain itself. The Sun is therefore, a sort of self-generating power station.

The part of the Sun which we see is called the photosphere. This marks the sharp boundary layer between the intensely compressed material and that

The Andromeda Nebula

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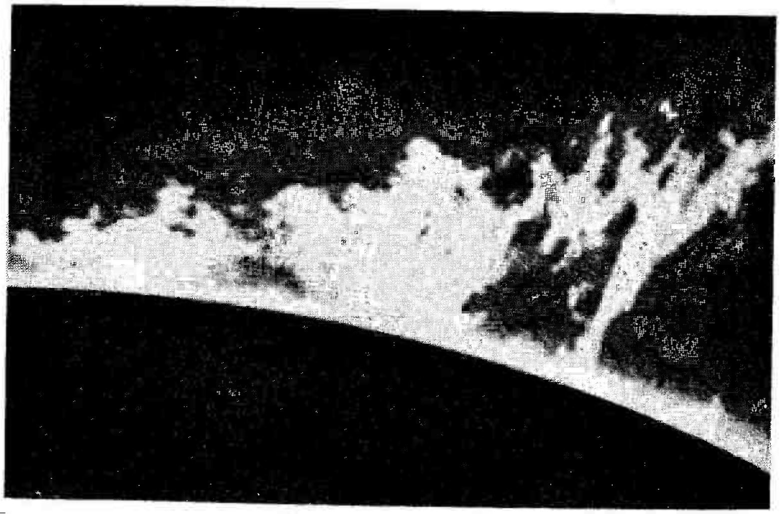
[1] The term light year, used by astronomers, indicates distance. i.e. one light year equals the distance covered in one year at the speed of light (186.000 miles per second). Thus, Proxima Centauri, the nearest star to the Earth, is some 25 million million miles distant and light would therefore require over four years to reach the Earth.

A further term often used in astronomy is the parsec, this equalling 3.25 light years.—*Editor.*



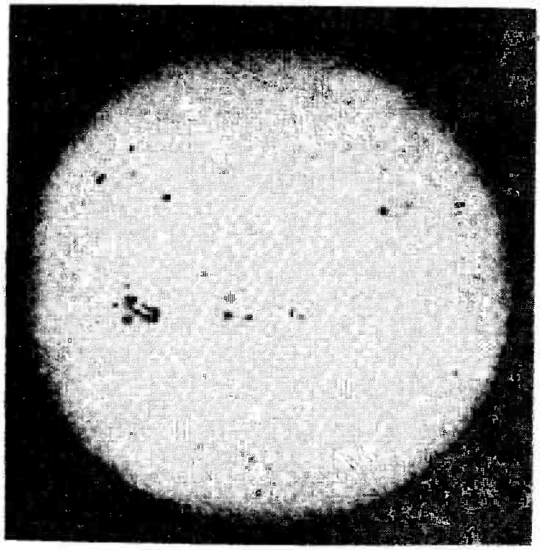
Solar prominence. These are vast extensions of hydrogen 25,000 to 40,000 miles in length and 4,000 miles thick and are supported on jets of gas which raise them to enormous heights of 50,000 to 500,000 miles. The speed of movement is very great, the jets moving at 250 miles per second

of the more diffused atmosphere around the Sun. The diameter of the photosphere is of the order of 866 thousand miles, and the surface temperature is of the order of 6,000 degrees Kelvin.

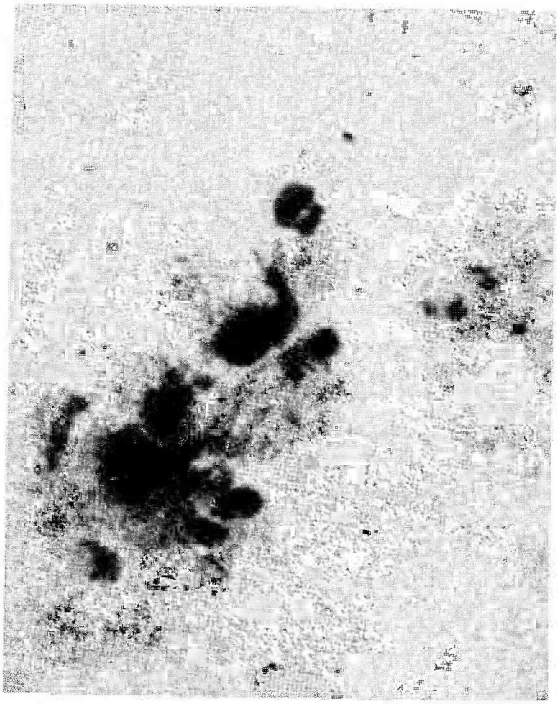
When we look at the Sun we are, in fact, able to penetrate to some extent through to the interior. This is the reason why, when the edge is examined on a projected image there appears to be a dark shadowing of the limb. This is because we are looking along the lower temperature area and this phenomenon is called limb darkening. If the surface is examined in monochromatic light, it is revealed that the surface is continually changing and exhibits an appearance of granulation, showing hot and cooler spots. At times of great activity there are often observed dark spots on the Sun which change in shape and size, often lasting for complete revolutions of the Sun on its axis. This phenomena is one of the things which makes our Sun a unique radio source, because so far as we know it is the only source which is variable.

The Active Sun

There are two main conditions of the Sun known



A projected image of the Sun showing limb darkening and sunspots



A close-up view of sunspots (14th July, 1961). Sunspots appear dark in comparison with the surrounding area because they are some 1,000 degrees lower in temperature

TABLE 1
Types of Radio Waves Emitted by the Sun
(Based on a table prepared by Dr. J. F. Denisse of Meudon Observatory)

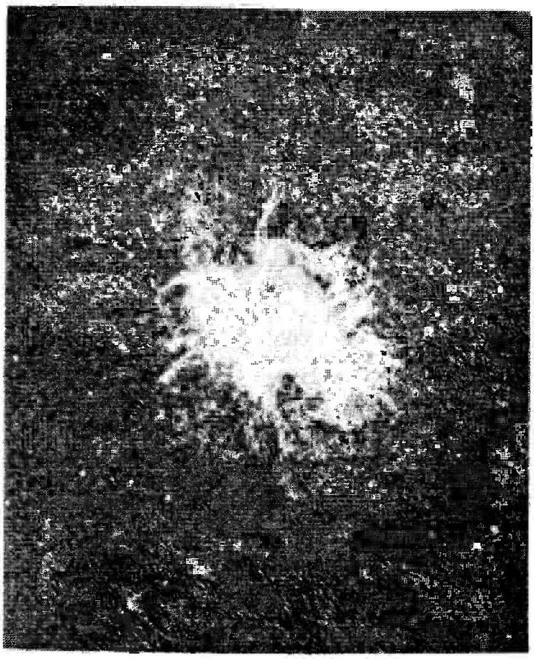
Type of Radio Emission	Duration	Wavelength	Related Optical Phenomena	Origin
Quiet Sun	Continuous	All wavelengths	Corona	Thermal radiation
Radio "condensations"	Several weeks	All wavelengths	Calcium plages, or faculae	Local hot spots in the corona
Micro-condensations	Several weeks	Short wavelengths	—	Uncertain
R Centres	Hours or days	Long wavelengths	Often above sunspots	Non-thermal "sunspot radiation"
Type I burst	10 or 20 seconds	Metre wavelengths	Occur in the R centres	Unknown
Type II burst	Several minutes	Moving slowly through the whole spectrum	Small eruptions, "puffs"	May be associated with the particles causing magnetic storms
Type III burst	Several seconds	Moving rapidly through the whole spectrum	Large solar flare	May be associated with cosmic ray particles
Type IV burst	Minutes or hours	"Noise storm": on a wide range of wavelengths	Following after a large flare	Unknown
U burst	Several seconds	Wavelength rapidly decreases and increases again	Often associated with flares	Similar to Type III

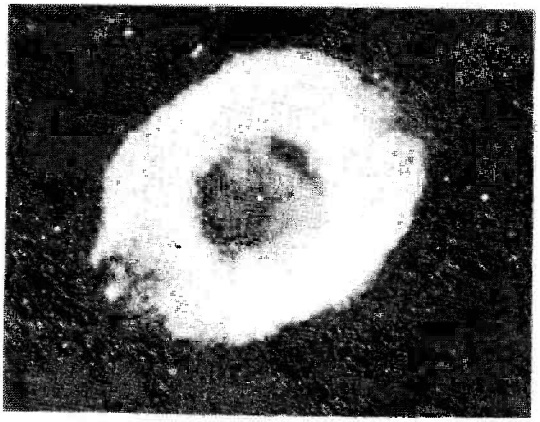
to radio astronomers, the quiet Sun and the active Sun. During the period of the active Sun, which has a regular cyclic history varying between 10 and 11.2 years, the so-called Sunspot maxima and minima occur. At times of sunspot activity we experience difficulties with radio communications and the earth is bombarded with many particles causing such phenomena as the Aurora and intensifying the ionisation of the upper atmosphere.

In order to understand more about this we must complete our picture of the Sun. Surrounding the photosphere is a layer which is called the chromosphere, this extending for about 12,000 miles. Beyond this is the corona which extends for many millions of miles. We are normally only able to see the chromosphere and the corona at times of eclipse. This is where radio astronomy comes into its own, for the radio Sun is very much more extensive than the visible Sun; even the corona is extended for many times the Sun's diameter into outer space. It is, however, possible to see this at all times with the radio telescope. These radiations are due to different causes. A large number of sunspots does not necessarily mean intense activity, in fact, many sunspots occur with no sign of any extraordinary or unusual activity. Intense activity and bursts are usually due to flares, whereupon they may sometimes be initiated by sunspots and sometimes occur spontaneously on the surface. The flare itself is usually of short duration but its effects can be spread over two or three days. Flares are intense spouts of highly energised gas which radiate over the whole of the electro-magnetic spectrum. The onset of a flare, of course, appears first as light which reaches us in about eight minutes. Ultraviolet rays affect the E layer of the ionosphere causing intense ionisation producing magnetic effects and causing fadeouts in radio communications in the frequency band from 5–20 Mc/s. Together with this there are outbursts of noise in the region of 60 Mc/s. Cosmic rays are produced and appear somewhat over an hour later. These are followed after a long period, and at intervals, by clouds of particles travelling at slower speeds and which reach our atmosphere between 20 and 40 hours later. The clouds of particles consist of ions and electrons which cause magnetic storms, ionospheric storms and under very severe conditions, displays of Aurora. Many readers may remember the intense display which occurred in 1957. Particles trapped in the magnetic field caused considerable interference with television and communications at high frequencies. The fact that the activity of the Sun operates on our upper atmosphere, thereby producing the ionosphere, makes communications on earth possible. We must, however, suppose that frequencies lower than we are able to detect from extra-terrestrial sources exist, and it is for this reason that satellite and probe programmes are geared to examining radiations at frequencies lower than 10 Mc/s.

