THE Radio Constructor

RADIO
TELEVISION
AUDIO
ELECTRONICS

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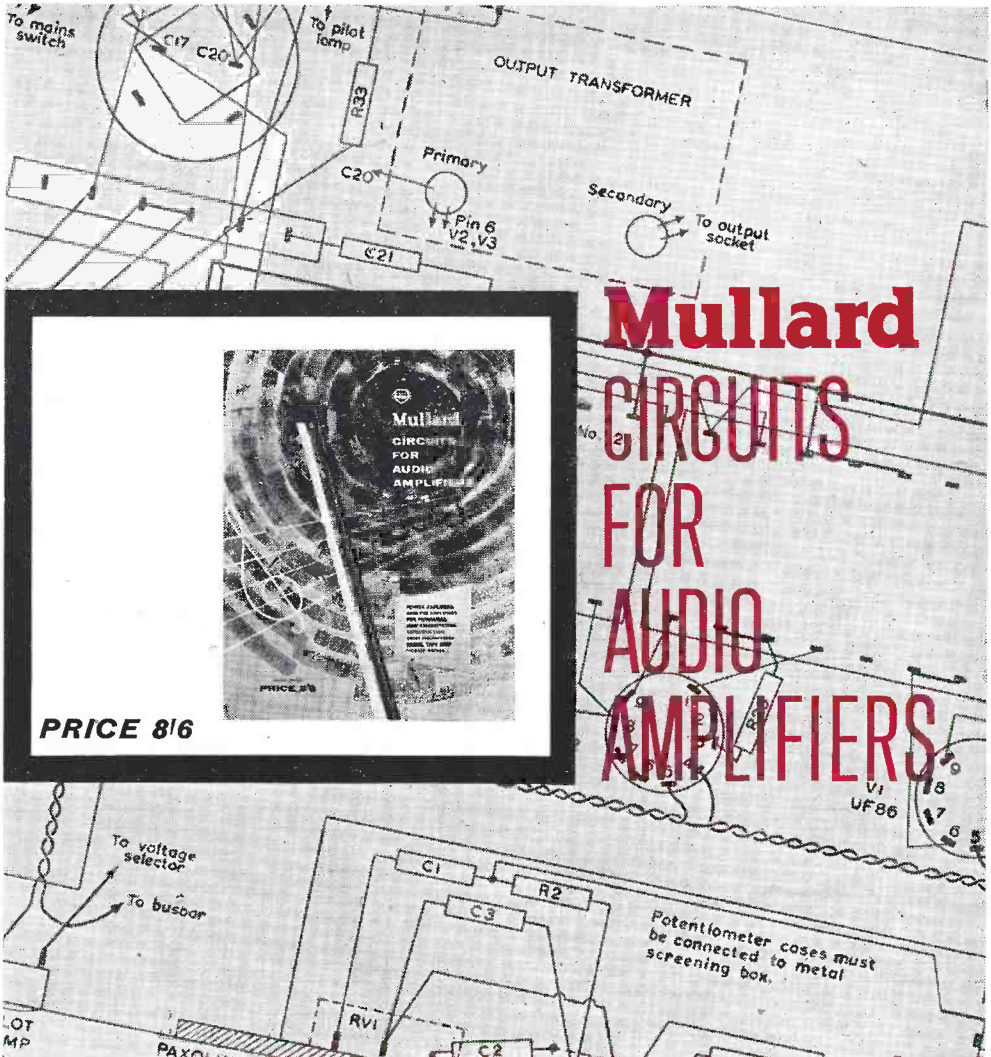
August 1961

Simple Switch Tuned Midget TRF for the Beginner

● Crystal controlled Oscillator for FM Pt.1 ● An Accurate Ohmmeter ● High Impedance Testmeter Converter: Suggested Circuits No. 129 ● Using a Grounded Grid PA Stage for CW or RTTY ● A Bass Reflex Enclosure suitable for the "Axiette" Loudspeaker ● A Constructor's Oscilloscope—a construction of the Mullard Design Pt. 2



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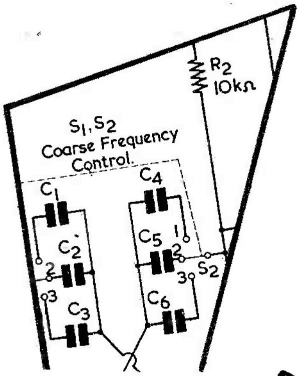

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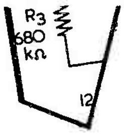


The Circuits presented in this series have been designed by G. A. FRENCH, specially for the enthusiast who needs only the circuit and essential data

No. 129 A HIGH IMPEDANCE TESTMETER CONVERTER

WHILST A MULTI-RANGE VOLTmeter having a sensitivity of 1,000 ohms per volt (i.e. 1mA full scale deflection) is of considerable use in normal servicing and experimental work, it is not capable of accurately reading voltages appearing across high impedance circuits. Also, since the connection of such a meter across a high impedance circuit may modify the functioning of the latter, any readings which are obtained become even less reliable. Several readers who have encountered this difficulty have asked the writer for a circuit which would allow a 1,000 ohms per volt testmeter to read voltages appearing in circuits having source impedances of several megohms, and the writer hopes to meet their requirements in this article.

The circuit published this month depicts a device which can be used for high impedance voltage measurement, and it has the advantage that low tolerance components may be employed throughout. It suffers from the disadvantage that it is not direct reading, since a potentiometer has to be adjusted for each measurement. There is also the disadvantage that, due to its method of functioning, the circuit offers a small inherent error. (The error can be reduced or eradicated by simple changes in components or component values, and this point is discussed later). The writer considers that this month's circuit can be of considerable use where high impedance voltage readings are required only occasionally, and is of particular value when the components needed are already on hand or are cheaply available.

In combination with a testmeter having a sensitivity of 1000Ω per volt (or thereabouts) the circuit enables d.c. voltages from 1.5 to nearly 50 volts to be read. The unknown voltages may be either positive or negative of chassis, and there is no change in reading for source impedances between zero and 10MΩ.

The Circuit

In the circuit, which accompanies this article, it will be noted that two potentiometers are connected across the h.t. supply. One potentiometer, consisting of R_5 and R_6, draws a standing current of 10mA; and voltages ranging from zero to 100 volts positive relative to the h.t. negative rail, can be tapped off by the slider of R_6.

The second potentiometer across the h.t. line is provided by R_3 and R_4, this drawing a standing current of some 22mA. The junction of these two resistors is approximately 50 volts positive of the h.t. negative rail, and it connects to the cathode of the triode via variable resistor R_2. An external voltmeter is connected between the junction of R_3R_4 and the slider of R_6, whereupon it indicates the potential difference between these two points.

The triode is a valve having a short grid base, one section of a 12AT7 being specified in the diagram. In the anode circuit of the triode is connected a meter whose full scale deflection is unimportant provided it can give a reliable indication at an arbitrarily chosen current between 2 and 4mA. The grid of the triode connects to the upper Test terminal via the 1MΩ resistor R_1.

To explain the working of the circuit, it will be helpful to commence with the process involved in setting it up. After the power supply has been switched on the valve is allowed several minutes to reach full operating temperature. R_6 is then adjusted to give zero reading in the external testmeter, the latter being preferably switched to a low voltage range. The Test terminals are next short-circuited and R_2 adjusted until the arbitrarily chosen current flows through the meter in the anode circuit of the triode.

The short-circuit is then removed and the Test terminals connected to the points across which the unknown voltage appears. If this voltage causes the upper Test terminal to go positive, triode anode current will increase. R_6 is then adjusted until triode anode current is, once more, at the arbitrarily chosen level. Under this condition, the grid of the triode will have the same potential relative to the junction of R_3R_4 as it had previously, and R_6 will have tapped off a voltage (relative to that juction) which is equal and opposite in polarity to that applied to the test terminals. The voltage between the slider of R_6 and the junction of R_3 and R_4 is then indicated by the external testmeter, and is equal to the unknown voltage.

The process just described may, perhaps, be more readily followed if a practical example is taken. During the setting up procedure R_6 is adjusted such that zero voltage appears across the testmeter, whilst R_2 is adjusted for the arbitrarily chosen current in the triode anode meter. Let us now assume that the short-circuit is taken off the Test terminals and a 9 volt battery applied with its positive pole connected to the upper terminal. If, now, the slider of R_6 is moved downwards so that it taps off a voltage which is 9 volts negative of the junction of R_3 andR_4, this voltage will be effectively connected in series with the applied 9 volt battery, whereupon the upper Test terminal will once more assume the same potential as it held in the previous short-circuited condition.

In consequence, the triode anode meter will, once more, give the arbitrarily chosen reading, whilst the testmeter will indicate a voltage of 9 which is, of course, that applied to the Test terminals.

When the unknown voltage causes the upper Test terminal to go negative, the slider of R_6 has to be moved upwards to provide a counter-balancing positive voltage and bring the triode anode meter back to its previous reading. Once more, the external testmeter indicates the unknown voltage.

The voltage tapped off by R_6, relative to the junction of R_3R_4, is opposite in polarity to that applied to the upper Test terminal. This fact should be borne in mind when evaluating the polarity of the unknown voltage. If it is remembered that the testmeter terminal connected to the junction of R_3R_4 corresponds in polarity to that on the upper Test terminal, determination of polarity may be readily carried out.

The h.t. supply specified in the diagram is 200 volts at 40mA, but it may, in practice, range from some 180 to 250 volts, the current requirement varying accordingly. It should be noted that the negative supply line has a varying voltage relationship with the "earthy" Test terminal, whereupon care should be taken to ensure that the negative h.t. line is in no way connected to the chassis or to any other point of the equipment under test. If a power supply whose chassis is at h.t. negative potential is used, such a chassis should be well insulated from earth and from the chassis of the equipment under test. The most preferable condition consists of having no chassis connection at all. One side of the triode heater may be connected to the h.t. negative rail.

Points of Design

In a simple device of this nature there is little point in employing close tolerance or expensive components because the circuit is largely self-balancing and the actual voltage readings are provided by a testmeter which is not built into the unit.

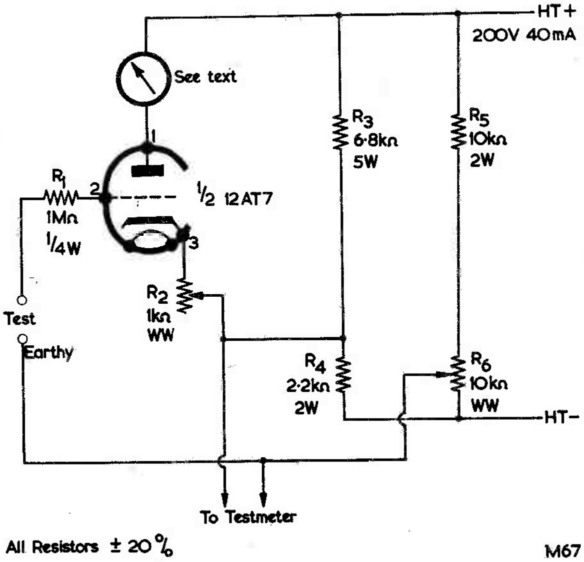
The triode employed needs to have a short grid base in order that small changes in grid voltage cause relatively large changes in anode current, thereby providing a reasonably high degree of resolution in readings. One section of a 12AT7 provides an excellent choice, but equally good results would be given by a single triode or triode-strapped pentode having similar characteristics. When the 12AT7 is used, the electrodes of the unused section may all be strapped to the cathode of the triode in use.

The inherent reading error in the circuit referred to earlier is caused by the fact that the testmeter draws current from the potentiometer given by R_3R_4. This current causes shifts in the potential at the junction of these two resistors, with consequent inaccuracies in the final reading provided. The standing current in R_3R_4 is approximately 22mA, with the result that a 1,000 ohms per volt testmeter at f.s.d. could cause the voltage at their junction to shift by nearly 5% from the potential given on initial setting up. This inaccuracy of reading will, of course, reduce by a proportional amount when the testmeter gives a reading lower than f.s.d. The inaccuracy may be halved by doubling the current flowing through the potentiometer R_3 and R_4; in which case suitable practical values (to the nearest preferred figure) for these two resistors would be 3.3kΩ 10W and 1kΩ 4W respectively. These new values would naturally cause an increase in h.t. current requirements. A much neater method of tackling the problem would consist of replacing R_3 with a VR150/30 regulator valve. In this case the source of inaccuracy would be eliminated, but it would be necessary to ensure that the applied h.t. potential remained close to the nominal value of 200 volts. (Alternatively, the h.t. potential could be made 225 to 250 volts, R_6 replaced by a 15kΩ potentiometer, and R_4 replaced by a VR75/30 regulator.)

The testmeter also draws current from the potentiometer R_5R_6, but this effect is unimportant.

It was found, with the prototype, that different 12AT7 valves showed characteristics which varied fairly widely when used in the present circuit. Because of this, the arbitrary current in the meter in the triode anode circuit is best chosen experimentally, and a figure lying between 2 and 4mA should be adequate in practice. Any instrument capable of indicating the desired current reliably may be employed, and a good choice would be given by a 0-10mA meter. With such a meter there is little risk of overload if positive voltages are momentarily applied to the grid of the valve, maximum anode current normally being of the order of 15mA.

Circuit of the high impedance test-meter converter



The 1mΩ resistor R_1 limits grid current to a safe value for positive voltages within the range of the circuit. It was found with the prototype that contact potential in the valve kept anode current at a low level when the grid circuit was open. If it is found that anode current is excessive when the grid circuit is open the upper Test terminal may be connected to the junction of R_3R_4 via a 10 or 20MΩ resistor. The inclusion of such a resistor will, however, introduce errors when the source impedance of the unknown voltage is high.

The long term stability of the circuit will be poor, as no attempt has been made to regulate power supplies or to counteract long term drift in the triode. For short term operation the device should give good results provided that mains supply voltages are steady, since it may be set up at zero voltage immediately before readings are taken.

Construction

The construction of the circuit should raise very few problems as there are hardly any precautions to observe in the layout. Reasonable ventilation will be necessary for R_3, R_4, R_5 and R_6, and the grid circuit of the triode should be kept will away from wires carrying a.c. voltages.

The insultation of the upper Test terminal needs to be of a high order, as also does that at the valveholder. The latter should be a moulded type. R_1 is best mounted by its lead-out wires between the upper Test terminal and the triode grid pin, tagstrip mounting for this component being avoided.

Results with the Prototype

A prototype was made up to the circuit, and it was found that the triode required some two to three minutes to reach full operating temperature, shifting only slightly in the following twenty minutes. The setting up process was simple to carry out although there was a slight interdependence between the settings of R_2 and R_6, this necessitating several successive adjustments if R_2 was initially a long way from its correct setting. This interdependence was due to the meter current drawn from R_3R_4.

After setting up, readings were taken from dry batteries offering voltages ranging from 30 to 1.5. The readings given were satisfactory within the error limits to be expected, but a little care had to be taken with the 1.5 volt reading because of the consequently low variation in triode anode current. In each instance a 10MΩ resistor was inserted in series with the lead from the upper Test terminal, no difference in triode anode current being detectable when this was short-circuited. There were, however, changes in anode current when a 20MΩ series resistor was substituted for the 10MΩ component; and it was decided that the maximum source impedance with which the device would give satisfactory results should be stated, in consequence, as being 10MΩ.

NEW VALVES
for stereo output

By J. B. DANCE, M.Sc.

In the past all stereophonic amplifiers have been fairly large for the reason that even the smaller designs required two output valves (one for each channel), whilst the larger push-pull stereo amplifiers required a total of four output valves.

In order to reduce the number of separate valves required in such equipment and to keep costs to a minimum, a small double pentode known as the ELL80 having a noval (B9A) base has been introduced. The ELL80 is available from Brimar Ltd. A single valve of this type can be employed as the output stages of both stereo channels in an amplifier providing a power output of some 3 watts per channel. It is therefore especially suitable for use in economical stereo amplifiers which must be small and reasonably portable for domestic use. An ELL80 may also be used to provide a class AB1 push-pull output stage for monaural amplifiers, whereupon a power output of 8.5 watts is available.

Three Valve Stereo Amplifier

The circuit of one channel of a compact stereo amplifier using only two valves plus rectifier for a.c. mains operation accompanies this article.[1] The circuit of the other channel is identical. The components marked a and b in Fig. 1 must be duplicated for the two channels, but the other components (e.g. the cathode bias resistor and condenser in the ELL80 circuit) need not be duplicated, they being common to both channels. The power supply circuit is also common to both channels.

The input voltages are amplified by the 12AX7 high gain double triode. One half of this valve is used in each stereo channel. The signals then pass via the RC couplings to the ELL80 double pentode; one half of this valve is also in each channel. Negative feedback is used in both channels. It is taken from the output transformer secondaries and is applied to the cathode circuits of the 12AX7 by means of the potential dividers $R_{4\,a\ and\ b}$, and $R_{1\,a\ and\ b}$. The rectifier is an EZ80.