From the point of view of the amateur, of course, we shall be compelled to confine ourselves to frequencies of the order of 30 Mc/s and upwards. The variations of the ionosphere are such that below 30 Mc/s, records are difficult to interpret.

Visible sunspots are dark areas which appear on the surface of the photosphere. They appear dark because they are approximately 1,000 degrees lower in temperature than the surrounding surface. The cause of sunspots appears to be due to dipoles of magnetic activity occurring within the Sun itself. A dipole and magnetic field develop as though a magnet was lying beneath the surface of the Sun some 30 or 40 thousand miles in length. The movement of the field sometimes causes one end of it to appear on the surface. The gas at a very high temperature, and confined to the magnetic field, travels along the lines of force, and the surface features around the spot called faculae, are the result of this activity and extend up into the corona where the temperature is raised. As the area increases so the dark spots develop and extend. Sometimes they represent the single end of the magnetic disturbance and sometimes both poles appear, one in the northern hemisphere and one in the southern. The radiations take place from the activity which is generated in the atmosphere of the Sun by these phenomena, and it is during these periods of activity that flares and their associated effects are observed. The flare itself is an increase of the emission from the area of the faculae. It is usually accompanied by terrific storms and explosions, and details of its effects have already been given in this article. Disturbances still continue after spots and flares have ceased to be observed, since the lingering effects of the disturbances are still present in the Sun's atmosphere. Table 1 shows the classification of activity on the Sun.


The Crab Nebula. Observed by the Chinese in A.D. 1054, it is situated approximately 4,000 light years from us and is the result of a supernova or exploding star. Its size is now of the order of 10 light years and the rate of expansion is some several hundred miles per second


The Ring nebula in Lyra. This has a faint star surrounded by a spherical shell. It is made luminous by the intense ultra-violet radiation from the central star. This is a fairly common type since there are some 60,000 of them in the Milky Way

The Quiet Sun

This is a subject which is now well understood. Throughout the solar corona the temperature can rise to something of the order of a million degrees K and at centimetre wavelengths the sort of temperatures that may appear are of the order of 10,000 degrees Kelvin at 1.25 centimetre wavelengths, and one million degrees K at 1.50 metres. Bursts of radiation within this frequency band have been observed and there is also revealed a slowly varying component. At the present time we have a unique opportunity of studying this slowly varying component, and a great deal of work has been done on this aspect of the Sun.

Crab Nebula

We must turn now to the other sources within our galaxy. The most important one is perhaps the

Cygnus A, which appears to be two galaxies in violent collision, the products of which are flying in all directions at speeds of 250 miles per second. Distance from the Earth is some 300 million light years

Crab nebula. This is the result of a supernova or exploding star. It was observed by the Chinese in A.D. 1054. It is situated at a distance of approximately 4,000 light years from us and its size now is somewhat of the order of ten light years. So great was the explosion that the rate of expansion which is taking place is of the order of several hundred miles a second. Such energy must mean that the source of power originates somewhere in the centre and is due to the spiralling motion of cosmic-ray electrons in a magnetic field. If the Crab nebula had exploded within a comparatively short distance of the earth it would have blotted out all communications entirely. During the 900 years since this nebula was born the Sun has been pouring out continuous energy, yet this is but one thousandth part of the energy which is being poured out from the nebula at the present time. The only possible source of such energy is nuclear energy. It is reasonable to suppose that nuclear processes are going on all the time, since light is still visible from this object.

It is fortunate for the radio astronomer that the Crab nebula is in such a position that the Sun passes in front of it in June of every year. This produces an occultation. Since the Crab nebula is an intense source of radio waves, if we arrange to observe it during the period of June we should be able to measure the intensity and extent of the Sun's corona. Since the radio corona of the Sun extends so far out into outer space we should find that the Crab nebula decreased in intensity, and the measure of that decrease would indicate the density of the solar corona. This in fact has been carried out now every year since 1952 and much useful information has been obtained from the observations. This is a field in which the amateur, in particular, can co-operate, and the author hopes that those readers who have built their radio telescopes will be willing to take part in this experiment during June 1962. It can be observed over the whole range of frequencies and, in fact, it would be useful if various people were to work on different frequencies as we should thus get a better picture of the degree of absorption or refraction that may be taking place in the corona. As this will be a period, we expect, of quiet Sun it should be a very valuable experiment. Observations should commence in the last week of May and continue until the first week of July.

Supernova

There are two other discrete cources which have been identified with visible objects and both of these are supernova. One is the supernova of A.D. 1572 known as Tycho Brahe[2] star and another in A.D. 1604 which is known as Kepler's[3] supernova. These are the only radio sources which have been positively identified as exploding stars. There are, however, other types which must have once been exploding stars although we are now able to observe only the remnants of these catastrophies.

Radio Galaxies

There are a number of external radio sources

The Saturn galaxy, so called because of its resemblance to the planet and its rings. The dark edge is due to clouds of cosmic dust which obscure the light from the central part. This galaxy is about 20,000,000 light years distant

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[2] Tycho Brahe (1546–1601) was a celebrated Danish astronomer and a fellow worker of Kepler. With sums of money placed at his disposal by Frederick II of Denmark, he constructed an observatory called Uraniborg on the island of Hveen near Copenhagen. Here, for over 20 years, he carried out a large programme of accurate and systematic observations of the heavenly bodies and compiled tables of their movements.—*Editor.*

[3] Johann Kepler (1571–1630), a German astronomer, was assistant to Tycho Brahe whose measurements he used when working on his laws of planetary motion. These laws are: (*a*) the planets describe elliptical orbits, of which the Sun is one focus; (*b*) the line joining a planet to the Sun sweeps out equal areas in equal times; and (*c*) the square of the period of revolution of a planet is proportional to the cube of its average distance from the Sun.—*Editor.*

Centaurus A, distant from us by approximately 400 million light years, is a further example of colliding galaxies

which are called radio galaxies. Many of these are beyond the range of optical telescopes. We have already mentioned the great nebula in Andromeda. There are also irregular types of galaxies which may still be termed normal, the closest of these being the greater and lesser Magallenic clouds. Some of the extra galactic sources merit special attention.

The first of these to be identified was Cygnus A. This would appear to be two galaxies in violent collision. The products of this collision are flying in all directions at enormous speeds of the order of 250 miles per second. The red shift[4] of this object shows that it must be at a distance of about 300 million light years. The radio source is several times the size of the optical source. It has a peculiarity in that the radio source appears to be divided into two parts. This suggests that the radio source must be a galactic corona which would appear in this case as two separate units, though the visible part of the colliding galaxies would appear as one object. It is an extremely powerful radio source and the amount of energy which it is dissipating is of the order of one hundred thousand million times the total energy radiated by the Sun.

A peculiar radio galaxy is Centaurus A. This is distant from us by about 400 million light years. It will be noted from the illustration that it has a peculiarity in that there is a dark patch of cloud cutting across the centre of the bright section. This is probably due to clouds of hydrogen which obscure the light but which in themselves, probably radiate. It is probable that these are the exterior arms of one galaxy. Here again the size of the radio source is many times that of the optical object, for this is really two colliding galaxies.

Still another quite remarkable radio galaxy is Virgo A. This has a peculiar jet extending from one

A spiral nebula with a long arm and smaller nebular attached. This is the Whirlpool nebula in Canis Venaceti. It is situated at RA 17h 27m and Dec. +47° 27′. It may be that this peculiar shape is the result of a collision with another passing galaxy in the distant past

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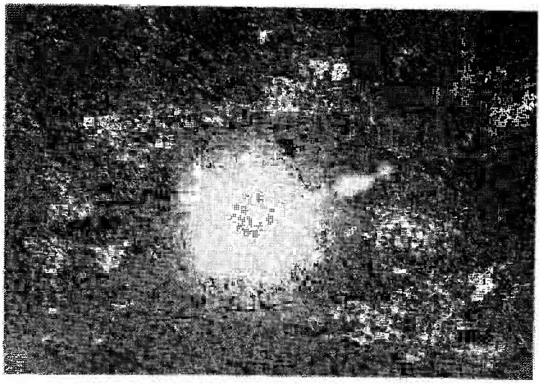
[4] The term red shift refers to the displacement of the Fraunhofer lines of the spectra due to the Doppler effect when obtaining a spectroscope analysis of the light, in this case that from Cygnus A. It has been shown that in the case of an approaching star, the lines of its spectrum are displaced towards the blue end of its spectrum and, if the star is receding, that they are displaced towards the red end.—*Editor.*

TABLE 2
Radio Sources

Identification	Right Ascension			Declination		Intensity (Watts/m^2/c/s x 10^{-26})
	H.	m.	s.	°	′	
Andromeda Nebula	00	42	00	+38	0	200
Small Magellanic Cloud	01	00	00	−72	0	300
M77	02	36	00	−30	0	12
Large Magellanic Cloud	05	15	00	−67	0	2,000
M81	09	51	20	+69	0	12
NGC4258	12	15	00	+47	0	7
M51	13	27	00	+47	27	8
M83	13	00	00	−20	0	12
NGC4945	13	22	34	+40	35	10
Colliding Galaxies and Excited Galaxies						
NGC1275	03	16	06	+41	19	161
Double Galaxy Hydra	09	16	46	−11	55	420
M87 Galaxy with Jet	12	28	18	+41	0	1,700
Colliding Galaxies	13	22	45	−40	35	1,600
Colling Galaxies	19	57	00	+58	35	13,500
Supernova						
Crab	05	31	30	+21	59	1,850
Cassiopeia A	23	21	00	+58	32	23,200

side and the energy needed to produce this jet must be enormous. This galaxy is at a distance of about fifty million light years.

Of the thousands of radio galaxies known to radio astronomers only about one hundred have been identified with optical objects. Some of them are so faint that it may well be that we shall have to wait for larger optical telescopes before they can be actually seen and identified. It is the ability of the radio telescopes to work in fields where the optical telescope can no longer reach which has provided the statistical computation of their number and density that led Professor Ryle to state that the steady state theory of the universe was no longer compatible with the results he has discovered, and this once again suggests that the universe is continually expanding.



Virgo A with its peculiar jet. Distance—50 million light years

A list of the radio sources which the amateur might care to observe is given in Table 2. This shows the position of the object in the sky and gives relative intensities and identification.

The other plates which have been included in this article but not mentioned in the text carry captions with full details.

It would be as well at this stage if those readers who are going to be active in this field should study a little astronomy, in particular radio astronomy. Accordingly it is suggested that the following books should be read: *Radio Astronomy*, by F. Graham Smith, Pelican; *Radio Studies of the Universe*, by Davies and Palmer, Routledge & Kegan Paul Ltd.; *Radio Astronomy*, by Pawsey and Bracewell, Oxford University Press.

(*To be continued*)

UNDERSTANDING RADIO

We regret that Part 7 of "Understanding Radio" has been held over until next month. We apologise to those readers who are especially interested in this series.

An inexpensive circuit offering timing periods up to 100 minutes

simple transistor time switch

By J. BURGESS

This article describes a simple time switch which has the especial advantages of being simple to construct and of requiring few components. After having been set into operation, the switch is capable of turning equipment on or off after periods ranging from less than 5 seconds to 100 minutes

The Basic Circuit

THE BASIC CIRCUIT OF THE SWITCH IS GIVEN IN Fig. 1. When, in this diagram, switch S$_2$ is depressed, capacitor C charges to the full potential of the supply. This causes a negative voltage to be applied to the base of the transistor, whereupon its collector current energises the relay. As soon as S$_2$ is released, capacitor C commences to discharge into R and the base-emitter resistance of the transistor. After a period, the length of which depends upon the values of C and R and the characteristics of the transistor, C discharges sufficiently to cause a reduced negative voltage to appear on the base and a reduced collector current to flow through the relay coil. The relay then de-energises, and the timing cycle is complete. Another timing cycle may be set into operation by closing, and releasing, S$_2$ once more.

Practical Points

The transistors used in the author's version of the circuit have been, at various times, red spot, yellow-green spot and yellow-red spot types. All these have given successful results but care has to be taken to select a transistor having as high a base-emitter resistance as possible. Too low a base-emitter resistance necessitates an increase in the value of R, and may even cause the circuit to become unreliable.

The relay employed in the original was a Siemens high speed unit type 73 with a single set of changeover contacts and two 1.7kΩ coils. This relay responds readily to a current of some 1 to 2mA and is, therefore, eminently suitable in a circuit of this type. When used, its two coils are wired in series. The Siemens relay is not capable of switching external circuits passing large currents and it is necessary, then, to have it control an auxiliary relay with heavier contacts. An alternative relay, an ordinary P.O. type with a 600Ω coil and two sets of changeover contacts, has also been used with success.

The values required in C and R will vary slightly according to the characteristics of the transistor, but the following figures should serve as a useful guide:

Time-Range	*C*	*R*
5–100 secs.	4–5μF	1–20kΩ
1–15 mins.	16–50μF	10–330kΩ
5–100 mins.	100μF	100kΩ–2MΩ

The capacitors may be electrolytic, and it is desirable to employ good quality components having low leakage values. The value of R should not be increased indefinitely in an attempt to increase the length of the timing period. There is an unavoidable limit to the useful value of R which, if exceeded, may actually cause the length of the period to be decreased. The limiting value of R depends upon the characteristics of the transistor employed.

Power Supply

It is a false economy to attempt to run the unit from a low voltage power supply. This is because such a supply causes C to charge to a low potential and reduces relay current. Both these effects narrow the switching period offered by a particular combination of C and R. It is preferable to use a reasonably high voltage supply, 6–7 volts maximum having been successfully employed with the author's version when using "surplus" transistors. A 12 volt supply has been used with branded transistors.

The author has also run his timer from the 6.3 volt winding of a small filament transformer via a bridge rectifier. Under these conditions smoothing is important (to prevent relay chatter) and a 50μF reservoir capacitor was found to give successful results. No smoothing choke or resistor was required, the timer circuit being connected directly to the 50μF reservoir capacitor.

Alternative Circuit Arrangements

Alternative circuit arrangements are given in Figs. 2 and 3. In Fig. 2, S_3 switches in one of four different resistors, thereby allowing four different time periods to be selected. In Fig. 3 the time period is capable of being altered by making R a variable resistor. The series limiting resistor in Fig. 3 prevents the flow of excessive base-emitter current and should have a minimum value of 1kΩ or more, according to the maximum permissible base current of the transistor employed. The switching circuit of Fig. 2 is preferable to that of Fig. 3 because, once it has been calibrated, it gives more consistent results.

An alternative, or complementary, arrangement offering different timing periods would be given by a switch which connected different values of capacitance into the C position.

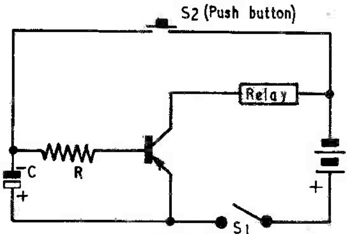


Fig 1

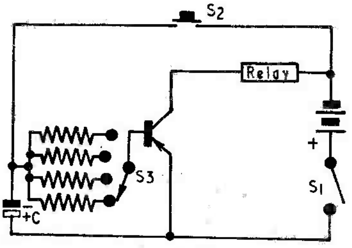


Fig 2

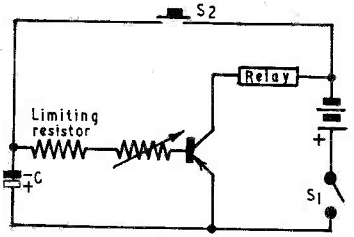


Fig 3

E179

Applications

There are, of course, a large number of applications for a timing circuit of this type, these varying from the operation of enlargers in the photographic darkroom to the switching on, or off, of radio or television receivers.

A particularly attractive arrangement would be offered by employing two timers. The first timer could be employed to switch on, say, a radio receiver and to actuate the second. The second timer would then switch off the radio after the requisite period of time had elapsed. By taking advantage of a spare relay contact, the timer may also switch itself off after it has completed its cycle.

BOOK REVIEW . . .

THE AMATEUR RADIO HANDBOOK, 3rd edition. Published by Radio Society of Great Britain, 28 Little Russell Street, London, W.C.1. Price 36s. 6d. post paid.

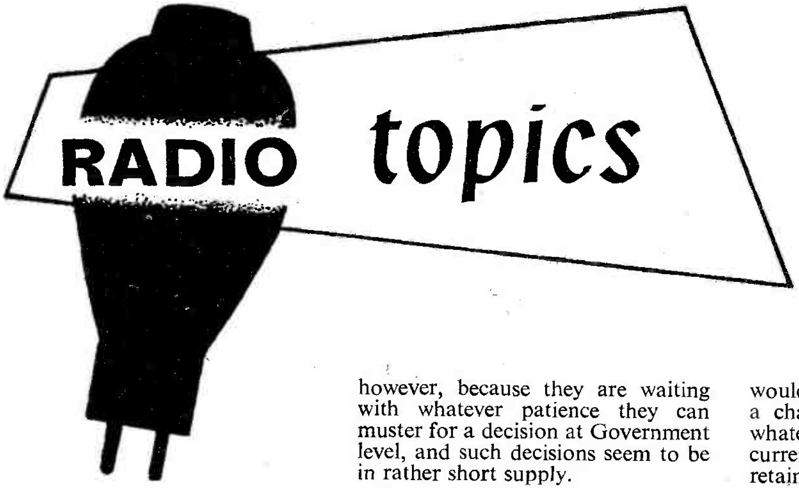
It was with very great interest that your reviewer turned the pages of this long awaited volume. The first edition appeared in 1938 and—we read from the Foreword to the Second Edition—"An unexpectedly heavy demand during the first six months of 1939 necessitated the preparation of a reprint which, as a matter of historical record, became available during the fateful week preceding the outbreak of war. For a few days early in September it seemed likely that the bulk of the reprint would remain unsold until the cessation of hostilities, but for many reasons the popularity of the *Handbook* continued unabated, with the inevitable result that stocks began to fall almost to vanishing point. This then is the sole justification for a Second Edition at the present time."

That was written in 1940. Just how right the decision was can be judged from the fact that this Second Edition sold 190,000 copies!

The Foreword to this new Third Edition draws attention to the major revolution which has taken place in the technique of radio since the previous editions of this *Handbook* appeared. What was at one time a most suitable text-book for the radio amateur and technician has inevitably become out of date. This necessitated an almost complete revision of the *Handbook*, a mammoth task which has taken some time to complete. The result has been very well worthwhile.

As one would expect from the extensive list of those who have contributed to its preparation, the volume covers every aspect of amateur radio. The chapters on Fundamentals and Valves are easily read and explicit, the latter dealing in a theoretical manner with these components. That on Semiconductors which follows is, of course, new material, replacing the chapter of Workshop Practice in the previous edition. Chapter 4 deals with H.F. Receivers as in the previous edition, although it has been completely rewritten, bringing the reader right up to date with a description of such advanced receivers as that described by G2DAF. The beginner need not feel his point of view has been neglected, however, as there is a very attractive little t.r.f. receiver described in this chapter. V.H.F. and u.h.f. receivers are dealt with in Chapter 5, with plenty of constructional data. Chapter 6 deals with h.f. transmitters which, as one would expect, are very thoroughly dealt with. V.H.F. and u.h.f. transmitters follow on in chapter 7 and again plenty of practical designs are featured. A whole section —Chapter 8—is devoted to Keying and Break-in. Modulation forms the subject of Chapter 9, the section on Adjustment and Monitoring being particularly praiseworthy. Chapter 10 is devoted to S.S.B. and Chapter 11 to Frequency Modulation. Chapter 12 is particularly interesting, being devoted to Propagation. Chapters 13 and 14 deal with h.f. and v.h.f. aerials respectively; and a complete chapter (15) deals with Noise. This chapter covers the nature of noise, its effect on reception, internal receiver noise, aerial noise, man-made and atmospheric noise and so on. Quite a unique section! Mobile Equipment is dealt with in Chapter 16, Power Supplies in Chapter 17, and Interference in Chapter 18. Measurement in Chapter 19 and Operating Technique and Station Layout in Chapter 20. Chapter 21 deals with the RSGB and the Radio Amateur and Chapter 22 features General Data.

Twenty-two chapters packed with information; over 500 pages of first-class information, nicely bound into a smart, presentable volume. This *Handbook* is certainly a credit to the society and is an absolute "must" for everyone interested in amateur radio, short-wave listening or even in radio theory and construction generally. No one will read this volume without having become the wiser for having done so.



RADIO topics

By RECORDER

UNLESS THE REPORT OF THE Pilkington Committee has already appeared by the time these notes appear (and this is very unlikely) February of 1962 should see the 405–625 line controversy warming up once more to its familiar sterile condition. This controversy has pursued its desultory way for quite a few years now, and it may be remembered that something approaching a culmination took place at last year's Radio Show. At the Show we had the sorry spectacle of leading TV manufacturers publicly disagreeing amongst themselves on whether we should introduce 625 lines or carry on with our present 405 line system. One tends to have sympathy with the manufacturers, however, because they are waiting with whatever patience they can muster for a decision at Government level, and such decisions seem to be in rather short supply.

To give an idea of the speed at which this matter has progressed we can consider the Report of the Television Advisory Committee, 1960. This body was asked in March 1956 to recommend whether the existing 405 line standards were likely to remain adequate for the next 25 years, and whether there was any reason why the U.K. should not adopt 625 lines for Bands IV and V.[1] In their subsequent report the T.A.C. stated that the existing 405 line system will not be adequate for all purposes for the next 25 years; that, assuming television were to be confined to Bands I and III, a changeover to higher standards (more lines) would not be practicable on these Bands; and that the use of Bands IV and V would offer the last chance to make a change in line standards. Also, whatever decisions are made, the current 405 line services should be retained for many years so that existing receivers would not become prematurely obsolescent. This report was published in May 1960 by the Postmaster-General, who emphasised in the foreword that "the Government has reached no conclusions on it".