Controls

The ganged volume control, $VR_{1\,a\ and\ b}$, alters the gain of both channels simultaneously. The ganged potentiometer, $VR_{2\,a\ and\ b}$, can be used to provide a top cut of up to 18dB at 10 kc/s simultaneously in both channels. The balance control, VR_3, enables the relative gain of the two channels to be altered by about 5dB.

The amplifier can also be used to provide approximately three watts of audio output from a monaural input. By means of the switch SW_{1a} and SW_{1b}, both channels can be operated in parallel (monaurally) from either input socket.

Performance

The amplifier gives its maximum power output of 1.5 watts per channel at 3.5% total harmonic distortion with an input of 150mV r.m.s.; it is thus suitable for use with a high output pick-up head. The frequency response is level to within 3dB from 50 c/s to well above the highest audio frequencies. The hum and noise is 55dB below the full output and "cross-talk" between channels is very small. The amount of negative feedback is 6dB.

[1] This circuit is reproduced from *Circuit Application Report on Brimar Three Valve Stereo Amplifier*, published by Brimar Ltd.

TABLE

	Half 6DY7 Class A	Single 6DY7 Class AB1	Single 6DY7 Class AB1
Anode Voltage	250	250	400
Screen Voltage	250	250	250
Input Volts, peak	12.5	16	20
Plate Current (zero signal) .. .. mA	50	77	58
Screen Current (zero signal) .. .. mA	3	3.5	1.7
Load Resistance .. .. .. ohms	5k	9k	14k
Output Power .. .. watts	5	11	20
Total Harmonic Distortion .. .. %	9	2.5	2

Typical Operating Conditions for Type 6DY7

The 6DY7 Valve

In America, the Sylvania Company has evolved a high performance double tetrode known as the 6DY7. A single 6DY7 used as the output stages of a stereo amplifier will supply up to 5 watts of audio per channel. The 6DY7 has an octal base. Whilst this valve has been especially designed for use in stereo equipment, a single valve of this type is also very useful in push-pull monaural amplifiers, giving a low distortion and a high power output. (See Table.)

Frame Grids

The wires of both the control and screen grids of the 6DY7 are mounted on rigid rectangular frames under slight tension. This type of construction enables the dimensions (especially the cathode-grid spacing) to be controlled much more accurately than in conventional valves in which the grid wires help to keep the grid side wires in position. This results in closer tolerances in the characteristics from valve to valve and renders changes of the characteristics small during the life of a valve even at high power dissipations. Such close tolerances are important in this type of valve because it is obviously not possible to select well matched pairs of valves for a push-pull stage when the two valves are enclosed in one envelope.

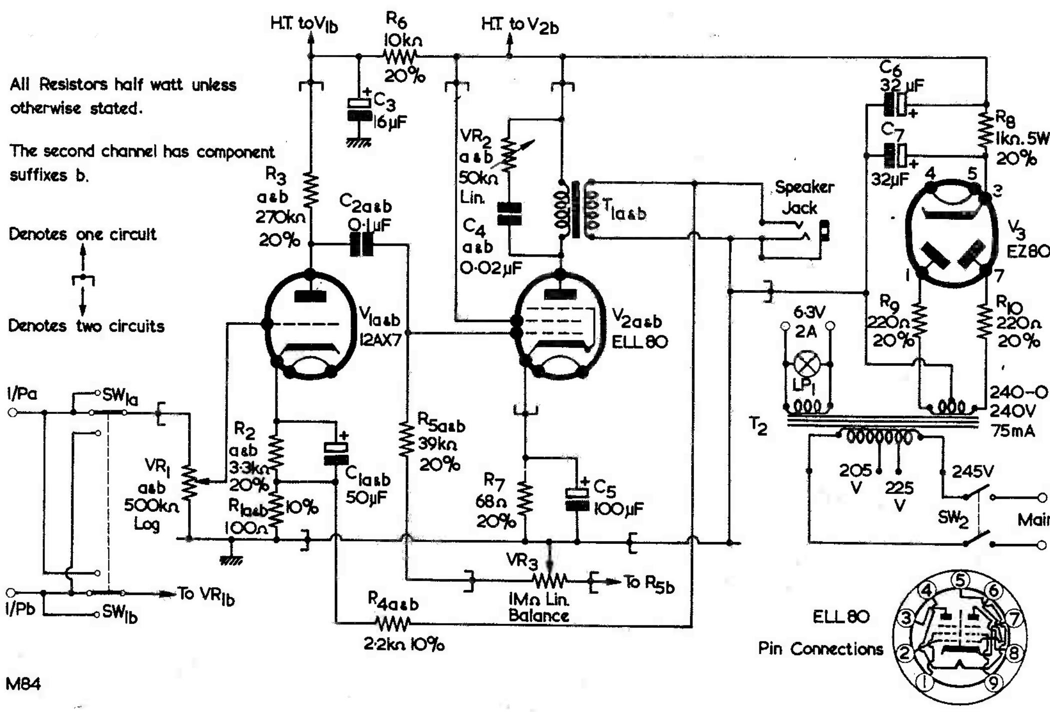


Fig. 1. Circuit diagram (one channel). Mains transformer: G.B. Electric type GB2553. Output transformer: G.B. Electric type GB2551.

In the 6DY7 the grid wires are exactly perpendicular to the sides of the frame. The diameters of the control and screen grid wires are carefully chosen and the grids are aligned during manufacture so that virtually the whole length of each screen grid wire is "in the shadow" of the control grid wire as far as the electron beam is concerned; this achieves excellent anode to screen current ratios. (See Table)

The control grid of conventional valves does not always exert full control near cut-off, as electrons tend to slip through at each end of the grid near the mica supports. This is effectively prevented in the 6DY7 by the top and bottom of the frame of the control grid. The frames of the grids also serve as heat sinks, helping to cool the grids and thus preventing any change of characteristics due to expansion of the grid wires.

A single cathode is employed and the two screen grids have a common base connection in order to limit the number of external connections to eight in order that an octal base can be used. In fact the construction of the valve is similar to a single beam tetrode in which the two sides of the control grid are electrically insulated from each other, as are the two sides of the anode.

The type of grid used is known as a "Framelok" grid and is very different from the frame grids described in the October 1960 issue of *The Radio Constructor*.[2]

Practical Uses

The following examples illustrate the versatility of the 6DY7 in practical circuits.

1. A single 6DY7 can be used as a power amplifier for two stereo channels. Under the operating conditions shown in the table for a single section of the valve, the power output is 5 watts per channel at 9% total harmonic distortion. The distortion would, of course, be vastly reduced in a practical circuit by the use of negative feedback. Measurements have indicated that cross modulation between the sections of the valve is about 50dB below signal level at full output.
2. A single valve can be used as a push-pull monaural amplifier in class AB_1 under either of the sets of operating conditions shown in the table. If an anode voltage of 400 is employed, outputs of up to 20 watts of audio at a total harmonic distortion of 2% may be obtained.
3. Two 6DY7's may be employed in a stereo amplifier with push-pull outputs. Audio outputs of up to 20 watts per channel can be obtained with this arrangement.
4. Two 6DY7's may be used in a parallel push-pull monaural amplifier providing up to 40 watts of audio output at about 2% distortion.

Conclusion

The use of the ELL80 and the 6DY7 will reduce the size of amplifiers, especially stereo amplifiers, and reduce the number of components, cost of wiring, etc.

Further details of the 6DY7, including circuits, are given in *Transactions I.R.E. on Audio*, Vol. AU7 (1959), No. 4, page 101.

Details of the ELL80 are available from Brimar Ltd., Footscray, Sidcup, Kent.

[2] J. B. Dance, M.SC., "The New Frame Grid Valves", *The Radio Constructor*, October 1960.

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

R1392 Receiver.—S. Hawley, 3 Elm Road, Hollins, Oldham, Lancs., would like to hear from any reader who has modified this v.h.f. receiver for continuous coverage over its complete frequency range.

* * *

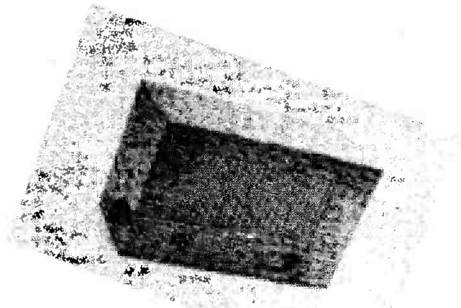
AVO All-Wave Oscillator.—J. Brookes, 1 Dean Street, Blackpool, Lancs, would like to obtain the operating instructions and any information of modifications to this instrument.

U.S. Navy Receiver CNA46081.—S. Smith, 19 Hyde Road, Kenilworth, Warwickshire, urgently requires the circuit or any other information on the equipment.

* * *

American Command Receiver R-19.—R. Livsey, 39 Welford Road, Shirley, Solihull, Warwickshire, asks if any reader can supply the circuit diagram and modification or conversion details of this 28V receiver. (118–148 Mc/s).

Cover Feature



A Simple

Switch Tuned Midget TRF for the Beginner

By V. E. HOLLEY

THIS RECEIVER IS SIMPLE BOTH IN DESIGN AND CONstruction and can be tackled with confidence by the beginner. It reproduces the B.B.C. Light and Home programmes at good quality and, if housed in the simple well-finished cabinet to be described, will make a useful domestic set. Assuming that all the parts have to be purchased, it can be built for approximately £5.

Circuit

Fig. 1 shows the circuit. Switch tuning is employed for simplicity and economy, the coils L_1 and L_2, which receive signals from the aerial, are tuned by means of their dust cores to the required frequencies. The fixed condensers connected across them, of which more will be said later, are chosen according to the stations it is desired to receive. S_1 and S_2 are two poles of the 2-band, 4-pole, Yaxley switch $S_{1, 2, 3, 4}$. The signal from the appropriate coil is presented, via the switch, to the grid of the r.f. amplifier valve V_1. In the cathode circuit is the potentiometer VR_1, by means of which the bias can be varied to control the gain of the stage, and the fixed resistor R_2 which ensures that the bias is not reduced below the proper minimum. The range of control obtainable with VR_1 alone is insufficient to reduce the volume of the receiver to zero, but the addition of R_3 between VR_1 and the h.t. positive

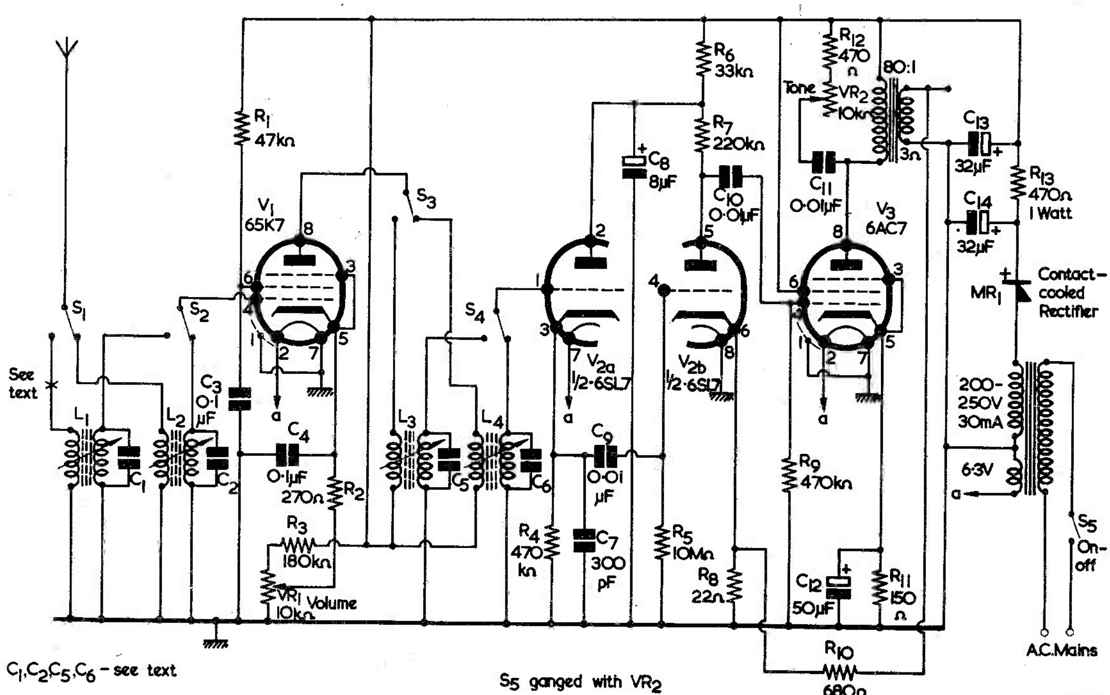


Fig. 1. Circuit of the switch tuned midget t.r.f. receiver

line brings about the desired result. The amplified signal at V_1 anode is carried via the switches S_3 and S_4 and the appropriate coil to the grid of $V_{2(a)}$. The coils L_3 and L_4 being tuned in the same manner as L_1 and L_2.

Detector

One half of a 6SL7 is employed as an infinite impedance detector, the high value of cathode load resistor, R_4, ensuring maximum detector efficiency. The impedance presented to the tuned circuit by this detector is very high indeed. Thus, full advantage can be taken of the high Q of the coils and good selectivity is obtained. The audio output is taken from the detector cathode, and condenser C_7 bypasses the unwanted radio frequencies.

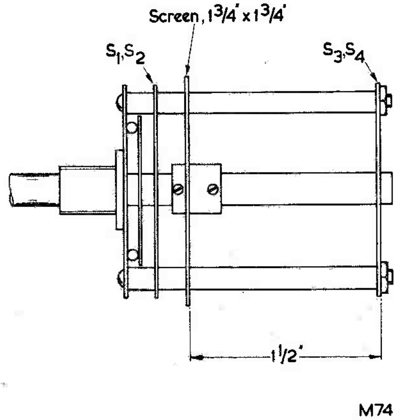


Fig. 2. The tuning switch

A.F. Stage

The other half of V_2 is used as a resistance coupled a.f. amplifier with an anode load of 220kΩ. Decoupling and additional smoothing are provided by R_6 and C_8, the latter also serving to decouple the anode of $V_{2(a)}$. Bias is obtained by the grid leak method, thereby dispensing with the bias electrolytic condenser which would otherwise be required in the cathode circuit. The 22Ω resistor in this circuit (R_8) is solely to provide a point for injection of voltage negative feedback.

Output Stage

This uses a valve type 6AC7, which is a very high gain pentode with the additional merit of being available cheaply. It is not a recognised output valve type, but will perform very satisfactorily in this role, producing adequate volume for ordinary listening. The output transformer has a ratio of 80:1 for a 3-ohm speaker and across its primary is connected the tone control network VR_2, R_{12} and C_{11}. The values of these components give a good range of control.[1] The mains switch is incorporated with VR_2.

Negative Feedback

Negative feedback, taken from the secondary of the output transformer to the cathode of $V_{2(b)}$,

[1] Theoretically, the tone control circuit should not be included in the negative feedback loop, as occurs here. In this receiver, however, the degree of feedback is not high and the circuit produces satisfactory results in practice.