It took over four years for the T.A.C. Report to appear and all it achieved was a statement that no conclusions were to be reached on it!

As we all know, the question of line standards has now been passed on to the Pilkington Committee, and this is due to report early in 1962.

Clearing the Fog

Many people are still not too clear about the differences between the 405 and 625 line systems, and the situation has been somewhat fogged over the last few years by statements which tend to amplify details rather

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[1] Bands IV and V are 470–582 Mc/s and 606–960 Mc/s respectively.

than deal with the fundamental facts. So let's tackle a few basic questions.

What is the 625 line system? The 625 line standard has 625 lines per picture, each picture consisting of two interlaced fields.[2] There are two main 625 line systems in use, these being the Western European system, which has a video bandwidth of 5 Mc/s, and the Eastern European (including Russia) system, which has a video bandwidth of 6 Mc/s. Apart from video bandwidth the systems are basically the same. Both have 50 fields per second, negative vision modulation (in which an increase in transmitter output causes a decrease in picture brightness), and f.m. sound. Both 625 line signals also have equalising pulses in the vertical sync period, and these assist in obtaining good interlace at the receiver. I should add that Australia also has a 625 line system, this being similar to that employed in Western Europe.

If we adopted 625 lines, which of the two European systems would we use? This question needs a crystal ball for its answer, and it is quite possible that we would use an alternative standard advocated by the T.A.C. The proposed T.A.C. system is, roughly speaking, half-way between the Eastern and Western European systems in that it has a video bandwidth of 5.5 Mc/s. The T.A.C. system advocates, also, the use of a vestigial sideband of 1.25 Mc/s, this being 0.5 Mc/s wider than either the Eastern or Western European vestigial sidebands. The extra width of vestigial sideband should help low frequency reproduction, and it causes the T.A.C. signal to take up the same channel width (8 Mc/s) as the Eastern European signal. (The 405 line system has a channel width of 5 Mc/s.)

Does 625 lines give increased vertical resolution? Yes. I dealt with this question in some detail in the September 1960 issue of the *Radio Constructor*, with the following conclusions. The 405 line signal has approximately 377 active lines, whilst the 625 line signal has approximately 585 active lines. (Active lines are those which carry picture information, the remainder being lost in the vertical blanking periods.) A change from 377 to 585 lines represents an increase in vertical resolution of 55%.

Does 625 lines give increased horizontal resolution? Yes. Returning again to the September 1960 issue, I showed then that, taking line sync pulses into account, the 625 line system put forward by the T.A.C. (5.5 Mc/s video bandwidth) can give an improvement in horizontal resolution of some 20% when compared with the 405 line system. At the same time, the Western European 625 line system (5 Mc/s video bandwidth) would give an improvement of approximately 10%. (The Eastern European 625 line system, with its 6 Mc/s video bandwidth, can offer a further improvement on the proposed T.A.C. system.) These improvements in horizontal resolution are not great, but they are there nevertheless.

Other Attributes

Are other attributes of the 625 line system important? Yes. As already mentioned, the 625 line system has negative vision modulation, f.m. sound, and vertical equalising pulses. These are important when compared with the positive vision modulation, a.m. sound, and lack of equalising pulses in the 405 line system.

Is negative vision modulation an advantage? It would appear to be so. With negative modulation interference pulses show up on the screen as black instead of white. Sync pulses correspond to full transmitter output and this enables simple vision a.g.c. circuits, either direct or gated, to be used. Such circuits can give *true* vision a.g.c. (Many of the cheaper 405 line receivers take their vision a.g.c. voltage from average picture level instead of from a constant reference level such as the sync pulses—and this means that contrast increases when the overall brightness of the picture decreases.)

Doesn't negative vision modulation require flywheel sync? It may well be argued that 625 line receivers are more prone to line tearing because interference pulses more closely resemble line sync pulses. In practice, flywheel sync appears to be standard with all Continental 625 line receivers (as it is with 525 line receivers in America, the 525 line system being basically the same as the 625 line system).

Would British 625 line receivers require flywheel sync? Almost certainly, if only because British 625 line sets will have to work on u.h.f. (Bands IV and V) where signal strength may be, in many localities, weaker than what we are used to at the time being. It is difficult to effect a direct comparison with positive and negative modulation experience here, because a peculiarity of present British television is that each receiver is expected to receive two signals only, these being B.B.C. and I.T.V. If a British receiver is in a "soak" area (i.e. a strong signal area) direct line sync may be quite adequate. On the other hand, a receiver working in a "fringe" area needs flywheel sync, because the ratio of interference to signal strength becomes greater. (Very often, the only difference between the "soak" and "fringe" versions of a particular 405 line model is that the latter has flywheel sync. R.F. and i.f. stages in both models are identical.) On the Continent (and in America) "soak" and "fringe" areas may not be so clearly defined as in the U.K., whereupon it would be a good manufacturing policy to fit flywheel sync to *all* sets.

Is f.m. sound an advantage? Yes. This is not because it may necessarily offer a higher fidelity of reproduction (high fidelity transmissions are feasible with our current 405 line a.m. sound channels) but because the receiver sound circuits can be made impervious to impulsive interference.

Are equalising pulses an advantage? Yes. This is because they improve interlace. It is a useful exercise to take a look at half a dozen present-day 405 line receivers, and see how many have true 50:50 interlace.

U.H.F. Tuners

Won't 625 lines mean that u.h.f. tuners will be required? Yes. We will have to go into Bands IV and V for 625 lines, so u.h.f. tuners will be needed.

Won't such tuners be over-taxing the abilities of service engineers? No. This sort of nonsense was put about when f.m. started and when Band III started. Competent service engineers can take u.h.f. tuners in their stride. They will, in any case, be backed by manufacturers' service departments.

Will Band IV and V transmissions cause problems with regard to receiver aerial siting? Very probably. The snag with u.h.f. is that the transmitted signal is more liable to maintain a straight path than do Band I and Band III signals. U.H.F. transmitters will, in consequence, probably have smaller "soak" areas around them. Also, reflections may be more prevalent, and will call for greater care in siting aerials. Further, aerial feeder losses will be greater. The same problems would, of course, apply if 405 line signals were transmitted in Bands IV and V.

Receivers

Is a standard 625 line receiver significantly different from a standard 405 line receiver? Yes. This is because, in a standard 405 line receiver, the sound i.f. is separated from the composite signal immediately after the tuner unit or immediately after the first i.f. amplifier. A separate sound i.f.

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[2] The term "field" nowadays supersedes the familiar word "frame". (The use of "frame" is deprecated in British Standard B.S.204:1960, *Glossary of Terms Used in Telecommunications and Electronics*.)

amplifier then brings the signal up to detection level, after which it passes to the a.f. amplifier and speaker in the normal way. In a standard 625 line receiver both sound and vision intermediate frequencies pass through the i.f. strip and are detected by the vision detector. The vision detector output then consists of the demodulated vision i.f., the demodulated sound i.f., and a third signal whose carrier frequency is equal to the difference between sound and vision intermediate frequencies. This third frequency is known as the "intercarrier frequency", and is produced in just the same manner as a heterodyne between any two frequencies in a mixer. The intercarrier frequency is modulated both by the f.m. sound and by the a.m. modulation of the vision i.f., and it may be extracted either after the vision detector or after the video amplifier. It is fed to an amplifier tuned to the intercarrier frequency. Using conventional f.m. techniques the vision a.m. is then limited out and the f.m. detected, the detected f.m. signal being passed to the a.f. amplifier and speaker in normal fashion. To give an idea of the frequencies involved, the Western European 625 line system has sound and vision carriers spaced (in every channel) by 5.5 Mc/s. The intercarrier signal is, therefore, taken out after the vision detector (or video amplifier) at 5.5 Mc/s. The advantage of the intercarrier system is that most of the sound i.f. amplification is carried out in the combined vision and sound i.f. stages, and the costs incurred by a separate sound i.f. amplifier are thereby reduced.

There are, of course, other obvious differences between 405 and 625 line receivers, such as dissimilar line timebase speeds and so on. But the two methods of handling the sound signal constitute the main difference.

What about convertible and switchable sets? Convertible and switchable sets (405 and 625 lines) are now on the market and they use a number of ingenious circuit devices to accommodate the two systems. In such receivers, it is a fairly easy design problem to change timebase speeds and reverse from positive to negative vision modulation when switching from 405 to 625 lines. The hard job consists of changing the i.f. stages when switching over. Most of the convertible or switchable receivers seem to be using intercarrier sound for the 625 line reception. Manufacturers' problems are made more difficult in this respect because nobody knows (at the time of writing) whether the future 625 line system—if it appears—will follow the T.A.C. recommendations, or use the Western or Eastern European standards or something else.

Export

Will a 625 line system in this country help exports? In my opinion, yes. Although early home production will consist of switchable receivers which could not be sold directly for export, the introduction of a 625 line system will enable our manufacturers to get more production and design *experience* in 625 lines. Such experience would be backed and financed by a high level of home sales. Don't forget that TV manufacturers learn a great deal about any shortcomings their products may have *after* they have been sold and are in the hands of the public. Whilst on the subject of exports it should be remembered that the two major television systems in use in the world are the 625 and 525 line systems. Basically, these systems are very similar (both use negative vision modulation and f.m. sound) and experience with 625 lines can in consequence be of almost equal assistance in the manufacture of 525 line equipment. It should be added that dissimilarities between 625 line systems (as is given for instance by the difference in video bandwidth between the proposed T.A.C. system and the Western European system) are of a minor order so far as receiver design and production are concerned.

Overall Advantages and Disadvantages

What are the overall *advantages of 625 lines?* First of all, there are the advantages already referred to: these consisting mainly of increased resolution, reduction of visible and audible interference, and better interlace. Secondly, the use of a 625 line system allows for direct interchange of programmes with the Continent, without the necessity for standards conversion. Thirdly, the system is the same as that of our neighbours, a factor which is of considerable value in the present state of the world, especially when it is remembered that television is now one of the major mediums for the dissemination of information.

What are the overall *disadvantages of* 625 *lines?* A number of reasons have been put forward against our changing to 625 lines. One opinion is that channel width (8 Mc/s in the proposed T.A.C. and Eastern European systems, 7 Mc/s in the Western European system) is too great as compared with our present 405 line channel width of 5 Mc/s. Fewer stations can be squeezed into the ether space available. A second opinion admits the advantages of changing over to 625 lines, but states that these are not great enough to merit the national expenditure involved in the manufacture of the necessary receivers (and converters). A third opinion states that the 625 line system does not give any advantages at all, and that it would introduce shortcomings in performance instead.

What is your personal opinion on these objections? I don't think that the question of channel width is essentially important here, although nobody likes to see ether space used up without good reason. However, it must be stated that it *is* possible to squeeze a third 405 line programme (with 95% national coverage—T.A.C. Report) into our existing Bands I and III, because of the 5 Mc/s channel width. After that, further programmes would have to go up into u.h.f. in any case. There is considerably more channel space in Bands IV and V, and it must be remembered that we can share the same u.h.f. channels as other countries because of the limited transmitter range. (We do this already, of course, in Bands I and III.) What the second opinion raises is a question of degree: are the advantages worth while or are they not? Taking into account the overall picture, including the points about export and that we will have the same television system as our neighbours, my personal opinion is that the advantages *are* worth while. I don't know what to say about the third opinion because I haven't yet seen any satisfactory explanation as to why a 625 line system *should* introduce shortcomings instead of advantages.

Finally, what about colour? The question of colour television doesn't really enter the present controversy. We can have colour television using either the 405 or the 625 line system. It seems pointless, however, to carry out a considerable amount of development work on colour in this country until the decision whether we should go into 625 lines or not has been made.

Full Circle

This brings us, full circle, back to my opening comment: a decision at Government level is required, but such a decision just does not not seem to be forthcoming.

The above questions and answers should, in any event, give a good background to the controversy. I have endeavoured to make the answers as factual as possible, and have clearly indicated those which express my own opinion.

AN INDOOR WORKSHOP

By D. W. Easterling

THE FIRST REQUIREMENT WITH ANY CONSTRUCTIONAL hobby is a place in which to work, and radio is no exception. The requirement is not always easily satisfied, especially as far as the young enthusiast is concerned. This article suggests one method of solving the problem.

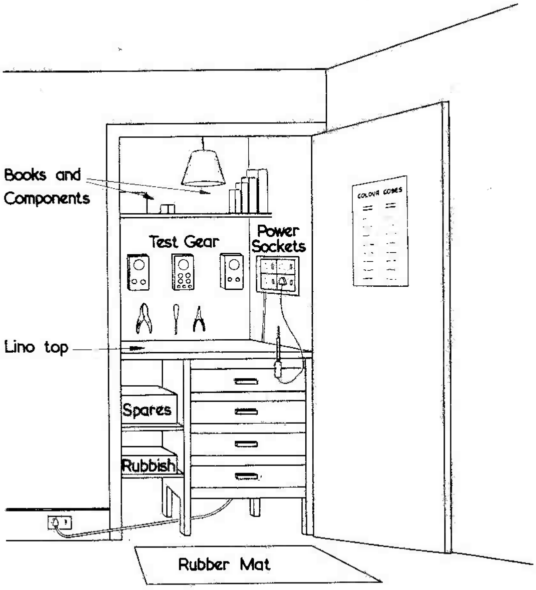
Two distinct types of work are carried out in the radio constructors' workshop: metal or woodwork, occasioned by chassis and cabinet construction and necessarily messy and noisy; and light assembly, wiring, and test, which is not noisy or messy, but which requires reasonable climactic conditions and an electric power supply.

If a good, dry, outside workshop is available there is no reason why it cannot be used for both types of work; although they are best separated as far as possible since radio equipment is sensitive to mechanical shock and iron filings can play the devil with magnetic components such as loudspeakers, etc. It is also desirable to be able to leave a job half finished without interference from other members of the family, especially where dangerous voltages or delicate instruments may be within the grasp of small children. Often it is more practical to have the two classes of work completely separate, heavy work being done in a shed or even in the garden, and light work indoors.

"Indoors" to many enthusiasts means an upstairs room, but it is strange how wives and mothers object to half-finished equipment spreading itself over dressing table and counterpane. Perhaps an idea successfully put into operation some years ago by the writer (although fortunately not now necessary) may be overcome domestic opposition.

It will be seen from Fig 1 that a built-in cupboard or wardrobe is used to accomodate the bench. This type of cupboard is found in many houses and is usually in the region of 2ft 9in wide, 7ft high and 2ft deep. The bench is 2ft 6in by 2ft, and this area is reasonably satisfactory, even if tailored to the transistor age. Incidentally the effective working space can be increased by using something like a tea trolley, which can then be pushed out of sight when not in use. Although bench area is limited wall space is not and so, as in New York, the answer is to build upwards, with test gear, etc. mounted on the wall instead of taking up bench room.

By using the "jam-in" method of construction the comprehensive fitment shown in Fig 1 can be installed with only a rudimentary knowledge of carpentry and without damaging the walls. Consequently it should not offend landlords, and can easily be removed later if desired. The "jam-in" method is shown in Fig 2 where it will be seen that side sections consisting of planks secured by cross-battens are pushed firmly against opposite walls by the bench and shelves which the battens support. The widths of the side sections are such that they will only just fit into the cupboard, so that they are prevented from moving backwards by the wall and from moving forwards by the door frame.



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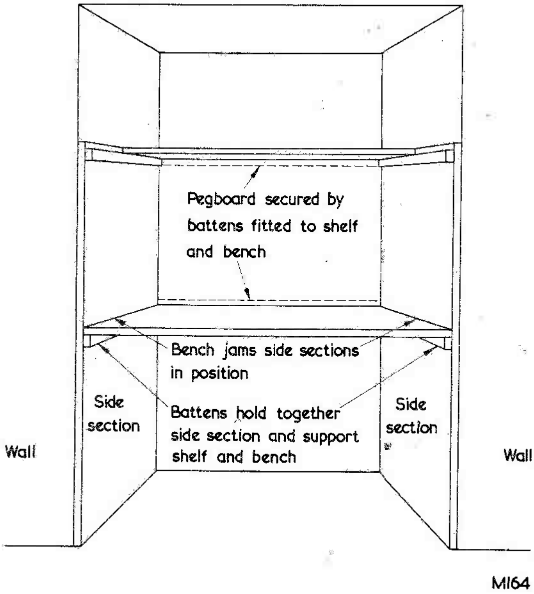
Construction

Before commencing the construction, it is best to produce a carefully dimensioned drawing. This will help in assessing the total quantity of wood required and in cutting it to the correct lengths.

Half-inch planed soft timber is suitable for the side sections, battens, shelves, and bench, providing the cupboard is not much wider than 2ft 9in. For wider cupboards it is best to use 1in timber for bench and shelves. The maximum plank width is usually in the region of 9in and so, for a cupboard 2ft deep, the bench and side sections could each consist of one 6in and two 9in widths. For battens, 2in width is suitable.

The solid plank side sections are preferred to an alternative open frame-work, since they provide a solid base for fixing hooks, test equipment, shelves, and so on. On the other hand, a solid back board would seem wasteful. Nevertheless, there is a need to provide something here, if only to protect the wall. The answer is peg board, which can be easily fitted to battens running along the back of bench and bottom shelf. Stout wire hooks can then be formed to hold small pieces of equipment and tools.

When purchasing the wood, it is a good plan to take a list of individual timber lengths rather than quote the entire length required. This will enable the timber yard to cut out the pieces most economically, both for themselves and the customer. Also they may be able to offer cheap off-cuts.



The actual constructional work should present little difficulty. First cut off the side section planks and battens (note that if the cupboard has a skirting board the side sections should stand *on* it, and so allowance will have to be made with the height). Next, fix the battens on the side sections at the appropiate places, keeping in mind shelf and bench height. Bench height is a matter of personal preference and build. The writer, who is about 5ft 10in finds a 3ft bench just right when standing or sitting on a kitchen stool. Screws are used to secure the battens to the side sections, allowing two for each plank. ¾in number 8 countersink screws are suitable.

The success of the construction depends on the bench and shelf planks being just the right length to hold the assembly firm, without being so tight that they will tend to warp. It is normally best to err on the tight side, and to remove any high spots locally, with a plane or "Surform" tool. Screws are not necessary to secure bench and shelf planks, a couple of thin wire nails or pins being quite adequate. A piece of linoleum on the bench will prevent small screws, etc. from falling between the planks, and will also provide a pleasant working surface.

The small chest of drawers illustrated in Fig 1 is the type purchased in white wood from ironmongers. Alternatively, it is often possible to pick up a cheap set from a sale, but be careful that precautions are taken regarding woodworm. It is essential that the chest be positioned so that the drawers clear the door frame, and this can be achieved by fitting wood spacers between the chest and the side section. The space between the chest and the other side section can then be fitted with shelves mounted on battens. Any space between the chest top and bench forms a useful shelf for keeping circuit diagrams, etc.

Electric Power

The cupboard has to be supplied with electric power to run the light, soldering iron, testgear, or equipment under test. The most convenient method is to use a four way distribution board supplied by a flexible lead going to the normal room outlet socket.

In a workshop planned for radio and television servicing, the distribution board is an elaborate affair, with the outlet sockets suitable for different types and ratings of plug. In the experimenter's workshop, such elaboration is costly and unnecessary. In fact, as already mentioned, all that is required are four outlets of suitable rating. It is usually advantagous to use the same type socket as those used elsewhere in the house, 5 amp 3 pin being a convenient and popular size.

Special precautions must be taken with a workshop electricity supply, since bad workmanship can easily prove fatal. If a properly installed wall socket is nearby, it can be connected to the distribution board by a plug and heavy duty flexible cable; thus all workshop supplies are quickly and unmistakably disconnected in an emergency, and there is little possibility of the cupboard being left with the door closed and equipment switched on (a possible fire risk).

Referring again to Fig 1, the rubber mat is an obvious safety measure against shock. For most purposes the thin bathroom type is adequate. Another advantage of the mat is that it collects odd bits of solder and wire which may otherwise be trod into expensive floor coverings. When work is completed for the day, these bits may be shot into the rubbish box and the mat, along with the mains lead, pushed under the chest out of sight.

a simple geiger-müller counter

By J. B. DANCE, M.Sc.

ACKNOWLEDGEMENT: The Geiger-Müller probe unit described in this article is based on a design published by the Mullard Educational Service.

THE GEIGER-MÜLLER COUNTER IS A piece of electronic apparatus which will detect the ionising radiations emitted by radioactive substances; it was developed by H. Geiger and W. Müller in 1928. In the very simple instrument to be described, each ionising particle entering the Geiger tube produces a click in a pair of headphones or in a loudspeaker, but in more complicated and expensive instruments each particle is automatically counted and the total number of counts shown.

The Geiger counter can be used for numerous simple experiments using substances which are very weakly radioactive and which are therefore perfectly safe.

Types of Radiation

Radioactive substances can emit at least three different types of radiation; these are known as alpha, beta and gamma rays.

Alpha radiation will produce much ionisation when it travels through a gas and each alpha particle which enters a Geiger tube will therefore be counted. This type of radiation cannot penetrate materials to any great extent, however, and will therefore not be able to enter a Geiger tube unless the tube has a very thin special "window" through which the particles can enter. Alpha particles are stopped by a few centimetres of air or by aluminium foil of about 0.002 cm. in thickness. They consist of extremely fast moving helium nuclei, that is two protons and two neutrons held closely together by internuclear forces; they are positively charged.