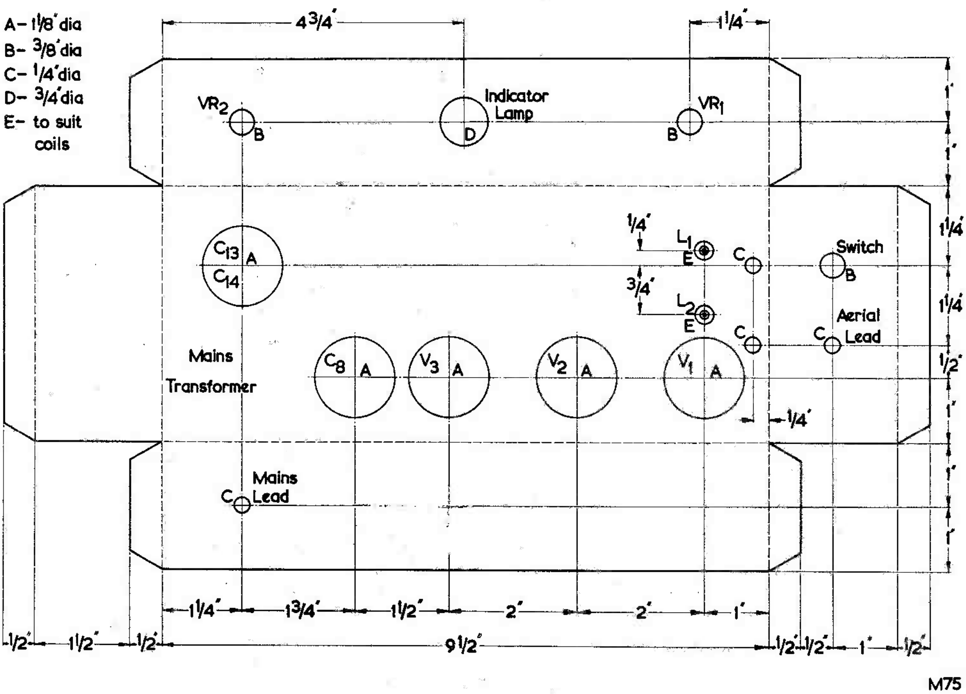
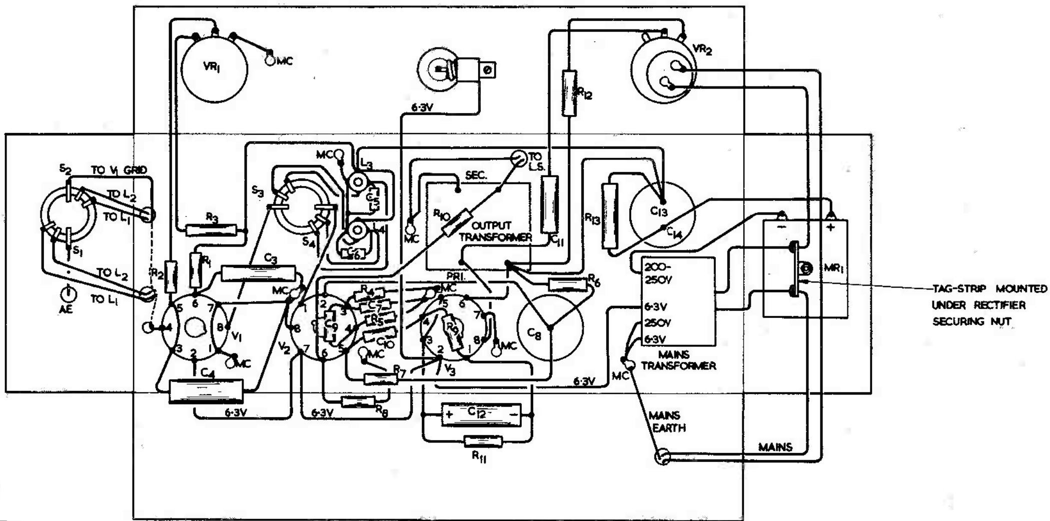


Fig. 3. Chassis dimensions



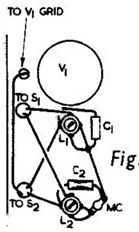


Fig. 4. Under-chassis wiring details

Fig. 5. (Inset.) Above-chassis coil wiring details. (It should be noted that the connections to the coils are those employed in the prototype. Alternative components may have different tag layouts.)

M76

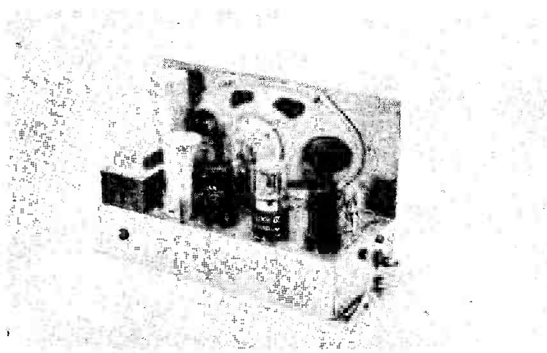
improves the response of the receiver and reduces the residual hum to inaudibility. The value of R_{10} will depend to some extent on the characteristics of the output transformer and some trial and error may be found necessary. With the prototype, it was found that it could be varied between 100 and 1,000Ω without encountering any instability.

Power Supply

The receiver is designed to operate from a miniature mains transformer of the type used in television converters, etc., and having secondaries of 200–250V at 30mA and 6.3V at 1.1A, minimum.[2] Rectification is by contact cooled rectifier and smoothing is provided by C_{14}, R_{13} and C_{13}. The value of R_{13} should be adjusted according to the output of the transformer so that the h.t. line voltage of the receiver lies between 200 and 240V. The value shown in Fig. 1, viz., 470Ω, is suitable for a transformer having a 200V secondary. The power consumption of the receiver is about 15 watts only, heat generation being negligible.

Components

The tuning switch should have its wafers spaced about $1\frac{3}{4}$in apart and a light aluminium screen is advisable between them. Fig. 2 shows the arrangement. If a switch of this type cannot be found, an ordinary one is easily modified with the aid of longer bolts and spacers, the operating spindle being extended by means of a brass coupler and a length of $\frac{1}{4}$in rod on which two flats have been filed to fit the wafer. Apart from this, no special components are required and the constructor can make use of whatever he has available; there is plenty of room in the chassis. VR_1 should preferably be wirewound but most carbon track components will perform satisfactorily. L_1 and L_3 are the Medium wave coils; L_2 and L_4 are the Long wave coils. If these are matched pairs, alignment will be simplified, but it is not essential. Provision can, of course, be made for receiving additional transmissions by using a switch with more than two positions and adding the necessary coils.



Rear view of the Midget T.R.F. Receiver

Construction

Fig. 3 gives a plan of the chassis, $9\frac{1}{2}\times4\times2$in on

[2] 1.35A minimum if the indicator bulb consumes 0.3A.

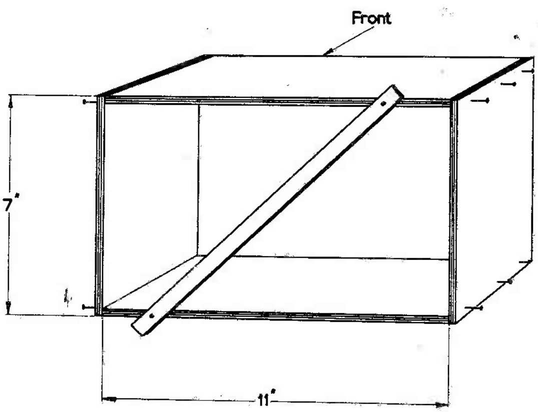
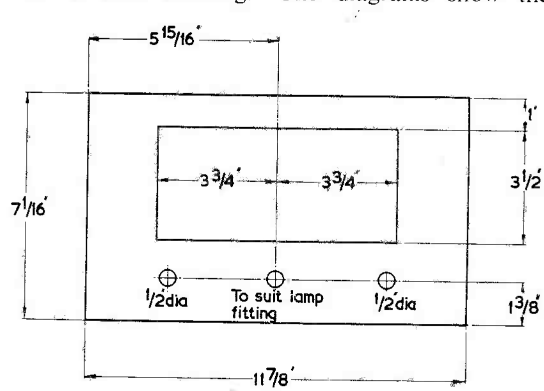


Fig. 6. Method of assembling the cabinet M77

which the receiver is built. It may be of 18 s.w.g. aluminium sheet. Construction may proceed in any desired order except that VR_1 must be fitted before the tuning switch. The contacts on the first wafer of the switch are inaccessible when it is fitted in the chassis and therefore three or four inches of wire should be soldered to each beforehand. The use of different colours for these will make them easy to identify afterwards. The 7×4in elliptical speaker is mounted on a piece of $\frac{1}{8}$in hardboard, $9\frac{1}{2}\times 6$in in which suitable holes have been cut for speaker and indicator lamp, this being bolted to the front of the chassis. Some support at the rear will be required and this may be arranged by means of an aluminium bracket between the speaker and the chassis; the exact method adopted will depend on the construction of the speaker.

Wiring

Complete details of the wiring are given in Figs. 4 and 5. Flexible p.v.c. wire is recommended for the heaters, and 22 s.w.g. tinned copper for the remainder, lengths of more than an inch or so being covered with sleeving. The diagrams show the



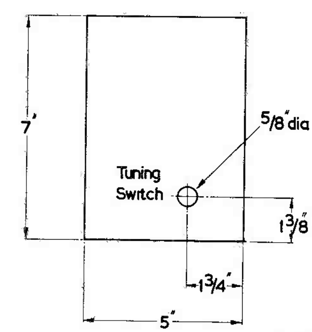
M78

Fig. 7. Front of the cabinet. Overall measurements allow $\frac{1}{16}$in for trimming. (The width of the panel assumes $\frac{3}{8}$in wood in Fig. 6)

wiring opened out for clarity; in the actual construction, the connections should be made as short as possible. Note that the connection to the signal grid of V_1 passes through the chassis immediately after the grid so that it is well screened from the anode lead.

Testing

When all the wiring has been completed, a check should be made with a meter between C_{14} and chassis to see that there are no short-circuits in the h.t. wiring. If all is well, the power can be connected and the h.t. line voltage measured. It should be between 200 and 240V and, if not, it must be brought within this range by altering the value of R_{13}.[3] If instability is found as the set warms up, it will almost certainly be due to incorrect connection of the feedback circuit and will disappear if the connections to either the primary or secondary of the output transformer are reversed. An aerial can now be connected and with the tuning switch in the Long wave position, it should be possible to tune in the Light programme by manipulating the cores of L_2 and L_4. The switch can then be turned to



M79

Fig. 8. Left-hand side of the cabinet

the Medium wave position and, if the choice of values for C_1 and C_5 is about right, the required Medium wave programme can be similarly tuned in. If not, it will be necessary to find the right values and some trial and error will be required. The average Medium wave coil will tune to 1,500 kc/s with 33pF, about 1,000 kc/s with 100pF and around 800 kc/s with 200pF. Exact tuning of the coils is best achieved by reducing the volume to the lowest audible level so that the effect of small adjustments is readily noticeable. It should be noted that the tuning of L_1 is affected by the aerial capacity and the final adjustment should therefore be made using the aerial to which the set is to be permanently attached. This effect is unimportant on the Long wave band.

Interference

The selectivity of the receiver is above average for

[3] If it is found necessary for R_{13} to have a value of 1.5kΩ or more, its rating should be increased to 2 watts.

Components List

Resistors (¼W unless otherwise stated)

R_1	47kΩ ½w
R_2	270Ω
R_3	180kΩ ½W
R_4	470kΩ
R_5	10MΩ
R_6	33kΩ
R_7	220kΩ
R_8	22Ω
R_9	470kΩ
R_{10}	680Ω (see text)
R_{11}	150Ω
R_{12}	470Ω
R_{13}	470Ω 1W (see text)
VR_1	10kΩ
VR_2	10kΩ

Valves

V_1	6SK7
V_2	6SL7GT
V_3	6AC7

Switch

S_1, S_2, S_3, S_4 4-pole, 2-way, 2-bank

Speaker

7×4in elliptical, 3Ω

Coils (all have adjustable iron-dust cores)

L_1	Medium wave aerial coil
L_2	Long wave aerial coil
L_3	Medium wave r.f. coupling coil
L_4	Long wave r.f. coupling coil

(The coils employed in the prototype are from the Repanco range, as follows: L_1 RA2; L_2 RA1; L_3 RHF2; L_4 RHF1.)

Condensers (350V wkg. unless otherwise stated)

C_1	As appropriate, silver mica
C_2	270pF, silver mica
C_3	0.1μF, paper
C_4	0.1μF, paper
C_5	As appropriate, silver mica
C_6	270pF, silver mica
C_7	300pF, silver mica
C_8	8μF, electrolytic
C_9	0.01μF, paper
C_{10}	0.01μF, paper
C_{11}	0.01μF, paper
C_{12}	50μF, electrolytic, 12V wkg.
C_{13}	32μF, electrolytic
C_{14}	32μF, electrolytic

Rectifier

Contact cooled, 250V, 40–50mA

Indicator Bulb

6.3V, 0.04A

(A bulb consuming 0.3A may be used if the mains transformer heater winding provides 1.35A minimum)

Output Transformer

80:1

Mains Transformer

Drop through type, secondaries 200–250V, 30mA, half-wave. 6.3V at 1.1A (see note above)

Cabinet

Small quantities of ⅜in plywood and laminated plastic

a t.r.f. In less favourable reception areas however interference may be experienced on the Medium wave band, during darkness, from an adjacent transmitter. A parallel tuned rejector wave trap, inserted in the Medium wave aerial circuit at point X in Fig. 1, is a most effective remedy. It may consist simply of a coil similar to L_1, tuned by a similar capacity and can conveniently be mounted alongside L_1 on the chassis. The unused primary winding should be left unconnected. Tune in the wanted station accurately during daylight on L_1 and adjust the wave trap after dark for minimum response from the interfering transmission. Mains-borne interference can be greatly reduced by an earth connection.

Cabinet

A cabinet of professional appearance in which to house the receiver can be made quite easily with only the simplest tools. Suitable material is 5-ply wood, ⅜in thick. Cut two pieces 11×5in for the top and bottom and two more, 7×5in, for the sides. They should be cut as accurately as possible so that the minimum subsequent attention is necessary to make them square and true. Assemble them temporarily as in Fig. 6, using two or three 1in panel pins or thin nails, driven halfway home at each corner, and nail a diagonal temporarily across what will be the back of the cabinet in order to maintain a true rectangular shape. The front is cut from hard laminated plastic of the type used for covering kitchen surfaces. This material, less than $\frac{1}{16}$in thick, is available in a wide variety of colours, patterns and finishes, and offcuts can be purchased very cheaply. An imitation wood grain was used for the prototype, but a pattern can be selected to match, for instance, the decor of the room in which the set is to be used. Place the plywood assembly front down on the "wrong" side of the laminated plastic and mark out the front. Transfer the lines to the "right" side and cut out the front so that it will be flush at the bottom of the cabinet but will project $\frac{1}{16}$in at the top and sides; then prepare it as in Fig. 7. Laminated plastic must be cut, drilled and filed from the faced surface and the best results are obtained, somewhat naturally, with sharp tools. A rectangular aperture for the speaker is preferred so that the edges can be trued up easily with a file. Curves are rather tedious to trim.

Assembly

The plywood should now be dismantled and a ⅜in hole made in the left-hand end for the tuning switch. The joints should then be coated with a good casein glue and reassembled permanently, the diagonal again being used to maintain shape until the glue is hard. The front can then be affixed with the special adhesive sold for use with laminated plastic. This is a powerful impact adhesive and it is essential to see that the surfaces to be joined are brought together in exactly the right position at the first attempt. Set aside for hardening.

Finishing

The top and sides should now be sanded off with No. 2 glasspaper to remove any projections and they can then be covered with laminated plastic. Start with the top. Cut the material very slightly longer than the cabinet to allow for trimming off, and ⅛in wider so that it will fit closely up against the front and will project ⅛in at the rear. This projection will form a rebate into which the back of the cabinet can be fitted. When firmly fixed, the top must be trimmed flush at each end with a sharp file.

The sides can then be dealt with similarly, again cutting the material ⅛in wider than the cabinet. Remember to make a hole in the left-hand side for the tuning switch. It is now advisable to allow 24 hours for the adhesive to become thoroughly set, after which the cabinet can be trimmed all round the front and along the top edge of each side. A piece of ⅛in ply or hardboard is required for the back and there should be ventilation holes at top and bottom and openings for the mains and aerial leads.

Fitting the Receiver

Glue a piece of suitable fabric over the speaker aperture and insert the lens of the indicator lamp into the hole provided. Cut off the tuning switch spindle so that its length is reduced to ½in, slide the receiver into position and mark underneath the cabinet the positions of the chassis end flanges. Drill a hole through the bottom at each end, countersink it and make corresponding holes in the chassis flanges. Secure the receiver with 4BA bolts or self-tapping screws; the latter are more convenient. Fit a brass coupler to the sawn-off portion of the switch spindle, pass it through into the cabinet and secure to the switch. Complete the job by glueing a piece of felt to the bottom of the cabinet so that it will not mark polished surfaces on which it may stand. Remember to make holes in the felt for access to the securing bolts.

Mullard Films Preserved

The National Film Archive, a department of the British Film Institute, which preserves in the national interest films of historic and artistic value, has selected no less than five Mullard films for preservation. These are: *Conquest of the Atom* (made in conjunction with the Educational Foundation for Visual Aids) (Colour, 22 mins.); *Manufacture of Junction Transistors* (Black/White, 21 mins.); *Mirror in the Sky* (made in conjunction with the Educational Foundation for Visual Aids) (Black/White, 22 mins.); *Ultrasonics* (Black/White, 21 mins.); *The Manufacture of Radio Valves* (Black/White, 22 mins.).

Mirror in the Sky and *Conquest of the Atom* have both gained premier awards at the Harrogate Festival of Films in the Service of Industry, and the latter also won a gold award for Educational Films at the first International Festival of Films for Television.

"I SAY, ISN'T THAT A SPELLING MISTAKE ON THIS PRINTED CIRCUIT?"

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

part I

understanding radio

By W. G. MORLEY

TO UNDERSTAND RADIO IT IS FIRST OF ALL NECESSARY to understand the basic principles of electricity. These we shall now consider by examining atomic structure and the nature of electric current.

Matter

All substances are made up of *molecules*, these representing the smallest amount of any substance which retains its individual characteristics. Thus, if it were possible to divide a substance such as sodium chloride (common salt) into smaller and smaller portions we would eventually arrive at single molecules. These molecules could not be further divided whilst retaining the properties of sodium chloride.