Beta radiation is able to penetrate through much more material than alpha radiation, but is largely stopped by aluminium of about 0.1 cm. in thickness. Beta radiation will pass easily through the thin mica windows used in many Geiger tubes and will ionise the gas inside; thus the Geiger tube can be used to count beta particles. These particles really consist of electrons travelling at an enormous velocity (nearly the velocity of light).

Gamma radiation is far more penetrating than either alpha or beta radiation. Several feet of lead is required to stop typical gamma rays and, therefore, they will enter Geiger tubes where they produce ionisation and are counted. Gamma rays consist of exactly the same type of radiation as x-rays which are, of course, very penetrating. Both gamma rays and x-rays (like radio waves and visible light) consist of electromagnetic radiation, but the wavelength is of the order of one ten thousand millionth of a centimetre corresponding to a frequency of the order of a hundred million million megacycles. X-rays are also counted by Geiger tubes. The only real difference between gamma-rays and x-rays is their origin.

The GM Tube

There are a large number of different types of Geiger-Müller tubes manufactured for a very wide variety of uses. Essentially they all consist of a wire (usually of tungsten) which passes along the centre of a metal cylinder and which is insulated from it. The cylinder may often form the outside envelope of the tube. There are only two connections, one to the central wire which is the anode and the other to the metal cylinder which is the cathode. A steady positive voltage is applied to the central wire and the metal cylinder is earthed.

A mixture of gases is present inside the tube. It contains one of the easily ionised inert gases. A thin window, usually of mica, is used for the detection of beta particles, but is unnecessary for tubes which are to be used only for the detection of the more highly penetrating gamma radiation. The window, if used, is normally placed at the end of the tube. If the window is made extremely thin, alpha particles may also be detected.

Principle of Operation

If an alpha or beta particle or a gamma-ray enters the space between the central wire and the metal cylinder, it will ionise the inert gas inside the Geiger tube. That is, a large number of electrons will be knocked out of atoms of the gas by the impact of the fast moving alpha or beta particle or gamma-ray; positively charged ions will also be formed. The electrons are attracted to the central wire (owing to the positive voltage of the wire), whilst the positively charged ions are attracted to the cylindrical cathode where they remove an electron to form a neutral atom of gas. This movement of electrons and positive ions causes more ions to be produced by collision; a single alpha or beta particle or gamma-ray will therefore produce a very large number of ions.

During the fraction of a second following the instant a particle enters the tube, electrons will pass to the cathode and will leave the anode; we therefore say that an electric current flows from the anode to the cathode for a fraction of a second.

Probe Circuit

The extremely simple circuit of the Geiger probe unit is shown in Fig. 1. The current which passes through the Geiger tube must also pass through the two resistors, R_1 and R_2, and therefore the junction of the resistors will become momentarily more negative when a particle of ionising radiation enters the Geiger tube.

The capacitor, C_1, prevents the steady positive potential at the junction of the two resistors from being applied to the output terminals, but it will pass the voltage pulses which occur when any radiation enters the Geiger tube. If one of the two Geiger tubes suggested below is employed in the Fig. 1 circuit, a pulse of about 12 volts will appear momentarily across the output terminals each time a particle enters the Geiger tube.

Suggested Tubes

The Mullard halogen quenched Geiger-Muller tubes are suitable for use in the probe. The type MX108 has a thin mica end window and can be used to detect beta particles and gamma-rays. The type MX115 will detect gamma-rays only, as it has no end window and is therefore somewhat cheaper than the MX108. These two tubes are completely

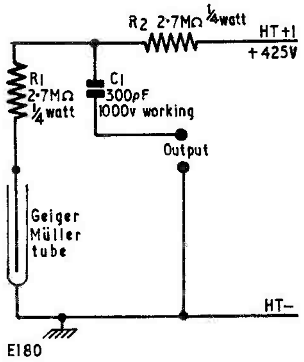


Fig. 1. Circuit of the probe unit

interchangeable and operate with an h.t. voltage of 425. The same probe unit can therefore be used for the detection of gamma-rays alone or for the detection of beta and gamma radiation by merely plugging in the appropriate Geiger tube. The tubes have chrome iron envelopes covered in neoprene jackets. The mica window of the MX108 is sealed to the chrome iron envelope with glass solder.[1]

The MX142 tube can be used for measuring the activity of liquid samples and is also interchangeable with the MX108 and MX115 tubes; it requires 2 ml. of the liquid sample. All three tubes fit into the special two-pin base manufactured by Belling and Lee under the type number L773.

Characteristics

When an increasing h.t. supply voltage is applied to a Geiger-Müller tube receiving a constant amount of ionising radiation, the number of counts per minute indicated by the apparatus increases as shown in Fig. 2. It is most important that the tube should be operated in the region of the characteristic between A and B where one particle almost always produces one count and where spurious counts are very few.

If the voltage applied to the tube is less than that corresponding to point A in Fig. 2, some counts will be missed. On the other hand voltages above that corresponding to point B will cause the counter to "count to itself" when no particles are entering the tube. The normal working voltage is half way between A and B and any slight changes of the h.t. voltage will not remove the operating point from the plateau of the characteristic curve. Accurate Geiger counters always employ a stabilised h.t. supply, but this is unnecessary in a simple instrument.

Details of the electrical characteristics of the MX108 and MX115 are given in the Table. The plateau region extends from about 370 volts to 470 volts and therefore an h.t. supply voltage of 425 volts will enable the tube to operate in the centre of the plateau region. The tubes are not permanently damaged by a supply of incorrect polarity or by the application of a voltage which is somewhat too high.

Quenching

If the Geiger tube were to be filled with a pure inert gas, spurious counts would occur from time to time, especially after a genuine count had just been recorded. Spurious counts tend to occur because any spare energy in the tube can cause ionisation. This is prevented by the addition of a gas which will absorb the excess energy.

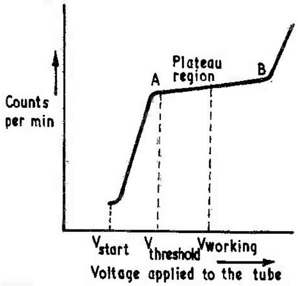


Fig. 2. Geiger-Müller tube characteristic

Organic gases, such as alcohol vapour, are much used for preventing spurious counts. Such gases are gradually destroyed when the tube is being used and the life of organically quenched Geiger tubes is thus limited to about 10^8 to 10^9 counts. In addition the h.t. supply required is usually over 1,000 volts. The halogen quenched Geiger tubes with a life of over 5 x 10^{10} counts and a much lower h.t. requirement were therefore preferred to organically quenched tubes for the simple counter described here. The electrical characteristics of Geiger tubes are very dependent on the quenching agent.

Further details on the tubes suggested may be obtained from the manufacturers.[2]

Headphones

The output from the probe unit is enough to produce loud clicks in a pair of high resistance headphones, but there is not enough power to operate a loudspeaker directly from the probe, as the probe output is of high impedance. The probe unit and its power supply can therefore be used as a complete Geiger counter if a pair of headphones is connected to the output terminals; a click will be heard each time an ionising particle enters the Geiger tube.

Loudspeaker

Alternatively the output of the probe unit may be connected to the input of a single valve power amplifier, such as that shown in Fig. 3, which is used to feed a loudspeaker. The suggested valve is an EL84 (miniature with B9A base), but any power output stage would be perfectly suitable. Ideally the primary winding of the output transformer should have an impedance of about 5kΩ to match the EL84 optimum load and the secondary

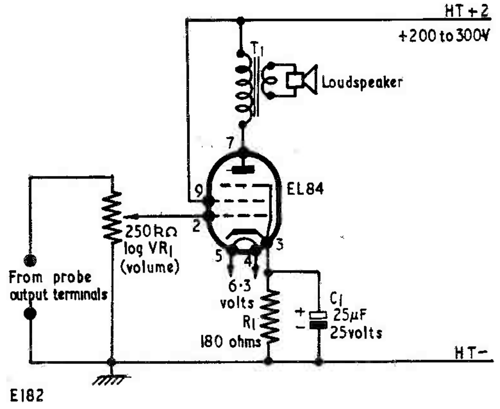


Fig. 3. Power amplifier circuit (optional)

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[1] The MX108 tube is also available with an untra-thin mica window (1.5-2.5 mgm./cm^2) and is then known as the MX108/01. The standard version of the MX108 can be used to detect beta particles arriving at the window with energies of 50Kev (i.e. 50,000 electron volts) or more and the MX108/01 can be used for the detection of beta particles with energies down to 30Kev. Readers should normally obtain the standard MX108 unless there is any particular reason for using the MX108/01.

[2] Mullard Ltd., X-Ray Division, New Road, Mitcham Junction, Surrey.

impedance of the transformer should match the speaker impedance. In actual practice, however, almost any output transformer would be perfectly satisfactory, as there is no shortage of power and any distortion is not important.

VR$_1$ is a volume control. This potentiometer also serves to shunt the high impedance probe output and thus reduces the output voltage from the probe to a value which can be handled by the EL84 stage.

The output stage of any existing receiver or audio amplifier could be used, if desired, instead of the Fig. 3 circuit.

Characteristics of the Geiger-Müller tubes types MX108 and MX115

	MX108	MX115
Threshold voltage	370	370
Plateau length (min.) volts	100	100
Plateau slope (max.) (% per volt)	0.15	0.15
Operating temperature range (°C)	-55 to $+75$	-55 to $+75$
Anode/cathode capacitance (pF)	4.8	4.8
Window area (mm^2)	227*	—
Active length (mm)	—	45
Background count (unshielded) count min.	45	45
Base	Belling-Lee type L773 (2-pin)	

* This is reduced by approximately 50% when nickel mesh guard is fitted.

Power Supplies

The only power supply required for the probe itself is 425 volts at a few microamps. The power valve circuit of Fig. 3 requires about 200 to 300 volts at about 55mA and 6.3 volts at 0.76A.

If these supplies are not already available, they can be obtained from the Fig. 4 circuit. The h.t. supply to the power amplifier is obtained by means of an EZ80 rectifier valve fed from a 350–0–350 volt winding of the transformer. Choke input is used so that the output voltage is not too high.

The power supply for the probe is obtained from one half of the same transformer winding but, as the current requirement is low, a small half-wave metal rectifier is used instead of a valve rectifier. The preset 100kΩ potentiometer serves as a smoothing resistor. In conjunction with the 270kΩ 1 watt resistor, the 100kΩ potentiometer also serves as a potential divider which enables the voltage applied to the Geiger tube to be set at 425 volts so that the operating point of the tube is at the centre of the plateau region.

If headphones only are to be used, the Fig. 3 circuit need not be constructed and the EZ80 valve, the 10 Henry choke and the 24μF capacitor can be omitted from the power pack. A transformer with a 350 volt untapped secondary winding would then be satisfactory.