Molecules are, in their turn, composed of *atoms*. Thus, a molecule of sodium chloride may consist of an atom of sodium and another of chlorine. Atoms are the smallest parts of matter which may enter into chemical combination, or which may be separated by chemical means.

The two substances just mentioned, sodium and chlorine, are *elements*. There are some 101 different elements known to science which, on their own or in combination with one another, form all the matter existing on Earth. These elements include hydrogen, copper, sulphur, carbon, silver, and many others which are generally familiar to us. When elements combine together the result is known as a *compound*. Thus, sodium chloride is a compound.

Atomic Structure

The structure of an atom varies with different elements, but it consists basically of a *nucleus* around which one or more particles called *electrons* travel in orbit. Electrons carry a negative charge of electricity. The nucleus contains one or more *protons*, each of which has a positive charge of electricity equal to the negative charge of electricity held by an electron. Normally, an atom has the same number of protons in its nucleus as it has electrons orbiting around that nucleus. In consequence, the overall electrical charge held by the atom is zero, since the charges of electrons and protons cancel each other out. Also to be found in the nucleus are *neutrons*. Neutrons have no electrical charge.[1]

Elements differ from each other in the number of protons contained in the atom nucleus. The hydrogen atom, for instance, has one proton only, the helium atom has two, and the lithium atom has three. A typical element having a larger number of atom protons is given by copper, with twenty-nine.

The orbiting of electrons around the nucleus is somewhat similar to the orbiting of man-made satellites around the Earth. The satellites orbit around the Earth instead of flying away from it because of the gravitational attraction between the two bodies. Electrons orbit around the nucleus because of the *electrical* attraction between the two bodies. This electrical attraction is due to the fact that *unlike electrical charges attract each other*. The electrons are attracted towards the nucleus because the latter has a positive charge. The reverse of this state of affairs also holds true, in that *like electrical charges repel each other*. Thus, one electron repels another electron because they both have a charge of the same type.

Electrons orbiting around the nucleus tend to fall into a particular pattern. Fig. 1 (*a*) shows an atom having a nucleus with one positive charge (i.e. one proton) and one electron orbiting around it, whilst

[1] Two further particles, the meson and the neutrino, have been recently discovered in the nucleus. These have no significance in the present simplified explanation.

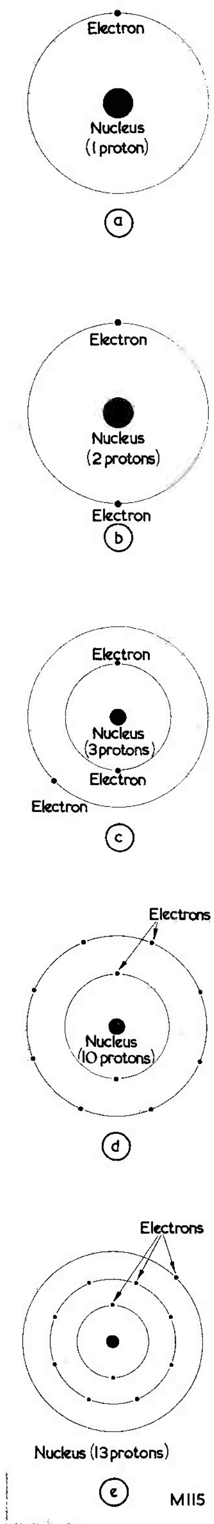


Fig. 1. Illustrating, in extremely simplified form, the "shells" around the nucleus of an atom as the number of protons and electrons increases. In (b) the second electron occupies the same shell as the single electron of (a). The third electron in (c) occupies a new shell because the innermost shell is "full" when it contains two electrons. The second shell is "full" when it contains eight electrons, as in (d); and an eleventh electron, shown in (e), causes the appearance of a further shell

Fig. 1 (*b*) illustrates another atom having two positive charges in its nucleus and two electrons. The two electrons of Fig. 1 (*b*) maintain the same distance[2] from the nucleus as does the single electron of Fig. 1 (*a*). If we carry on to an atom having three protons in its nucleus, as in Fig. 1 (*c*), a pronounced change occurs. Two of the electrons orbit around the nucleus in the same manner as those of Fig. 1 (*b*), but the third electron takes up an orbit considerably further removed from the nucleus. Continuing with the process we encounter, in Fig. 1 (*d*), an atom containing ten ptotons. The ten electrons take up the positions shown. Two orbit close to the nucleus, as did those of Fig. 1 (*b*), whilst the remaining eight orbit at the same increased distance as did the third electron in Fig. 1 (*c*). Adding yet another proton and electron to the atom gives the result shown in Fig. 1 (*e*). In this diagram, the first two electrons orbit close to the nucleus, as in Fig. 1 (*b*), whilst the second eight electrons orbit at a further distance from the nucleus, as in Fig. 1 (*d*). However, the eleventh electron now takes up a position which is further removed, again, from the nucleus than are the second eight electrons. If we added a further proton and electron, the new electron would orbit at the same distance from the nucleus as the eleventh electron of Fig. 1 (*e*).

[2] In this simplified explanation it is assumed that the electrons travel in circular orbits. The actual shapes of the orbits are not known.

The groups of electron orbits shown in Fig. 1 may be described as "shells". In Fig. 1 (*e*) the innermost shell contains two electrons, the second shell contains eight electrons, and the third one electron. As we have seen, the shell structure builds up as the number of protons and electrons in the atom increases. It is possible to have as many as six shells around the nucleus, and the first four of these are formed in the following manner: the first shell is "full" when it contains 2 electrons; the second shell is "full" when it contains 8 electrons; the third shell is "full" when it contains 18 electrons; and the fourth shell is "full" when it contains 32 electrons. It is not known how many electrons the fifth and sixth shells may hold. As has been inferred, a new shell (in the first four) does not appear until the previous shells have been "filled".

When the outermost shell of an atom has its full complement of electrons, the electron structure tends to remain stable and the atom is chemically inert. An instance is given by neon which has ten electrons, two in the first shell and eight in the second shell. The outermost shell is, in consequence, "full", and the neon atom does not readily give up or acquire an electron, nor does it readily enter into combination with other elements. If the outermost shell has less than its full complement of electrons the electron structure is less stable, electrons are more readily given up or acquired and the atom becomes more readily capable of combination with others.

Electric Current

Metals have atoms whose outermost shells do not have a full complement of electrons. Also, the atoms are closely packed together. In consequence, electrons on the outermost shells (which are already held relatively insecurely to their own nucleus) tend to come under the influence of neighbouring atoms. The net result is that a number of *free electrons* move continually through the material, joining first with one atom and then with another. If an additional electron joins an atom the resultant unbalance causes the atom to have a negative charge equal to that of the electron. Similarly, if an atom loses an electron the resultant unbalance causes it to have a positive charge equal in magnitude to the negative charge of the missing electron. Atoms possessing charges because of dissimilarities in their complement of electrons and protons are known as *ions*, and may be qualified as *negative* or *positive* according to the nature of the charge they hold.

Fig. 2 (*a*) shows a metal wire, whilst Fig. 2 (*b*) gives a simplified picture of the movement of free electrons inside a very small portion of it. In Fig. 2 (*c*) we connect a source of *electromotive force* (which may be derived from, say, a battery) to the ends of the wire, the positive terminal of the source of electromotive force connecting to the right-hand end of the wire. Free electrons near the right-hand end of the wire are attracted to the positive terminal, and they leave their parent atoms. These atoms become positive ions which, in turn, attract free electrons further along the wire. A change in the general direction of free electron motion in the wire is brought about by the application of the electromotive force, and this is virtually instantaneous. Whereas the general movement of free electrons was previously of a random nature, there is now an overall tendency for free electrons to move from left to right. See Fig. 2 (*d*). This flow of electrons through the wire constitutes an *electric current*.

We may now also visualise the concept of a *circuit*. In Fig. 2 (*c*) we have the case where a source of electromotive force is applied to the wire. What happens here is that the electrons attracted to the positive terminal of the source of electromotive force actually *leave* the wire and *pass into* the source. At the same time a similar quantity of electrons *leave* the negative terminal of the source of electromotive force and *pass into* the wire at its left-hand end. Whilst there is, therefore, a continual flow of electrons, at no time has the wire or the source of electromotive force any more or any less electrons than it had before the connection was made. If the source of electromotive force were disconnected the flow of electrons would cease, whereupon both the wire and the source of electromotive force would have their correct number of electrons as before; although the source of electromotive force would now have some electrons that previously belonged to the wire, and the wire would now have some electrons that previously belonged to the source. In Fig. 2 (*c*) we have a set of conditions which allows electrons to travel continuously *around* the combination of the wire and the source of electromotive force. We can say, as a result, that we have set up an electrical circuit.

We have referred to the fact that the flow of electrons through the wire constitutes an electric current. This is true, but it must be remembered that the speed at which the electrons themselves move is comparatively very slow. A flow of electrons occurs almost instantaneously after the application of the source of electromotive force to the wire but this is due, not to the movement of the electrons themselves, but to the changed status of the atoms along the wire. In practice, there will still be a considerable random movement of free electrons about the wire, even after the application of the source of electromagnetic force. However, there will also be a marked tendency for free electrons to move from left to right because of the electromotive force, and this definite movement constitutes the electric current. The random movement does not constitute a useful electric current because the varying directions in which the electrons travel cancel each other out.

Because metals have free electrons they become good *conductors* of electricity. Some materials have very few, some virtually zero, free electrons, and these do not readily allow the passage of electricity. Such substances are known as *insulators*. There is a range of substances varying, so far as electrical conductivity is concerned, between the efficient conductors and the efficient insulators. Notable amongst these are the *semiconductors*, such as germanium and silicon.

Electrical Units

Before concluding this month's contribution, let us examine the practical units employed for measuring current and electromotive force.

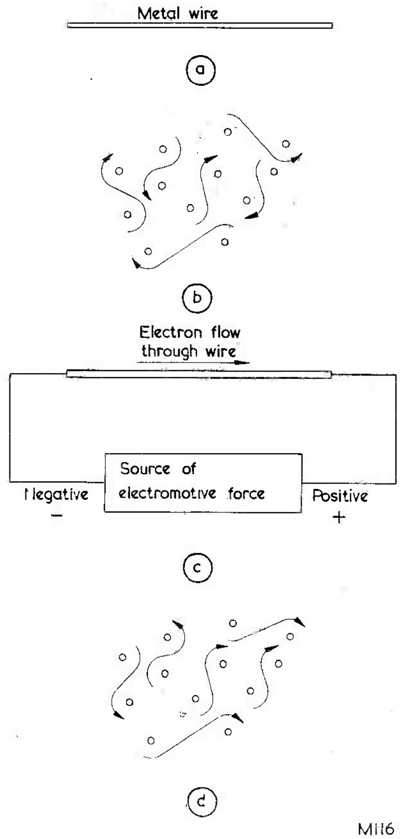


Fig. 2 (a). A metal wire, through which it is possible to pass an electric current

(b). Illustrating, in simplified form, the routes taken by free electrons in a very small portion of the wire. The arrows represent the paths of the electrons, and the circles the nuclei of atoms. (Electrons in regular orbit around the nuclei are not shown.) It will be seen that the general movement of the free electrons is of a random nature

(c). Connecting a source of electromotive force to the wire, as shown, causes electrons to flow in it from left to right

(d). Whilst, with the electromotive force applied, there is still random movement in the free electrons, there is now a general tendency to move towards the right

A *quantity* of electricity is measured by a unit known as the coulomb. The coulomb was introduced before the charge held by an electron was known and is, in fact, equal to 6.29×10^{18} electrons.[3]

The practical unit of current is the *ampere*, this being equal to the flow of one coulomb in one second. Coulombs are infrequently encountered in normal radio work, whereas amperes are generally employed. The word ampere may be abbreviated to amp, or to the single letter, A. In radio work, subdivisions of amperes are often employed. Thus, we have the milliampere (milliamp, mA) which is equal to one-thousandth of an ampere, and the mocroampere (microamp, μA) which is equal to one-millionth of an ampere. When current in amperes (or subdivisions of amperes) is expressed in a formula or equation, it is normally represented by the letter I.

[3] Quantities of electricity, in coulombs, were originally measured by weighing the mass of silver deposited on an article in an electroplating bath through which the current passed. (One coulomb causes 0.001800 grs. of silver to be deposited in a 10% aqueous solution of silver nitrate.)

The practical unit of electromotive force is the volt,[4] and this may be abbreviated to the single letter, V. Subdivisions of the volt likely to be encountered in radio work are the millivolt (mV) which is equal to one-thousandth of a volt, and the microvolt (μV) which is equal to one-millionth of a volt. There is also the kilovolt (kV) which is equal to one thousand volts.

The term electromotive force is commonly abbreviated to e.m.f. E.M.F. in volts (or subdivisions or multiples of volts) is normally represented in a formula or equation by the letter E.

Next Month

In next month's issue we shall carry on to resistance and potential difference, introducing practical examples to illustrate the theory involved.

[4] The volt is related to the ampere in that, if a joule of electrical energy is converted into some other form for each coulomb which flows, the electromotive force is one volt.

International Television Conference

for London in 1962

The Electronics and Communications Section of The Institution of Electrical Engineers is organising an International Television Conference covering all scientific and engineering aspects which will be held in the Institution building in London from 31st May to 7th June, 1962.

This period will overlap the last three days of the International Instruments, Electronics and Automation Exhibition being held at Olympia, London, at that time, at which most British and many oversea manufacturers of professional television equipment and apparatus will be exhibiting. Arrangements are being made for linkage with this exhibition, and it is expected that the coincidence of these two attractions will increase the number of electronic engineers and technologists from abroad, who will take the opportunity of attending both events.

The Conference will from many points of view be an important milestone in the history of television development. It will follow the twenty-fifth anniversary of the first regular television programme in the world by the B.B.C. from the Alexandra Palace at the end of 1936; it will mark an interval of 10 years from the Conference on the British Contribution to Television held by the I.E.E. in 1952 when many other countries were starting television; it will occur at a time when this country has achieved a density of television coverage unmatched elsewhere, when the whole future pattern of broadcasting in Britain will be under active consideration at Government level; and when the planning of wide scale television coverage is being considered by countries all over the world.

The next ten years will see television spread to most areas of the world, with international links which will provide an interchange of culture, education and ideas undreamed of in those pioneer days in 1936.

The Conference will cover technological aspects of the whole television field, including programme engineering, transmission, reception, standards, colour, industrial and educational television, pay television, links and relay including the use of communication satellites and it is expected that over 1,500 experts from all over the world will attend. A balanced technical programme will include about 150 lectures, papers and contributions, and the information and ideas presented and discussed will form the technical basis of the future pattern of television for the next generation.

An Organising Committee has been set up under the Chairmanship of Dr. R. C. G. Williams, and includes P. A. T. Bevan, C.B.E., Captain C. F. Booth, C.B.E., Dr. J. S. McFetrie, C.B., Commander C. G. Mayer, O.B.E., M. J. L. Pulling, C.B.E., Dr. R. L. Smith-Rose, C.B.E., Dr. J. A. Saxton, R. C. Winton and A. J. Young, C.B.E.

The submission of papers is invited and further information may be obtained from the Secretary, The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

IN YOUR WORKSHOP

This month Smithy the Serviceman and his able assistant, Dick, handle receivers whose initial faults have been made much worse by the enthusiastic but misguided attentions of their owners

"YOU KNOW, SMITHY," SAID DICK, "it *is* too bad!"

"What's too bad?"

"The way people expect us to repair their t.v.'s and radios after they've messed around with them themselves."

"It sounds," said Smithy, "as though you've been visited by the Phantom Fiddler!"

"I wouldn't know about that," replied Dick. "Anyway, just have a look at this turret tuner."

Smithy wandered over and examined the tuner. At first sight he clicked his tongue mildly but, after a closer examination, his expression showed nearly as much annoyance as did his assistant's.

"Well," he remarked. "I don't know who's had a go at that tuner, but he certainly seems to have done his best to wreck it."

"Which means a lot more trouble for us," complained Dick.

Philosophic Attitude

Smithy reflected for a moment.

"To use a current expressive phrase," he said eventually, "it's no skin off our nose if the customer chooses to mess around with his own t.v. and leaves a trail of destruction behind him in the process. It's our job to fix sets and, if we have to put right what customers put wrong, then they just have to pay more. Still, I must admit that it *is* annoying, if only because it is such a waste of time to repair snags that are caused by pure ham-handedness."

"I'm sorely tempted," said Dick, "to fit another tuner, and sling this one away."

"Well, let's just have a go at it," replied Smithy, "it mightn't be too bad. The main trouble is the contacts. This tuner employs a standard arrangement of coil biscuits fitted in a drum, and it's obvious that the chap who's had a go at it has tried to increase contact pressure by pushing the fixed contacts inwards."