Construction

The suggested method of construction is shown in Fig. 5. The Geiger tube itself projects in front of the probe, the dimensions of the tube being shown in Fig. 5 for types MX108 and MX115. The two resistors and the capacitor are mounted inside the box, but as the tube itself is not very small, it is not wise to make the attached box too small or it will easily topple over. An Eddystone diecast box is very convenient. A Bulgin two-pin connector may be used for the power supply connection, whilst insulated terminals may be most convenient for the probe output—especially if headphones are to be used at any time. The base for the tube requires a panel hole of 1⅛in diameter. The base has four fixing holes, and the anode and cathode pins are clearly marked “A” and “C”, as are the pins on the tube itself.

Assuming a loudspeaker is to be used, the amplifier of Fig. 3 and the power pack of Fig. 4 may be constructed on the same chassis. No difficulties at all should arise here as, with the possible exception of the wiring in the EL84 grid circuit, all leads can be of any convenient length. Tubular electrolytic capacitors are probably most convenient, but if the vertically mounting type are used, neither valve should be mounted so close to a capacitor that the latter over-heats. Screened wire should be used to connect the probe unit to the power amplifier.

Sources of Radiation

One of the most convenient sources of ionizing radiation is the radioactive luminous paint found on the face and hands of luminous watches. If this is brought near to the window of an **MX108** tube in a Geiger probe, many clicks should be heard per second.

Another safe source of radiation is a small quantity of any uranium or thorium compound—a very small amount is sufficient.

Taking one gram of uranium (about $\frac{1}{28}$ of an ounce), about 10,000 of the uranium atoms in this will disintegrate radioactively each second, emitting 10,000 alpha particles. Many of these alpha particles will not escape from the uranium. Of the ones which do escape, not all will have enough energy to enter a Geiger tube and of the ones with sufficient energy, only a fraction will be travelling in the right direction to enter the Geiger tube window. Thus the number of particles counted will be much less than 10,000 per second —even if the Geiger counter could count at such a rate.

On the other hand it must be remembered that the decay of

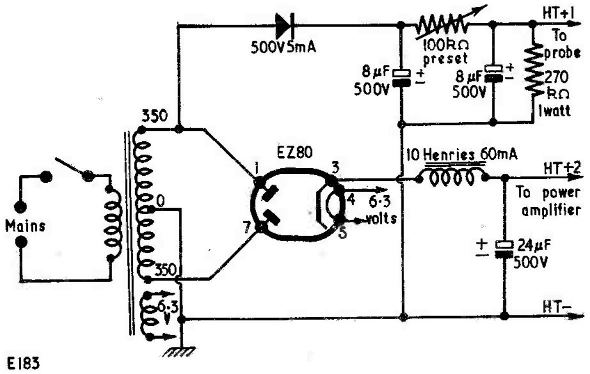

Fig. 4. Circuit of a power pack which can supply the h.t. required both by the probe and the power amplifier

Components List
(Fig. 5)

1 Geiger-Müller tube (see text)
2 Resistors 2.7MΩ $\frac{1}{4}$ watt
1 Capacitor 300pF 1,000WV
1 Tube Base. Belling-Lee type L773
2 Output terminals. Belling-Lee type L1001/1W or similar
1 H.T. input plug and socket. Bulgin connector type P161 or similar
1 Diecast case $4\frac{11}{16}$ x $3\frac{11}{16}$ x $2\frac{1}{16}$in. Eddystone Cat. No. 650
1 Chromium plated handle 3in mounting centres. Eddystone Cat. No. 608

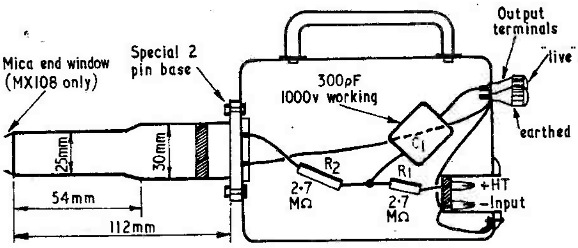

Fig. 5. The probe unit, showing also the dimensions of the Geiger-Müller tubes MX108 and MX115

uranium leads to the formation of other radioactive elements. Although they are formed in very small quantities, they are mainly very radioactive and increase the number of counts obtained in a certain time from a specimen of uranium.

The uranium used is ordinary uranium and not the special isotope from which the early atomic bombs were made.

Although in each gram of uranium 10,000 atoms disintegrate per second, it takes about 4,600 million years before half of the uranium in any given initial quantity of it is used up in this way. Uranium is fairly safe (provided that care is taken not to swallow any of it), but radium is extremely dangerous as one gram of pure radium will emit about 36,000 million alpha particles per second and half of any quantity of radium is changed to other elements in about 1,590 years. The radioactive elements formed by the decay of the radium increase its activity above these figures.

Background Count

If all radioactive materials are kept well away from the Geiger tube, about 45 counts per minute will be recorded when one of the two tubes shown in Table 1 is employed. This is called the background count.

The background count will occur because a certain number of ionising particles will enter the tube, no matter how much care is taken to ensure that radioactive sources are kept well away from the counter tube. Many of these counts are due to high energy cosmic rays which come from outside the solar system and which produce many ionising particles of lower energy when they collide with atoms of the upper atmosphere. If one or more of these ionising particles enter a Geiger counter, a click will be produced. In addition, there are always some radioactive atoms present everywhere and radiation from these adds to the background count. Even the products from atomic bomb explosions in a remote part of the world may result in a radioactive atom coming within range of one of our Geiger counters and adding to the background count.

Expensive tubes are made which enable a background count of about one per minute to be obtained. Such tubes are surrounded with lead and used in pairs in anti-coincidence circuits; they are not therefore likely to be used by the amateur experimenter.

When a radioactive source is gradually brought closer to the Geiger tube, the counting rate will increase from the background count rate of about 45 per minute to a number which depends on the strength of the source and the distance of the source from the tube.

Practical Uses

Keen experimenters will be able to use a Geiger counter for many different kinds of experiments, such as finding the fraction of the total radiation from a source which is absorbed by a sheet of paper or, in the case of the more penetrating gamma radiation, by a sheet of metal. Those interested in the chemistry of the elements of low radioactivity will also find a Geiger counter invaluable.

Radioactive elements continue to emit radiation no matter what chemical changes they may undergo. Radioactive iodine atoms (not ordinary iodine), for example, will have exactly the same activity no matter whether they exist as iodine itself, potassium iodide, ethyl iodide or any other iodine-containing chemical. The Geiger counter can therefore be used to detect radioactive atoms anywhere and in any form. It has been much used in medical work for detecting radioactive tracer atoms in living creatures; the radiation can be detected by an external Geiger counter. The Geiger counter is a very useful research tool in many very different spheres of work.

A much wider range of work can be carried out if a piece of equipment which automatically counts each particle and which shows the total number of counts on an indicator is connected to the probe output. This apparatus tends to be expensive, however, especially if a group of neon counters is used in order to obtain a fast counting rate.

A Geiger counter will warn anyone of the presence of substances which are emitting dangerous amounts of radiation. Portable instruments of this type are used by prospectors searching for the mineral pitchblende which is the material from which uranium is extracted.

The fact that such a simple instrument as the Geiger probe described here can detect a single beta particle weighing about one thousand million million million millionth of a gram and travelling at about 600 million miles per hour certainly provides one with much food for thought!

NEXT MONTH . . .

Converting a Record Player to a Portable Radiogram

MODEL TP5S

A.C./D.C. voltage up to 1,000 in 5 ranges. D.C. current 4 ranges up to 500 mA. 4 range resistance to 10 megs. Capacity, dB scales, etc.

20,000 ohms/volt
Size 5¼" x 3½" x 1¾"

£5.19.6
P.P. 1/6.

With Test Leads, Battery and Instructions

MODEL 200H

20,000 ohms per volt
Size 4½ x 3¼ x 1⁵⁄₁₆in.

£6.19.6 P.P. 1/6.

With Test Leads, Battery and Instructions.

6 Ranges D.C. voltage to 2½ kV.
5 Ranges A.C. voltage to 1 kV.
3 Ranges D.C. current to 250 mA.
Resistance to 6 megs.
Capacity and dB ranges

ALSO **MODEL TE10**

10,000 ohms/volt version of above, identical in appearance.
£5.19.6 P.P. 1/6. Fully Guaranteed.

AVO-7

Famous Multi-meter. Reconditioned and fully guaranteed. Full A.C./D.C. voltage and current, resistance, dB, power, etc., etc. Supplied with Batteries, Leads and Instructions.

£11.10.0 Regd. Post 5/-.
(Normal Price £19.10.0.)

LEATHER CASE 30/- EXTRA

MODEL TP10

A.C./D.C. voltage up to 1 kV. in 4 ranges. D.C. current up to 500 mA in 2 ranges. 2 Range resistance to 1 meg.
Capacitance, dB ranges, etc.

2,000 ohms/volt.
Size 5" x 3½" x 1½".

79/6
P.P. 1/6

With Test Leads, Battery and Instructions.

GUITAR PICK-UP

High impedance contact microphone for guitars etc. Complete with lead **12/6** P.P. 1/-

★ TRANSISTOR STANDARD AND MINIATURE COMPONENTS

We stock the largest range of components in the country for the home constructor.

WE HAVE
YOUR ITEM
IN STOCK.
Just ask and we will quote competitive prices.

★ RANGER 2 ★

PERSONAL POCKET RADIO

● Two Transistor Two Diode, fully tunable over Medium waves. Good reception of Radio Luxembourg. Size 4⅜ x 3 x 1¼in.

All Parts **59/6** **No extras to buy.**
P.P. 1/6.

● **PICTORIAL PLANS AND DETAILS FREE ON REQUEST**

"BAIRD" RECORD PLAYER AMPLIFIER

★ 2-watt output.
★ Ready built with valves and 8" x 5" speaker, tone and volume controls. Printed circuit.

75/- P.P. 2/-

Ideal for Portable Record Player.

★ UA8 4-speed Record Changer, ideal for above. **£6.19.6.** P.P. 3/6.

SUB-MINIATURE JACK PLUGS and SOCKETS, 3/6 pair.

1 KΩ DYNAMIC MICROPHONE

Hand held or desk stand, complete with screened cable. Excellent response. **49/6.** P.P. 1/-.

★600Ω PERSONAL EARPHONE

with jack plug and socket. **10/6.** P.P. 1/-.

MINIATURE PANEL METERS (D.C.)—Brand new

0/50 microamp	**39/6**
0/500 microamp	**32/6**
0/1 milliamp	**27/6**
Vu meter	**42/6**
"S" meter	**35/-**

TELEPHONE ADAPTOR

★ Ideal for recording telephone conversations. Supplied with screened cable. Fitted rubber sucker. **14/-.** P.P. 9d.

1000 ohm IMPEDANCE MINIATURE PERSONAL EARPHONE

Complete with jack plug and socket **12/6** P.P. 1/-.

CRYSTAL MICROPHONES

ACOS 39-1. Stick Microphone with screened cable and stand (list 5 gns), **32/6.** P.P. 1/6.

ACOS 40. Desk Microphone with screened cable and built-in stand (list 50/-), **15/-.** P.P. 1/6.