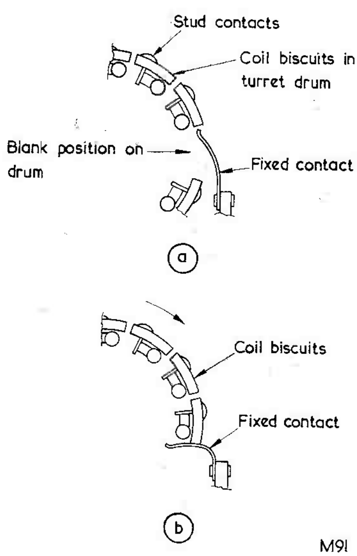


Fig. 1. The sad tale of the over-adjusted turret tuner contact. In the cross-sectional view of (a) the fixed contact has been pressed inwards whilst the turret is set to a blank channel. The result is that rotating the turret clockwise, as at (b), traps the contact and bends it back on itself.

"Exactly," said Dick. "The drum has got several blank positions and he must have selected one of these for his attack on the contacts. (Fig. 1 (a)). The result is that, whilst the contacts may have stayed in position when the drum was turned one way, they got folded completely over when it was turned in the reverse direction." (Fig. 1 (b))."

"Which has happened in this case to two of the contacts," said Smithy. "Any chance of repairing them? If you can't we might as well fit a new tuner, as you suggest, and call it a day."

"Well, they aren't actually broken. I'll see if I can get them back to their former shape."

"I should get the drum out first," remarked Smithy, walking away.

"Okey-doke," said Dick equably.

Now that he had started work on the tuner his spirits were rising and his annoyance at the unnecessary work was beginning to dissipate.

Dick released the springs holding the turret drum in position and placed them carefully on the bench so that he would remember the points on the chassis to which they fitted. He next lifted the drum, complete with the channel selector shaft, the concentric fine tuner shaft, and the fine tuner dielectric vane, clear of the tuner chassis. He then tackled the contacts.

"It's not too bad, Smithy," he called out after a moment. "Fortunately, they didn't get bent too abruptly, and they seem to have retained their springiness."

Smithy returned to Dick's bench

and examined the contacts.

'They seem fair enough," he pronounced. "But it's extremely fortunate that they weren't damaged beyond repair. Having got over that particular hurdle, I suppose we had better keep our eyes open for any other man-made faults in the tuner."

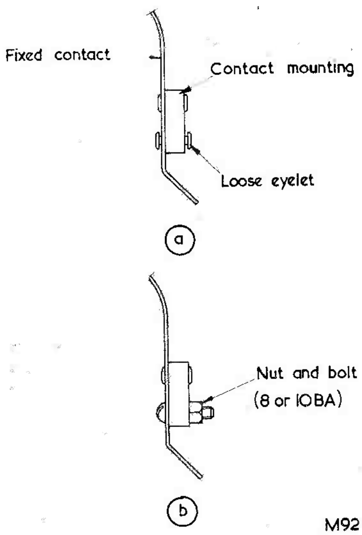


Fig. 2 (a). Illustrating, in exaggerated form, a loose eyelet in a fixed contact mounting assembly.
(b). The loose eyelet may be cut out and replaced by a nut and bolt.

"Sometimes," said Dick, "the fixed contacts in a tuner are eyeletted in position and the eyelet springs, or works loose. (Fig. 2 (*a*)). Is it worth trying to repair a fault like that?"

"You *can* have a bash at a repair of this nature," replied Smithy, "if you feel in a mood for a rather fiddling job. You may be able to cut out the eyelet—don't try to drill it out—and replace it with an 8 or 10 BA nut and bolt. (Fig. 2(*b*)). But that's just about as far as you would go in normal servicing."

"Fair enough," said Dick. "I'll put the drum back now."

"Before you do so," said Smithy, "it mightn't be a bad idea to quickly check one or two of the obvious points which could cause a turret fault. I'm assuming, of course, that it *was* a fault in the turret which caused the Phantom Fiddler to start his operations."

"That's the second time you've mentioned the Phantom Fiddler," remarked Dick. "I'm not quite with this one."

"It's a bit of servicing folk-lore," explained Smithy. "To give you an example, you may get a set in for repair with all the trimmers screwed up tight. The set owner insists that nobody whatsoever has touched the trimmers, and that the set has packed in of its own accord. The only thing you can do is to accept this statement, and mentally ascribe the screwing-up of the trimmers to the Phantom Fiddler!"

"It's a new one on me," remarked Dick.

"The phrase was very common at a place I worked in before the war," said Smithy, "and it's stuck in my mind ever since. In those days the machinations of the Phantom Fiddler were much wider than they are now. Receivers were simpler and people were less scared of playing around with them than they are nowadays with expensive t.v. sets. We used to have a lot of trouble with the Phantom!"

Dick grinned.

"That's an expression I must remember," he chuckled. "Anyway, getting back to this tuner chassis, what should I look for now the drum is out?"

"Poor connections mainly," said Smithy. "Something started off the contact bending business, and it may well have been that reception was intermittent when the tuner knob was waggled. This could have been contacts, of course, but I should have a quick look for cold joints in the chassis as well. It won't take you a moment, and you may well save yourself the job of lugging the drum out all over again later on. Oh yes, and check the decoupling resistor feeding the cascode anode coil, and the cascode cathode bias resistor, to see if they're the right values and haven't cooked up. I've got a special reason for checking these particular components."

Even as Smithy spoke, his assistant was quickly examining the inside of the tuner chassis.

Smithy looked pleased.

"I've found something already," said Dick excitedly. "There's a pretty crummy looking connection to pin 2 of the cascode. This pin's got a 1,000pF disc ceramic taking it down to deck. Why, I can actually move the condenser wire in the valve holder tag hole!"

"A cold joint at this point would certainly cause alterations in tuner performance," he said. "That particular condenser's just about the hottest component in the tuner!"

"How come?"

"In this tuner," said Smithy, "the cascode is a conventional PCC89, and pin 2 connects to its upper grid (Fig. 3). Unless this grid is well and truly anchored down to chassis by that condenser the cascode breaks into oscillation. If ever you have to *replace* a condenser in this particular part ofthe circuit you must always choose a new component of the same type—that is, disc or tubular—and with the same value. And you should always connect the replacement into circuit with *exactly* the same length of lead-out wire to the joints as was used in the original. Otherwise you upset the alignment of the turret."

"That's easier said than done," said Dick, as he bent over the tuner chassis with his soldering iron. "Because these particular condensers are usually connected into circuit with very short leads. And a lot of replacement condensers have

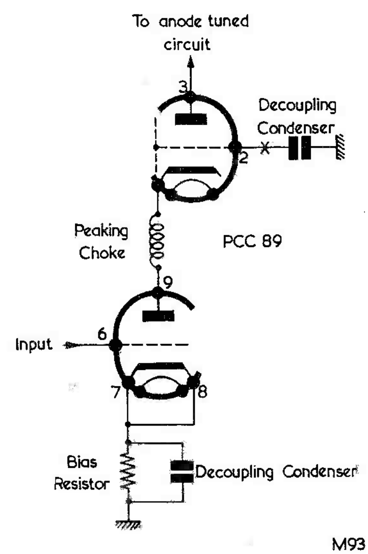


Fig. 3. Dick found a cold joint at the point marked with a cross; that is, between the upper grid of the PCC89 cascode and its decoupling condenser.

got wodge all down the wires."

"What you refer to as 'wodge'," said Smithy, reprovingly, "is the cement coating protecting the condenser. This will easily crumble off the leads if you squeeze them with a pair of pliers."

"What happens if some of it crumbles away from the works of the condenser?"

"I shouldn't worry too much about it," said Smithy. "Indeed, quite a lot of ceramic condensers are made these days with only part of the body protected. (Fig. 4). They are perfectly normal condensers, but they haven't been dipped quite so far into the cement during manufacture. These condensers have leads which are completely free of cement and the fact that part of the ceramic is bare doesn't matter in ordinary domestic applications."

"That's interesting," remarked Dick. "Anyway, I've resoldered this joint now."

Black Jam

"Righty-ho," said Smithy cheerfully. "With a bit of luck you've also cleared the intermittent which started the trouble as well. I should clean the contacts up a bit and pop the drum back again."

"This drum certainly looks pretty grimy," remarked Dick. "It's got deposits of black stuff all round the contacts."

"Those deposits," pronounced Smithy, "consist of a special compound which is known to science as Black Jam."

"Hey!"

"That's right," continued Smithy gravely. "Black Jam. It's a substance beyond the capabilities of even the most competent chemist to analyse. It grows in radio sets, in television sets, and in hand-wound gramophones. The only known property on which the scientists agree is that it is soluble in carbon tet."

"I'll have a stab at it," grinned Dick. "I must say I'm learning a bit today, what with Phantom Fiddlers and Black Jam!"

Smithy wandered back to his bench and resumed his own work. He was not to be left in peace for long however.

"Smithy."

"Hullo!"

"I've cleaned up the fixed contacts and the stud contacts on the drum biscuits," began Dick a little doubtfully.

"Yes?"

"The trouble is," continued Dick, "that the stud contacts don't half look discoloured."

Smithy laid down his soldering iron and walked over once more to Dick's bench.

"I must admit they *do* look a little dirty," he remarked, examining the turret drum carefully. "These contacts are almost certain to be silver plated and I should guess that the discolouration is silver sulphide. Somebody told me once that silver sulphide on a contact doesn't cause any trouble because it's conductive. But I'm not so certain about that myself, especially in a turret. Fortunately it's quite easy to clean up silver plated stud contacts on a turret drum by burnishing them, and I've got a gadget that's just the job for it."

Smithy walked to his bench, rummaged in a drawer, and returned to his assistant.

"That's a suede shoe wire brush," protested Dick.

"Exactly," chuckled Smithy, picking up the turret drum. "I'll just try it out first on the studs of a channel that isn't being used. Ah, there we are!"

After a few brisk rubs, the stud contacts on the turret biscuit selected by Smithy glowed brightly.

"Just like new," commented Smithy. "Now, you burnish up the studs on the biscuits for our two local channels and you can then put the drum back in the turret. After which I would advise a spot of Electrolube on each fixed contact for lubrication. Before you try the turret out, however, there's one thing left to do."

"What's that?"

"Didn't you spot it?" asked Smithy. "The Phantom Fiddler did something else wrong. He put the bottles in the wrong holes!"

"Well, I'm dashed," said Dick. "Still, it won't take a moment to put them right again!"

"I should check the valves first," warned Smithy, "because they may have been passing some fairly dirty currents in the wrong sockets."

The Serviceman sat down alongside Dick and scribbled on his pad.

"As you know," he continued, "a typical PCC89 cascode circuit of the type we have in this tuner applies h.t. to the anode of the top triode via the anode coil and a decoupling resistor. Also, approximately half the h.t. is fed to the grid of the top triode by means of a simple fixed potentiometer. (Fig. 5 (*a*).) This is the grid, incidentally, whose decoupling condenser you've just re-soldered. If you put a PCF80 in the cascode socket, (Fig. 5 (*b*)), you connect the potentiometer to the grid of its pentode section, and the anode coil to its screen grid."

"With the result," said Dick, studying Smithy's sketch, "that you apply h.t. to the pentode grid, a fact which does it no good at all. Also, the screen-grid of the pentode may, as a result, draw sufficient current through the anode coil to cook up the decoupling resistor. It's just possible that the cathode resistor might suffer also."

"That's right."

"I can see now why you wanted me to check those resistors when I had the drum out."

"You've got it," said Smithy. "In practice, a PCF80 in a PCC89 socket may not do all that much damage, even though it does look horrible on paper. The top resistor in the potentiometer through which the grid current flows usually has a pretty high value, and so the valve may not pass so much grid current after all. But there's a *risk* of excess current, anyway, and the valve should be considered suspect in consequence."

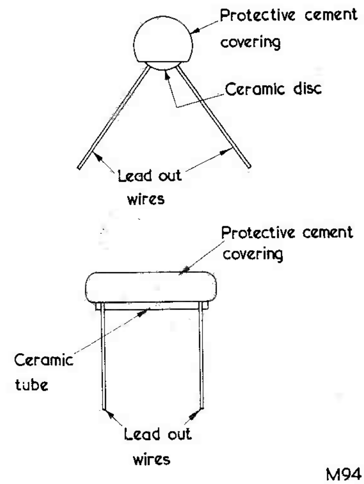


Fig. 4. It is common practice for modern disc and tubular ceramic condensers to be only partially covered by protective cement. This ensures that the lead-wires are clear of cement, the fact that part of the ceramic body is exposed being unimportant in domestic receiver applications.

Smithy lit a cigarette.

"Now, a far worse state of affairs occurs when you put a PCC89 into the PCF80 holder," he carried on. "The pentode anode of the PCF80 connects to the i.f. coil and thence to h.t. via a low value decoupling resistor. (Fig. 5 (*c*).) When you insert the PCC89, the grid of the lower triode connects to this i.f. coil (Fig. 5 (*d*)) and a really serious grid current can flow in consequence. This won't do the valve the slightest bit of good and it could burn out the decoupling

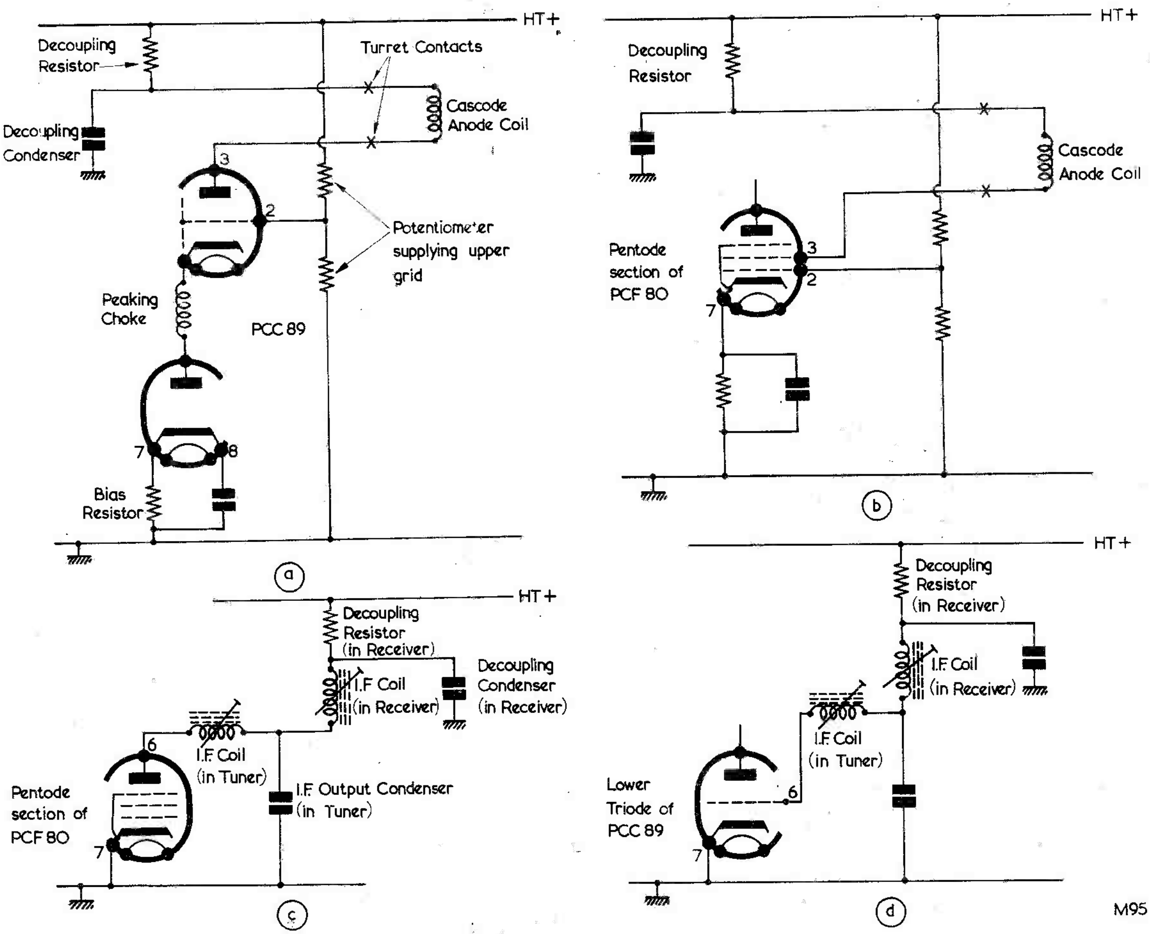


Fig. 5 (a). Typical supply connections to a PCC89 in a turret tuner.
(b). If a PCF80 is accidentally inserted in the PCC89 holder, a positive potential is applied to the pentode grid and the screen-grid connects to the cascode anode coil.
(c). A representative example of the manner in which h.t. is applied to the pentode anode of a PCF80.
(d). Plugging a PCC89 into the PCF80 valveholder causes a positive potential to be applied to the grid of the lower triode.

resistor as well. In this particular instance, the decoupling resistor is in the receiver chassis and not in the tuner, and it's another component you'll have to look at before replacing that tuner. I might add," said Smithy finally, "that all I've said up to now about the PCC89 applies to the PCC84 as well, because it has the same pinning."