ACOS 45. Hand Microphone with screened lead, very sensitive, **25/-.** P.P. 1/6.

100C STICK MICROPHONE with muting switch, detachable table stand, neckcord, screened lead, **39/6.** P.P. **1/6.**

★ **Brand New—Fully Guaranteed** ★

1 WATT TRANSISTOR AMPLIFIER

● EMI 4-Transistor Amplifier with speaker, tone and volume controls. Ready assembled. For use with crystal pick-ups. 6–9 volt operated. **89/6** P.P. 1/6.

BATTERY RECORD PLAYER

● 6–7½ volt Garrard turntable with crystal pick-up. Plays 45 r.p.m. Ideal for above amplifier.

65/- P.P. 1/6.

★**PORTABLE RECORD PLAYER CABINET** for above player & amp. **22/6** P.P. 1/6

TUBULAR LOUDSPEAKER UNIT

Extension portable speaker unit to give big set performance from any transistor pocket radio. Fitted 2 sizes of jack plug. Just plug into earphone socket, **57/6.** P.P. 1/6.

★ CRYSTAL LAPEL MICROPHONE

Ideal for tape recording. Very sensitive.

17/6
P.P. 1/-.

★ LIGHT-WEIGHT 4,000 OHM HEADPHONES,

12/6
P.P. 1/-.

Transistors

We stock a transistor for every need from **3/6** each.

SEND FOR LATEST PRICE LIST

● **1st Grade Fully Guaranteed** ●

WE CAN SUPPLY MOST OF THE COMPONENTS USED ON CIRCUITS PUBLISHED IN THIS AND OTHER MAGAZINES QUOTATIONS BY RETURN

PORTABLE LOUD HAILER

★ Pistol grip action. Special shape horn. Built-in batteries and detachable microphone. Made of lightweight materials. Weight 4 lb. **£14.10.0.**

CRYSTAL MIC. INSERTS

★ ACOS 43-2 2" round, **10/-.** P.P. 6d.
★ ACOS 1½" round, **7/6.** P.P. 6d.
★ 1" square, **3/6.** P.P. 6d.

TAPE HEADS. Wright and Wearite Record and Erase Heads, Type FE7 and FR7. Brand new, **19/6** pair. P.P. 2/-.

PRACTICAL TRANSISTOR CIRCUITS

3/6
Post Free.

Contains easy to follow plans of 40 all transistor units, including light operated switches, amplifiers, transmitters, receivers, test oscillators, signal tracers, hearing aids, radio control, etc. All parts available separately.

● *Designed for the Home Constructor*

★ STEREO AMPLIFIER ★

BARGAIN OFFER

- 2 watts per channel.
- Full tone, balance and volume controls.
- Complete with sockets, dials, etc.

97/6 P. P. 2/6.

Suitable Speakers, 8" x 5", **49/6** pair.
UA14 Stereo Deck, **£8.19.6.** P.P. 2/6.

BATTERY ELIMINATOR AND CHARGER

9 volt charger for pocket transistor radios. Charges PP3 or equivalent to give 5 times life. Runs radio from 200/250 volt mains. Price **29/6,** P.P. 1/-.

ALL TRANSISTOR FM PRE-BUILT UNITS

★ RF Amplifier/OSC stage	**106/3**
★ 10–7 Mc/s IF/Disc-Strip	**119/6**

Uses 5–Transistors; 2–OC171, 3–AF116, 3–OA79. AF output with full AFC and AGC. 6–12 volts supply. Each unit is prealigned and tested.

Henry's Radio Ltd

PADdington 1008/9
5 HARROW ROAD LONDON W2
Open Monday to Sat. 9–6, Thurs. 1 o'clock

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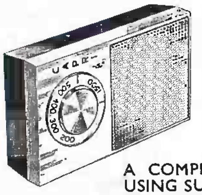
ANNOUNCING A COMPLETELY NEW 6-TRANSISTOR POCKET SUPERHET RADIO

THE "CAPRI" POCKET SIX



Size only 4½ x 2¾ x 1¼in.

REALLY POCKET SIZE!

- ★ Full medium wave tuning—preset light on long wave.
- ★ 6 Mullard transistors and diode.
- ★ Push-pull output.
- ★ Printed circuit construction.
- ★ High flux speaker.
- ★ Fitted earphone/record socket.
- ★ Moulded two-tone cabinet with mesh grille.
- ★ Amazing Performance.

A COMPLETELY NEW SUPERHET DESIGN USING SUB-MINIATURE COMPONENTS AND TRANSISTORS.

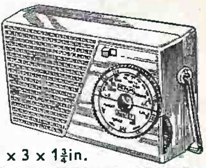
● **Fully Descriptive Leaflet on Request** ●

TOTAL COST OF ALL PARTS **£7.10.0.** P.P. 2/- Battery 2/6 Extra

"QUINTET" (As described in Dec. edition)

MEDIUM AND LONG WAVE POCKET LOUDSPEAKER RADIO

- ● 250mW Push-Pull Output.
- ● Plainly marked Printed Circuit Board.
- ● 5 Mullard Transistors plus Diode Carded Components.



Size 5¼ x 3 x 1¾in.

A new design, fully tunable on both wavebands. Guaranteed reception of Continental and local stations, including Luxembourg, anywhere with full station separation. Fitted Car Aerial and Earpiece Sockets.

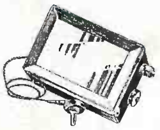
TOTAL COST OF ALL PARTS **£5.10.0** P.P. 2/-. NO EXTRAS TO BUY.

VERY EASY TO BUILD AND USE

You will be amazed by the performance

● **Illustrated Instructions FREE ON REQUEST** ●

3 TRANSISTOR AND DIODE PERSONAL POCKET RADIO



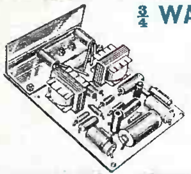
Quality Output on Personal Earphone.

A simple to build local station with personal earphone output. Built-in Ferrite Aerial and Battery lasting 9 months.

Size 4⅝ x 3 x 1¼in.

ALL PARTS **37/6** P.P. 1/6

¾ WATT 4 TRANSISTOR AMPLIFIER



1 watt peak output. ±3dB 70 c/s to 12 kc/s. Output to 3 ohm speaker. 9 volt operated.

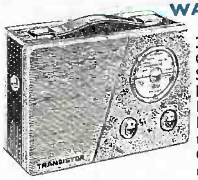
Details on request.

Built and Tested **69/6** P.P. 1/6.

A printed circuit high gain amplifier size 4 x 2¾ x ⅜in using Mullard OC71/OC81D and 2-OC81 Transistors. Ideal for Intercomm., Record Player. Tuner Amplifier or any application requiring a quality and reliable amplifier.

"TRANSFIVE" PORTABLE

MEDIUM & LONG WAVE PORTABLE RADIO



Size 8½ x 6½ x 3½in.

325mW Push-Pull Output on 5" Speaker. Fully illustrated Plans. Easy to Build Printed Circuit. Carded Components. 5 Mullard Transistors.

After Sales Service and Fully Guaranteed

TOTAL COST OF ALL PARTS **£6.19.6** P.P. 2/6. NO EXTRAS TO BUY

● Full coverage on Medium and Long wavebands. Excellent quality with full station separation. Car aerial socket.

● **BUILDING PLANS AND PRICES FREE ON REQUEST** ●

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Send 1/- Stamps for New Illustrated Price Lists

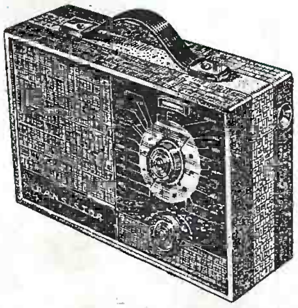
"CONTESSA"

6 TRANSISTOR MEDIUM AND LONG WAVE SUPERHET

★ TERRIFIC SENSITIVITY ★

UNBEATABLE IN PERFORMANCE AND APPEARANCE

COMBINED PORTABLE AND CAR RADIO



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

Descriptive Leaflet on Request.

- ★ 425mW Push-Pull Output.
- ★ 6 "Top-Grade" Ediswan Transistors.
- ★ New Type Printed Circuit with all Components marked.
- ★ Full Medium and Long Wave Tuning.
- ★ High "Q" Internal Ferrite Aerial.
- ★ Car Radio Adaptation and AVC.
- ★ Slow Motion Fingertip Tuning with Station Names clearly marked.
- ★ "Hi-Fi" Quality Speaker.
- ★ Attractive Rexine Covered Cabinet, Red/White or Blue/White.

TOTAL COST OF ALL PARTS **£10.19.6** P.P. 3/6

★ NO EXTRAS TO BUY ★

WITHOUT DOUBT THE "CONTESSA" IS THE FINEST PORTABLE AVAILABLE TO THE HOME CONSTRUCTOR. GOOD LOOKS, QUALITY OUTPUT, AMAZING SENSITIVITY, EASE OF CONSTRUCTION. SIZE 10½ x 8 x 3½ ins.

POCKET IRON

● Pocket Soldering Iron, 220/250V A.C./D.C. 30 watts, complete with mains plug, case, etc. Handle unscrews to cover element enabling iron to be carried in pocket, **18/6.** P.P. 1/-.

LET US QUOTE FOR COMPONENTS FOR YOUR CIRCUIT.

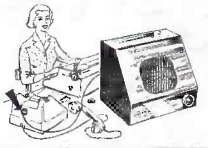
ALL-TRANSISTOR

● TIME SAVER ●

OFFICE OR HOME TELEPHONE PICK-UP AMPLIFIER

★ No more "holding on" wasting time waiting for your call to come through. When it does the amplifier can be switched off if required. **No** connections, just press the pick-up coil to back of phone as below. Fully Guaranteed.

★ **3 months battery life. 400mW output.**



BUILT, TESTED, READY TO USE

£5.10.0

P.P. 2/6

ALSO ALL-TRANSISTOR BABY OR INVALID ALARM **£5.10.0** P.P. 2/6

★ RANGER 3 ★

Size 4⅝ x 3 x 1¼in.

ALL COMPONENTS

79/6 P.P. 1/6

NO EXTRAS TO BUY

Everything Supplied

NO EXTERNAL AERIAL OR EARTH—3-TRANSISTOR and 2 DIODES

Personal Pocket Radio with 5 stages giving clear reception on medium wave, amateur top band and shipping.

- ● Easy to follow instructions with pictorial layout.
- ● Reception of Radio Luxembourg guaranteed (most areas).

Free Instructions and Price List on request. Easy to build.

NEW 'PW' SUPERHET

6-transistor medium and long wave superhet.

- ● Two tone cabinet with gold trim. Size 5¾ x 3½ x 2in.
- ● Push-pull speaker output.
- ● Printed circuit design.
- ● 1st grade components.

Improved circuit and styling of the well known "PW" design.

TOTAL COST OF ALL PARTS **£8.10.0** P.P. 2/6.

All parts sold separately—send for details and prices.