Dick looked dejected.

"I can only hope," he remarked dolefully, "that the geyser who had a go at this tuner didn't attack the chassis trimmers as well."

"You're safe enough there," said Smithy. "That was the first thing I looked for when I examined the tuner. The manufacturer's paint seals haven't been broken."

"Thank goodness for small mercies," said Dick, relieved. "I suppose I'd now better get on with the job!"

Dick re-assembled the tuner and fitted it back on the chassis. He checked the chassis decoupling resistor referred to by Smithy and was comforted to find it satisfactory. Finally, he fitted new valves to the tuner and switched on the receiver. Much to his surprise, it worked perfectly. Brightening considerably, Dick replaced the original PCF80. There was no apparent difference in the performance of the receiver. He next fitted the original PCC89, whereupon contrast dropped and the picture showed an excessively noisy background. Dick reinserted the new PCC89.

"This set's going fine now," he called out happily. "And the old PCF80 seems to be O.K. too. However, when I tried the old PCC89, all I got was a dirty picture!"

"Some people have all the luck," commented Smithy.

A.M. Receiver

Cheerfully, Dick put the chassis, of his receiver back in its case gave it a final check and pronounced it fully repaired. He then wandered over to the rack and selected a rather venerable a.m. receiver. Dick liked a little variety in his work.

He took the receiver back to his bench, connected it to the mains and an aerial, and switched on.

After the set had warmed up, he found it was possible to receive the local Medium wave programme very weakly at an incorrect setting of the tuning dial, and that was all. Dick quickly removed the chassis and laid it on his bench. With the aid of a screwdriver he applied his finger to the grid of the a.f. voltage amplifier triode and was rewarded with a comfortingly loud hum from the speaker. On an impulse he inserted his screwdriver into the i.f. transformers, only to find that, in each case, the blade travelled nearly to the centre before encountering the core.

"Smithy!"

"What is it now?" called out the long-suffering Serviceman over his shoulder.

"It's the Phantom again," pronounced Dick. "He's had a go at *this* set too!"

"Don't say you've got another tuner with bent contacts!"

"Not this time," replied Dick. "It's a Medium and Long wave set, and some silly twerp has gone and screwed all the i.f. cores up tight!"

"Well, make certain you re-align the i.f.'s at the right frequency," said Smithy. "Use a signal generator."

"Righty-ho," replied Dick cheerfully.

The i.f. transformers were of the type which have two coils wound on a single internally-threaded former. (Fig. 6 (*a*).) Hopefully Dick inserted a hexagonal core trimming tool into the top of the first i.f. transformer. His face fell a little as he found no corresponding hexagonal hole in the core. He picked up an insulated trimming tool made from a thick plastic knitting needle filed to fit into a dust core screwdriver slot, and inserted it into the former. This engaged reliably with the core, and Dick was able to unscrew the latter until its top surface was flush with the top of the former. Dick then inserted his trimming tool into the bottom of the former to engage the lower core. The tool turned round uselessly. It was obvious that whatever slot the core had previously possessed at its bottom end had been worn away. Sighing, Dick returned to the top of the former and unscrewed and removed the core he had already shifted. He then inserted his trimming tool into the top of the former, engaged this with the upper slot of the remaining core and screwed the latter down till it fell out at the bottom; after which, he picked up the core and examined it with disgust. The screwdriver slot at one end, that which he had located from the top of the former, was perfectly sound. The slot at the other end had been completely worn away by the person who had previously attempted to adjust it. Dick returned the lower core to the former, good slot outwards, and refitted the top core.

He next attacked the second i.f. transformer. This time he found the two cores screwed very tightly against each other, and it was only after careful adjustment of the bottom core that he was finally able to loosen them. He unscrewed the bottom core, to find that the outer slot was reasonable and that the inner slot was in perfectly good order. Intending to profit from his previous experience, Dick next attempted to screw out the upper core from below. But there was very little purchase for his trimming tool. Dick next tried to shift the core from the top of the former, only to find a similarly weak purchase.

Dick gave voice to his misery.

"I've got a stuck core now, Smithy."

The Serviceman's soldering iron descended to its stand with slightly more force than was really necessary, and Smithy once more walked the well-worn path to Dick's bench. Dick indicated his predicament.

"Well, you're certainly stuck here." said Smithy, after a quick examination. "Pass me another trimming tool and hold the chassis on its side."

Smithy grasped both tools and applied them firmly to either end of the recalcitrant core, feeling for best purchase. (Fig. 6 (*b*).) Keeping both tools pressed firmly inwards, Smithy carefully turned them in the same direction. The slug slowly rotated, becoming easier after several revolutions. Shortly afterwards Smithy was able to bring it out through the top of the former.

"Well," he remarked briefly, after he had completed his task, "the chap who had a go at that core really *knew* how to create destruction. After he'd partly chewed up one end he must have taken the core out and put it back so that he could chew up the other end as well!"

"What's the advantage of using *two* trimming tools to shift the core?" asked Dick who had watched the proceedings with great interest.

"To begin with, you get twice the purchase on the core," said Smithy, "Also, you can press harder without increasing the friction between the core threads and the

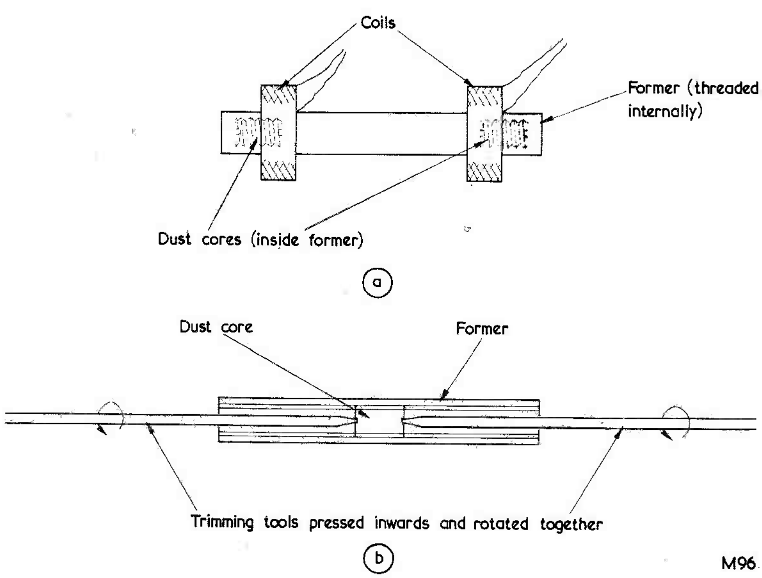


Fig. 6 (a). The type of i.f. transformer coil and former assembly encountered by Dick. This diagram emphasises that the cores are intended to have screwdriver slots at both ends. (In practice, the slots would not extend for the full width of the core, and may not be in the same plane).
(b). Shifting a dust core whose screwdriver slots have been worn away by careless treatment.

inside of the former. You'd better find a replacement core in this case," he added, "the one I've removed has had it."

"Will a core with a hex hole do in place?"

"I should use a screwdriver slot type if you can," replied Smithy. "Cores with hex holes have rather less iron-dust material in them, and they don't increase coil inductance quite as much. It's safer to replace a screwdriver slot core with one of a similar type if it's at all possible. We've got a graveyard of old coils in the Workshop, and you shouldn't have any difficulty in finding another core with the same thread and length."

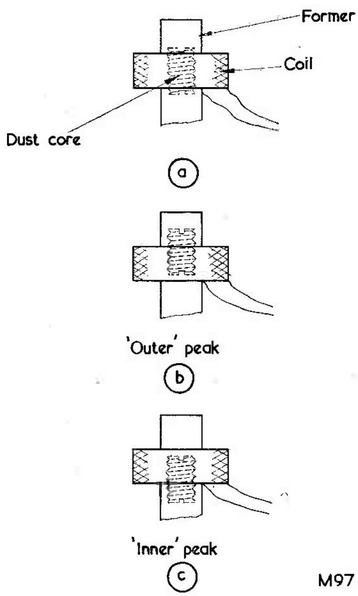


Fig. 7. If an attempt is made to tune a coil to too low a frequency, a central setting of the core (equivalent to maximum coil inductance) may give the impression of a true resonance peak. Such a core position is shown in (a). True resonance conditions are indicated if two core positions give a peak, as in (b) or (c).

"Don't dust cores have different permeabilities for different frequencies?"

Smithy looked surprised.

"There *are* different types of dust core material," he remarked, "where did you learn that fact?"

"Oh, I read it somewhere," said Dick proudly.

"Well, you're quite right," commented Smithy. "However, you're bound to get a dust core of the same material as this if you whip it out of another 465 kc/s i.f. transformer. You'd probably be near, enough, too, if you took it out of an f.m. or a t.v. i.f. transformer."

"As you say," said Dick, who was already looking through the box of old coils referred to by Smithy.

Dick soon found a suitable dust core and inserted it into the transformer. He then commenced the i.f. alignment. Peace descended upon the Workshop, broken only by the occasional 400 c/s wail from Dick's receiver as he worked on its i.f. transformers.

False Peak

Dick completed the alignment and tried out his receiver. This time several strong signals were received, these being reasonably near to the correct part of the dial and at comfortable volume; but there was still a distinct lack of sensitivity. He quickly checked r.f. trimming but this seemed adequate. Deciding that there must have been a fault in the receiver which had prompted the original outrage on the i.f. transformers, Dick reached for his testmeter and took some quick voltage checks. His face broke into a beatific smile when he found a reading of 20 volts only on the i.f. amplifier screen-grid. It was a matter of moments to check the resistance of the screen-grid feed resistor, find this satisfactory, and then clip out one end of the screen-grid decoupling condenser. The latter showed a leak of some 20kΩ, and Dick replaced it immediately.

Dick switched on the receiver and his spirits rose as it came to life. This time the set was much more lively and he grinned as he swung the dial. As he tuned in the stations, however, his grin gradually faded, and he decided he was in need of assistance once more.

"Smithy!"

The Serviceman grunted.

"I've found the original fault in this set," said Dick, encouraged by this response, "and I've lined up the i.f.'s spot-on. But it still doesn't seem to be right."

"What's wrong with it?"

"Well, the selectivity seems to be down somehow, and the stations don't come in cleanly."

Smithy walked over yet again to his assistant's bench and carefully tuned the receiver.

"Well, the i.f.'s are certainly spread out a bit," he remarked. "Slap the sig genny in at i.f."

Obediently Dick connected up the signal generator. Smithy looked at its frequency setting.

"You've lined them up a bit low, haven't you?" he remarked, "The signal genny's only reading 445 kc/s."

"Is it?" said Dick anxiously. "I meant to set it at 450 kc/s."

"That may still be a bit low," commented Smithy.

Without altering the setting of the signal generator, Smithy checked several of the i.f. dust cores.

"Ah, here we are," he remarked, "this one's on a false peak."

"False peak?"

"That's right. Unless there's a fault in this transformer, you've been trying to line it up at too low a frequency. What has happened is that the coil can only *approach* the low frequency, and cannot actually *tune* to it. When you adjust the core towards the centre of the coil, signal level increases, becoming maximum when the core is right in the middle. (Fig. 7 (*a*).) Because this gives you a form of peak you then think that the coil is resonant at the frequency you've selected. But it isn't. All that has happened is that it's got as close to the frequency as it can."

Smithy put his hand on the tuning knob of the signal generator.

"I'm now going to gradually increase sig genny frequency," he announced, "whilst still checking the core. Ah, here we are! I've brought the frequency up to 455 kc/s and the single peak given by the core is now breaking up into two separate peaks, one given by the core going into the coil and another as it comes out again. (Figs. 7 (*b*) and (*c*).) Both core positions are correct so far as frequency is concerned, and the fact that I've got two means that I'm truly going through resonance each time."

Smithy put down his trimming tool.

"The main reason for your low selectivity," he remarked, "was that you were trying to line up the i.f.'s at too low a frequency. If you don't know the correct i.f. for this set, I should work to 465 to 470 kc/s. From what I've seen here this should be pretty safe."

"Thanks Smithy," replied Dick. "If each core gives a peak in two positions, does it matter which position I choose?"

"Definitely," replied Smithy. "Normally, 465 kc/s i.f.'s of this type should be lined up with all cores on the outer peak position. If you line any cores up on the inner peak you increase the mutual inductance between the two coils in the transformer, and your bandwidth increases accordingly. So you'd be back with low selectivity again!"

The Final Straw

It did not take Dick long to re-align his receiver, whereupon it worked perfectly and could be considered as being fully repaired.

Dick walked over to the rack again and, rather warily, examined the remaining receivers. His eye caught the long, strikingly coloured, tuning scale of an a.m./f.m. receiver and, with crossed fingers, he ventured a silent hope that this, at least, had not been meddled with.

He carried the set to his bench and plugged it into the mains. Idly, he turned the tuning knob. The tuning scale pointer stayed fixed for a moment, then slowly moved across to its new position. Incredulously, Dick turned the knob once more. Again there was a delay, after which the pointer travelled leisurely to its fresh location. Dick turned the knob in the reverse direction and gazed with fascinated eyes at the pointer as it slowly and languidly returned along the scale. Finally, Dick turned the knob as swiftly as he could, and was rewarded with the sight of the pointer slowly gathering speed as it went towards the end of its travel. There was suddenly a loud snapping noise from inside the cabinet and the tuning knob turned loosely in Dick's hand.

Dick opened the back of the cabinet, peered inside, and gave voice to a loud bellow of laughter. Startled, the Serviceman wheeled round, to see his assistant drawing from the inside of his receiver what was obviously the tuning scale pointer and carriage, together with at least a yard of delicately shaded pink elastic.

"The Phantom," called out Dick, helplessly, holding his prizes up in the air, "has struck again!"

A Microphone Matching Unit

by A. H STRANGE

Many tape recording enthusiasts using moving coil or ribbon microphones have no doubt, at times, considered it desirable to place the tape recorder in a room other than that of the sound source, whereupon the increased length of cable involved causes no problem if the microphone has a low impedance output. If, however, the moving coil or ribbon microphone has been transformed to high impedance and has no alternative low impedance tap, the distance between the sound source and tape recorder is limited due to the risk of high frequency attenuation.

Therefore, a simple matching unit with a high impedance input and a comparatively low impedance output for connection between the microphone and a long cable could be of advantage. Such a unit may be constructed to the circuit given in the accompanying diagram using a transistor connected as a grounded collector stage with its base fed via a series resistor R_1. The input impedance is then a fair match to the majority of high output impedance moving coil or ribbon microphones. The necessary inclusion of the series resistor reduces the level from the microphone to the transistor and, in fact, the unit introduces a loss. However, most recorders can counter this loss by increasing the record level control above the position normally used for recording. A 50μF output condenser is employed to maintain a low impedance at low frequencies, and the 10kΩ resistor R_4 completes its polarising path, should the tape recorder have a condenser input.

Battery power is derived from a 1.5 volt cell and the consumption of the unit is approximately 0.3mA. The whole unit may be constructed on a small Paxolin tag panel, and no precaution need be taken in respect of layout. It is most important that the unit be enclosed in a metal container, which of course must be earthed and contain the appropriate input, and output sockets.

Components List

Resistors

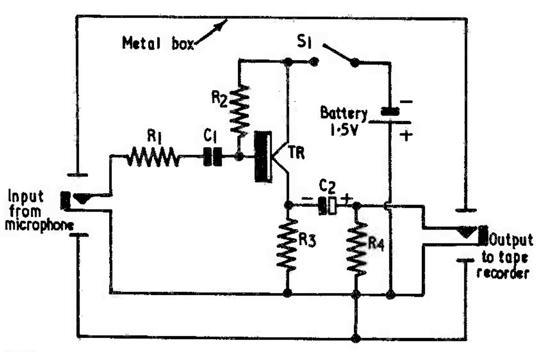
- R_1 33kΩ
- R_2 220kΩ
- R_3 1.8kΩ
- R_4 10kΩ

Condensers

- C_1 0.25μF paper
- C_2 50μF electrolytic, 3V or 6V wkg.

Miscellaneous

- S_1 On/off switch
- TR OC71
- Input/Output jacks (2)
- Metal box



E103

A Constructor's Oscilloscope

—A Construction of the Mullard Design

Part 2

by D. NOBLE, G3MAW and D. M. PRATT, G3KEP

Chassis Construction

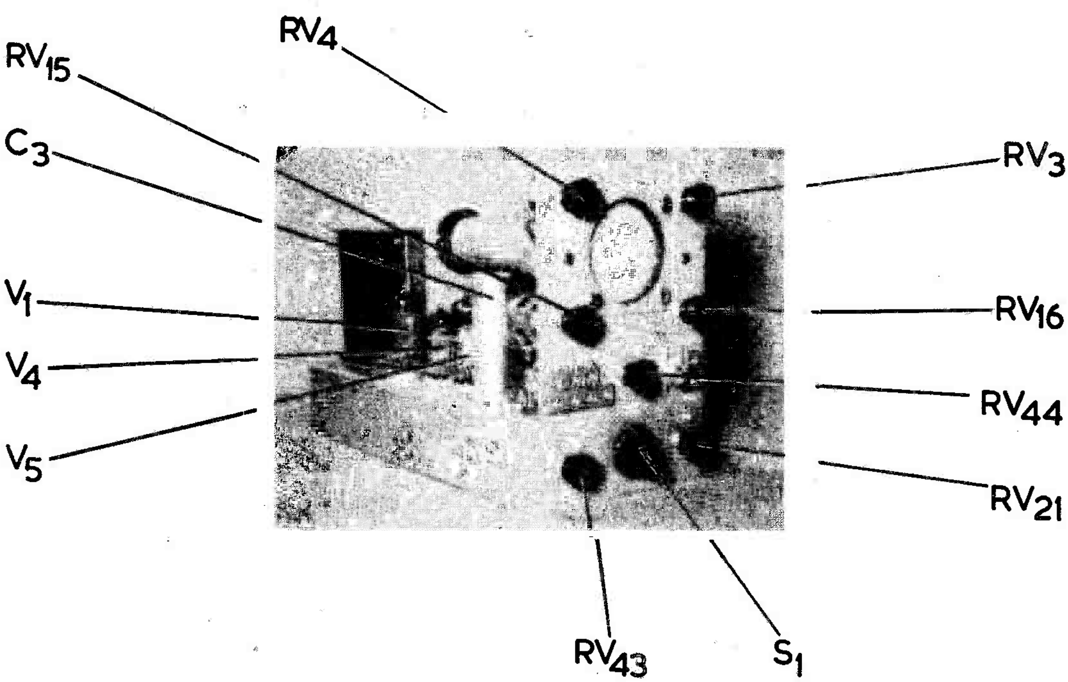
ALTHOUGH THE CIRCUIT IS NOT PARTICULARLY critical, care is needed in the layout and the wiring, the timebase and Y amplifier being kept as far apart as practicable.

The instrument is built on a conventional type of chassis 11 x 5 x 2in of 16 s.w.g. aluminium (Fig. 2). In order to prevent the trace being affected by the magnetic field of the mains transformer, this component is mounted at the rear of the chassis.

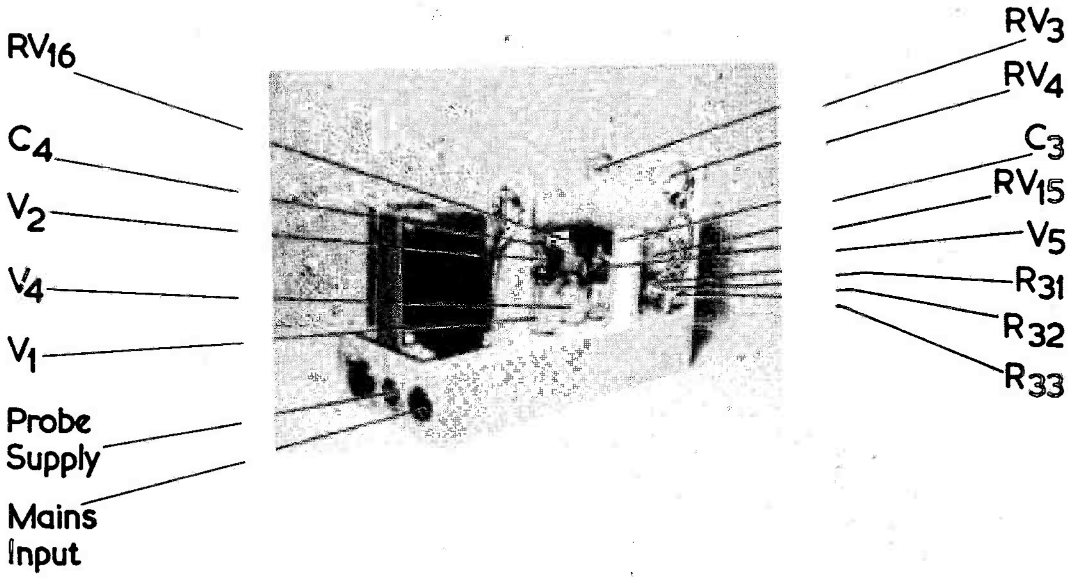
The positions and types of the various Bulgin tagstrips are indicated on the chassis drawing. For ease of assembly, the orientation of the valve holders is shown, the dots at the valveholder holes indicating the space between pins 1 and 9.

The front panel is made of 16 s.w.g. aluminium, and the drawing (Fig. 3) is similarly self-explanatory. The panel drawing also carries information with regard to the wording used and the positions of the Data Publications "Panel-Signs". No allowance has been made on the front panel for overlap to enable the oscilloscope to be fitted into a cabinet. If it is required that the instrument be fitted into a case, the necessary adjustments to the dimensions of the panel should be made to suit individual requirements.

The tube is fitted with a rubber mask and mumetal screen, and is supported front and rear. The front support consists of an aluminium ring riveted to two feet. The assembly is then screwed to the front panel. At the rear it is supported on a tube base mounted on a bracket. Full information of the tube mounting arrangements is given in Fig. 4.



Three-quarter view of front panel and chassis



Three-quarter rear view of the chassis with the main components being clearly designated

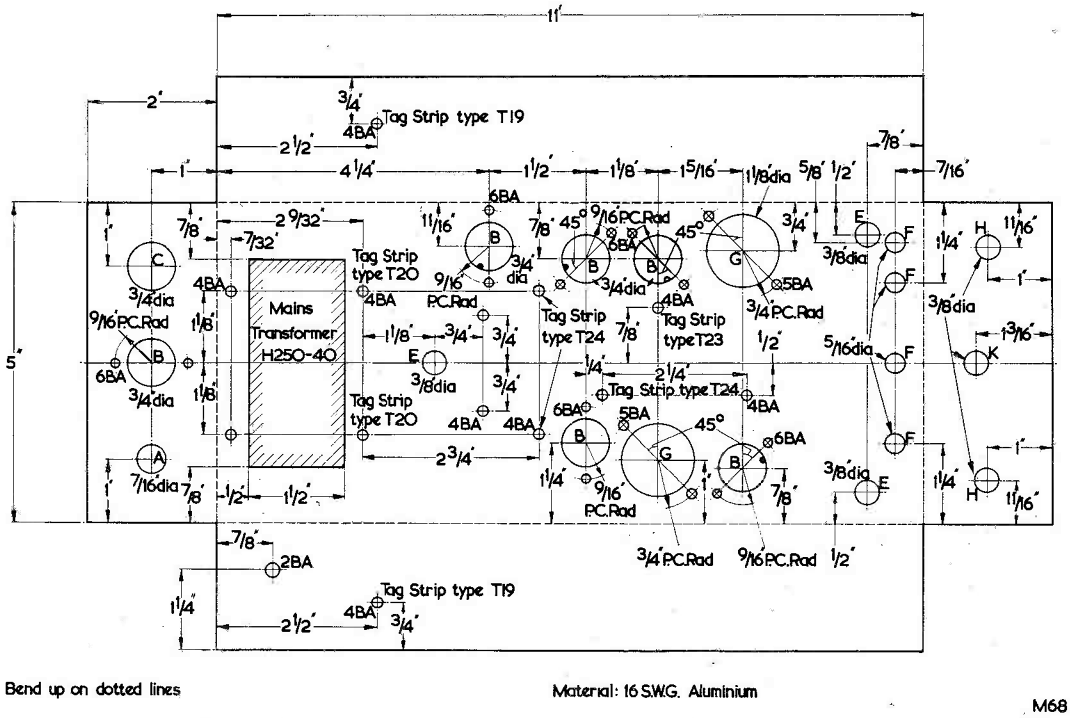


Fig. 2. Mullard oscilloscope chassis drilling dimensions. Key: A, Fuse holder (Belling-Lee type L575); B, Noval bases; C, Mains socket (Bulgin type P429); D, Westalite contact cooled rectifier; E, ¾in rubber grommets; F, ½in rubber grommets; G, electrolytic condensers; H, potentiometers and K timebase switch S1a, S1b

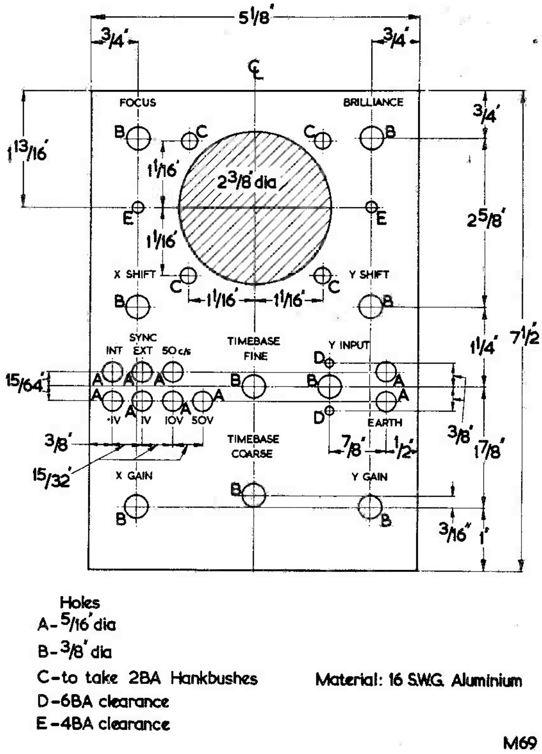


Fig. 3. Front panel of the oscilloscope

A McMurdo type X12/E base is considered to be the most suitable available for the cathode ray tube. This base is intended for decade counter tubes, however, and it has a central spigot contact which is not required, and which may be sawn off or ignored as preferred. The photographs show another type of tube base which was used before the X12/E was brought to notice.

After the metalwork has been completed the sections may, if desired, be silver-hammer sprayed as was the prototype. Many cycle shops are able to undertake such painting, which has been found to greatly enhance the appearance of home constructed equipment.

Graticule

Fig. 5 shows a suitable filter and graticule for use with the instrument. The graticule is a great asset when using the oscilloscope whilst making voltage measurements of waveforms, while the filter is useful under conditions of high ambient illumination.

The graticule is made of $\frac{1}{16}$in Perspex sheet and has gradulations every 5mm. To make the scribed markings clearer, they may be filled with indian ink, the surplus of which can be wiped off after it has dried.

The green filter is recommended if the oscilloscope is to be used in daylight. It is made of green gelatine which is manufactured by Strand Electric Co. Ltd., and the four holes in this are best made with an ordinary office paper punch.

To retain the graticule and filter four 2BA hank bushes are fitted to the front panel before painting, as can be seen from the panel drawing, Fig. 3.

Timebase Switch

Details of the timebase switch are shown in Fig. 6. The switch can be made to order from most leading manufacturers of wafer switches. In the model shown, the switch uses the N.S.F. "Oak" wafers type H, which have been found to be the most suitable. If constructors prefer, standard 2-pole 5-way wafers may be modified to suit.

The components associated with this switch are mounted between the live tags of one wafer and the dummy contacts of the other. Care must be exercised in positioning these as the chassis depth is limited.

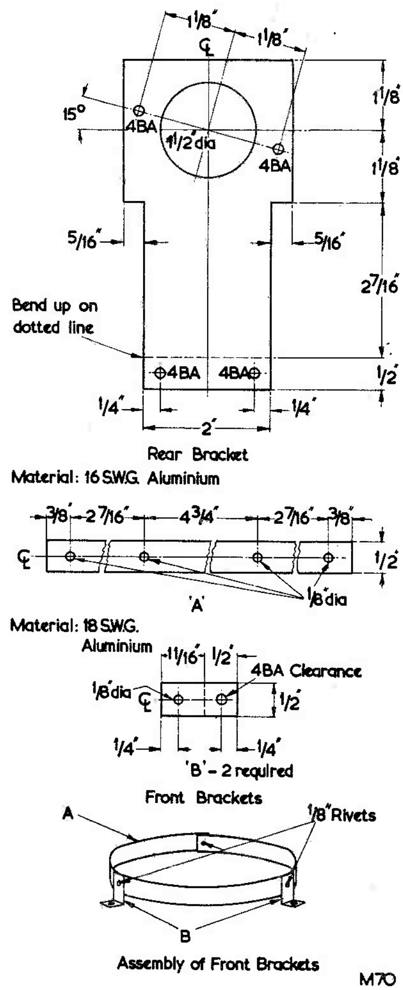


Fig. 4. Tube mounting brackets

Assembly

Before the various components are assembled "Panel-Signs" may be positioned on the front panel. After fitting the sockets to the front panel, the chassis is attached by the bushes of the "X-Gain" and "Y-Gain" potentiometers and the timebase switch. The other front panel control, tube support and graticule may then be fitted. Before commencing with the wiring the other fixed components should be mounted on the chassis. Although the position of individual components is not critical, it is recommended that the suggested layout be followed as closely as possible, as it will be found that the components will then more readily fall into place.

There are very few points which need to be mentioned with regard to the wiring of the instrument. It should be remembered that the prevention of damage to the germanium diodes can be ensured by the use of a pair of pliers as a heat shunt while soldering the connections.

A neat appearance to the various wires which feed the potentiometers on the front panel can be given by binding them together with waxed thread.

The lead from the EF80 timebase oscillator valve (V5) to the potentiometer (RV_{43}) should employ screened wire to avoid spurious hum pick-up.

Performance Checking

The brilliance control should be turned to a minimum before switching on, then advanced to a suitable level after a sufficient time has elapsed to permit warming up. The trace may then be focused, and the X-gain control should increase its length when turned clockwise. Similarly, movement of the shift control should displace the trace in the appropriate directions.

With the timebase controls turned to their extreme low-frequency positions, a lead connected between the Y-input and the 1-volt calibration point should permit several cycles of the 50 c/s waveform to be displayed. Upon advancing the Y-gain control to its maximum, the trace should just occupy the whole height of the screen. A lead connecting the "Sync. Int." to the "Sync. Ext." socket should enable the trace to be synchronised. If the fine frequency potentiometer is now advanced, several positions at which the trace is stationary will be obtained.

The Y-amplifier response should be about 3dB down (i.e. 0.7 x its low frequency value) at about 2.5 Mc/s, and this can be checked using the unmodulated output from a signal generator. The output of the generator should be terminated by an 82Ω resistor and connected to the Y-input socket. With a suitable output level from the generator, and the Y-gain set at maximum, the trace should not shrink to less than 0.7 of its value at 300 kc/s when the frequency is increased to 2.5 Mc/s.

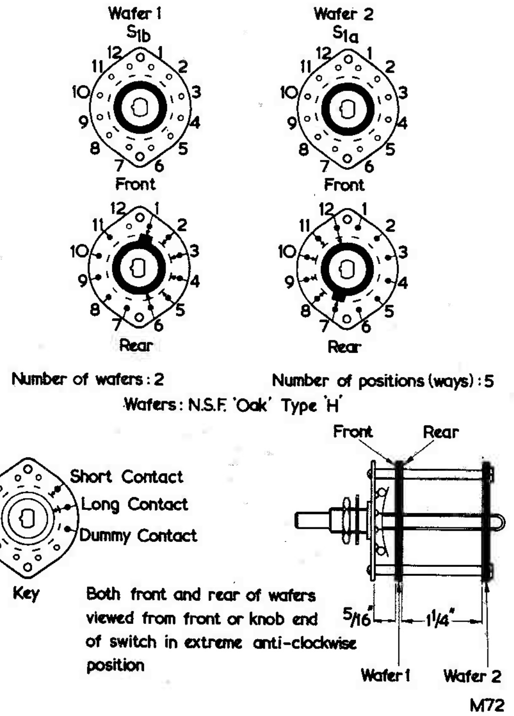


Fig. 6. Timebase switch details S_{1a}, S_{1b}

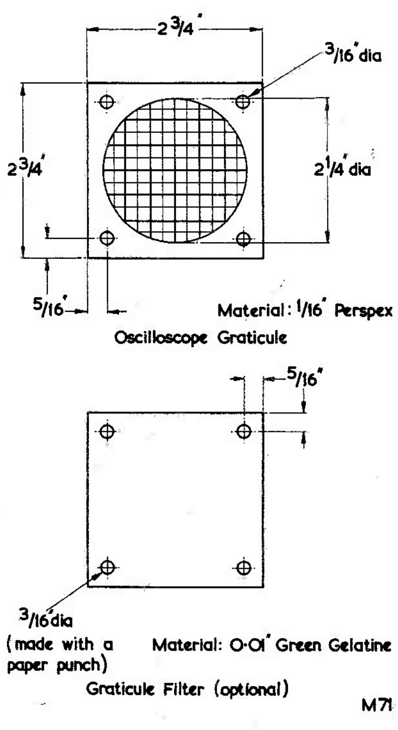


Fig. 5. Oscilloscope graticule and filter

If the oscilloscope passes these tests, its performance may be deemed satisfactory; but to assist in diagnosing possible faults, the voltages measured at various points in the circuit are set out herewith.

Voltage Table

	Meter Reading (Volts)	Meter Range (Volts)
V_1 cathode	310	1,000
Junction R_6–C_3	300	1,000
Junction R_7–C_3	300	1,000
Junction R_8–C_4	200	250
Junction R_9–C_4	105	250
CRT a_1, a_3 (pin 8)	310	1,000
CRT a_2 (pin 4)	–100	250
CRT g (pin 2)	–240	250
CRT k (pin 3)	–200	250
V_2 k_t (pin 8)	41	100
V_2 a_p (pin 6)	81	100
V_2 k_p (pin 7)	1.5	10
V_3 a_p (pin 6)	166	250
V_3 k_p (pin 7)	3.1	10
V_3 a_t (pin 1)	125	250
V_3 k_t (pin 6)	75	100
V_4 a′ (pin 6)	120	250
V_4 a″ (pin 1)	115	250
V_5 a (pin 7)	150	250
V_5 g_2 (pin 8)	215	250
V_5 g_3 (pin 9)	50	250

The above readings were taken with the timebase running at 50 c/s and with no input to the Y-amplifier. The brilliance and focus controls were adjusted to give a normally focused trace. They are typical of the values which may be encountered; but some viariation is to be expected.

These voltage measurements were taken with an Avometer model 8 (resistance 20,000 ohms per volt).

(To be continued)

Answers to Valve Codes (*see page* 57)

GZ32	5 volt full wave rectifier, octal base (Mullard).
X78	Frequency changer. (Marconi).
1T4	1.4 volt, 4 electrode. (American.)
6D2	6.3 volt diode. (Mazda.)
PCF80	0.3 amp, triode-pentode, B9A base. (Mullard.)
UU8	Full wave rectifier. (Mazda.)
12AX7	12.6 volt, 7 electrode. (American.)
KTW61M	Variable-mu, metallised pentode. (Marconi.)
EABC80	6.3 volt, triple diode triode, B9A base. (Mullard.)
6SK7G	6.3 volt, single ended, 7 electrode valve with large glass envelope. (American.)
N66	Output pentode. (Marconi.)

A small Bass Reflex Enclosure suitable for the "Axiette" loudspeaker

by M. J. PITCHER, B.SC.

IT GOES WITHOUT SAYING THAT A GOOD AMPLIFIER deserves a good loudspeaker, yet how many constructors give their speaker as much priority as the rest of the equipment in their budget? There is no doubt that a good loudspeaker with almost any amplifier may sound better than an inferior one with the very best system. There is, in consequence, a good case for considering the speaker before building, or buying, the associated amplifier.

Economy is the factor which generally weighs against the provision of a satisfactory speaker system; considerations of cost, size, performance, and decorative value are bound to conflict on a tight budget—so why not build your own?

The main problem with Hi-Fi reproduction is to produce sufficient bass of reasonable quality and the enclosure described in this article meets this requirement very effectively. The Axiette speaker* was chosen for the enclosure because of its wide frequency range, but methods of adapting the enclosure for other speakers will be explained.

Construction

The form of construction is to screw pieces of wood all round two large panels, which then become the top and bottom of the enclosure. (Fig. 1.) The pieces of wood are set in by their thickness so that, when finally assembled, the enclosure has great rigidity. The joints can be glued if desired, but do not glue the back in position because it may be necessary to make an alteration to the interior some time later.

The ⅜in plywood panels specified in Fig. 1 may seem to be too thin to keen students of Hi-Fi literature, but prolonged listening tests have shown that the material can be recommended without reservation. Liberal use of screws is, however,

* The Axiette speaker is manufactured by Goodmans Industries Ltd., Axiom Works, Wembley, Middlesex.

essential and there should be very few left from a gross box when the enclosure is finished. When the author bought his timber there were two "offcuts" of ½in chipboard standing by. One was used for the back and another to stiffen the front, so that any constructor wishing to get exactly the same results as shown in the response curves will need to include similar pieces.

In Fig. 1 the round hole in the front panel is, of course, intended for the speaker. The rectangular hole is the vent.

Now for a practical point that will make all the difference to the finished job: obtain the plywood cut to size. Most do-it-yourself timber suppliers have an electric saw and can produce the panels true to size, with nice square edges, in a fraction of the time that it will take at home on the kitchen table. The slight extra charge is money well spent.

Another difficulty is that of making the holes in the front panel. These can be cut with a fretsaw, or a power tool if one is available. Here again many timber shops have a power tool and will cut the holes, if required. This is worth asking for. If a double panel of ⅜in ply and ½in chipboard is used, see that they are correctly located together and firmly pinned, then cut through both panels.

Mark the position of the square pieces of timber using the panels to gauge them in from the edge. Drill through the panels at about 3in intervals with a No. 29 drill, this will give clearance for No. 6 screws. Countersink the holes and start assembly. A considerable saving of time and effort may be effected here by the use of a Yankee "pump" screwdriver.

Finishing-off the Enclosure

The box-shaped lump of wood made so far has not yet been tuned, but it can already give a good account of itself. However, for acceptance by the family, it needs to be converted into an item of furniture!

Paint or plastic contact film finishes are quite satisfactory but, for a touch of real luxury, use Formica. This material has a pleasing appearance and will last for ever; it is also easy to apply using a latex adhesive. It may be just as well to buy the Formica slightly oversize and reduce it with a plane, or rasp, after sticking it on the box. For a further touch of luxury the front of the box can be covered with expanded aluminium, the edges of this being retained with a half-round rebate moulding. The moulding can be given two coats of clear varnish for a light finish. This is the finish given to the enclosure shown in the photograph, which was fitted also with legs. The enclosure illustrated can be used as an occasional table or television stand, and its dual-purpose function makes the construction all the more worthwhile.

Bass Reflex—How it Works

Let us imagine that a new speaker is bought, taken out of its wrapping, and connected to an amplifier. Reproduction will lack both volume and bass, and even the most expensive unit will sound horrible. The simplest method of improving matters is to cut a hole in the centre of a large sheet of thick plywood and mount the speaker behind it. The ply acts as a baffle at low frequencies so that the air being pushed one way by the cone cannot interfere with

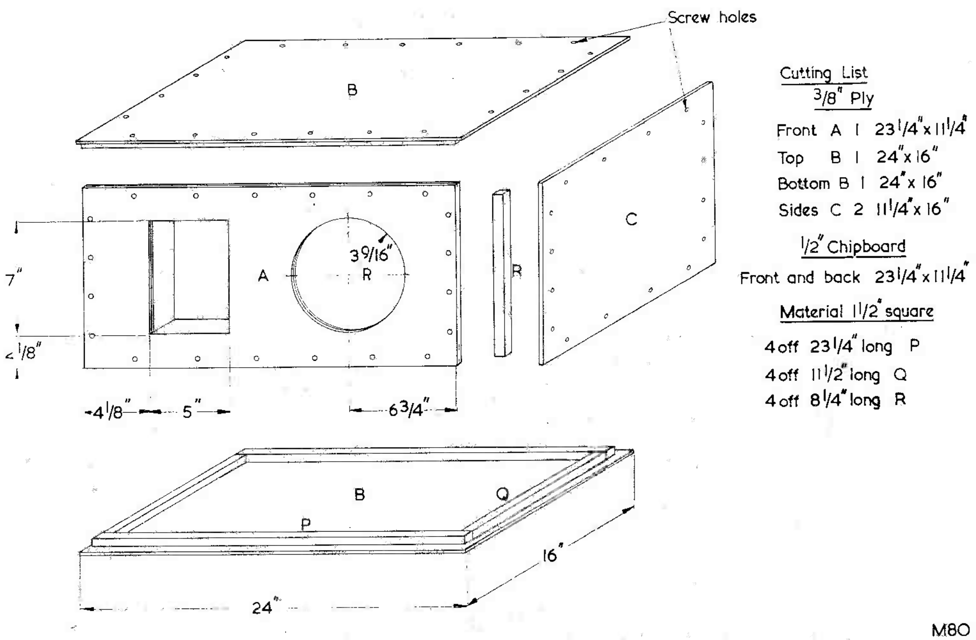
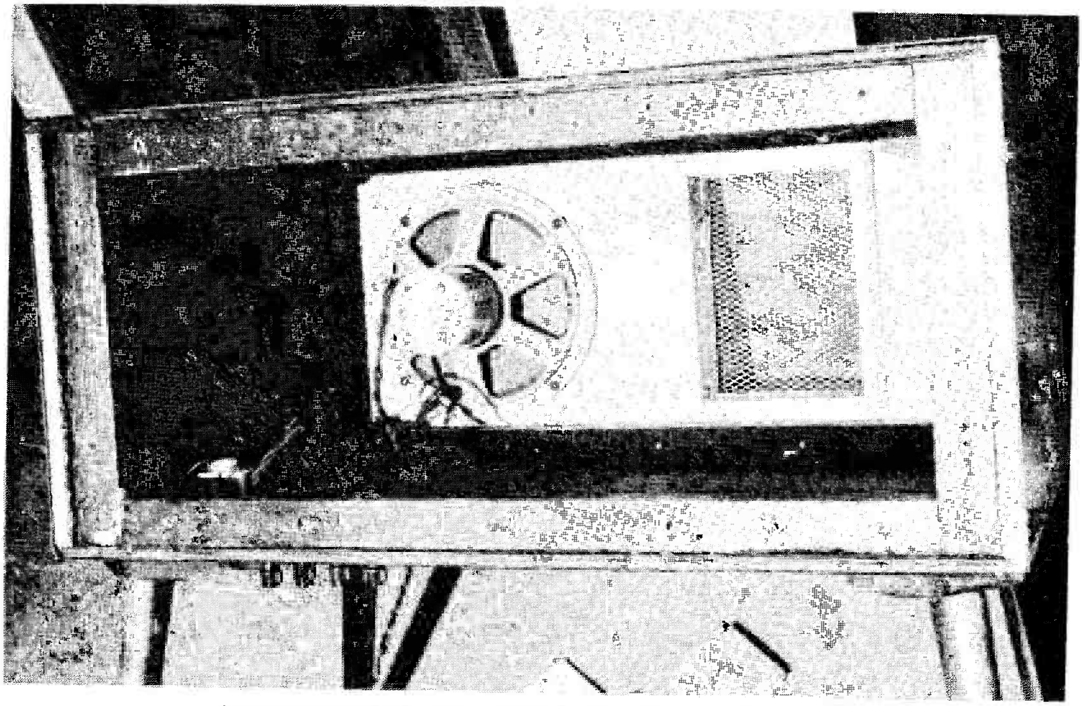


Fig. 1. Exploded view of the bass reflex enclosure



Interior view of the Small Bass Reflex Enclosure constructed by the author

the pulling movement on the air at the other side. This effect is low frequency "phase cancellation"; and it follows that a large baffle will give a good front to rear separation and, hence, an improvement in the bass.

Most people find that a really large plain baffle is difficult to fit into a normal living room. By folding the edges of the baffle round to make a box we arrive at the conventional form of loudspeaker enclosure. Thus a large box, acting as a baffle, produces bass reasonably well provided that it is fairly shallow.

Suppose now that the back of the box is closed by fixing another panel. The front and rear of the

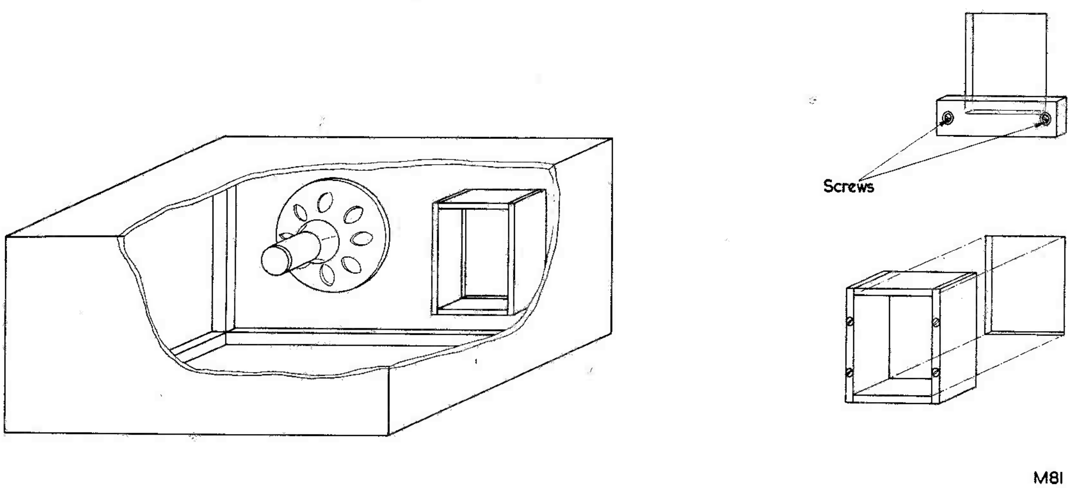
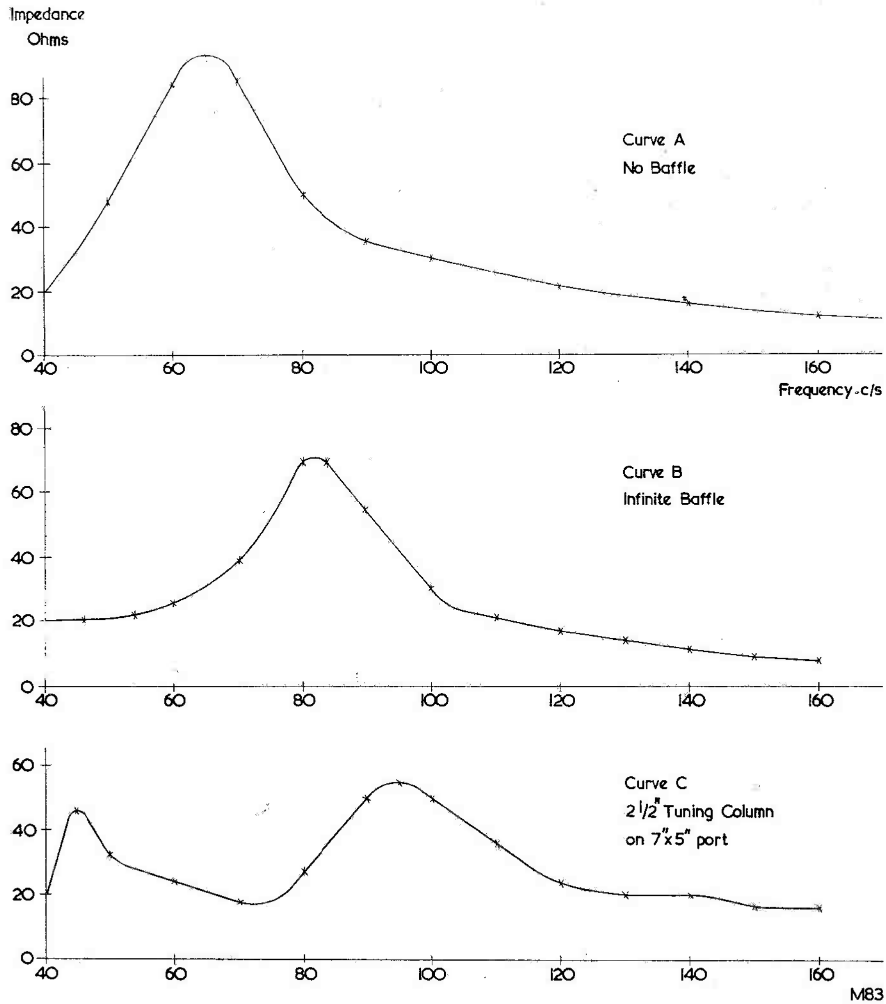


Fig. 2 (left). Cut-away section showing tuned vent.. Fig. 3 (a) (top right). Tuning the vent by partial closing. Fig. 3 (b). Tuning column speaker are completely separated, and it might seem that perfect bass should result. A completely closed box makes an "infinite baffle" and there are many such enclosures on sale. The bass response is quite good if your ear is not too critical. The enclosure described in this article can be used as an infinite baffle by closing the vent with a piece of wood. There will be lots, and lots, of bass but a check with a signal generator will reveal that it is

size of the hole, or by fitting a tuning column or pipe projecting back into the enclosure. Note that decreasing the size of the hole lowers the resonating frequency as does the addition of a column.

Tuning the Enclosure

The possibility of tuning the enclosure gives an improvement in sound quality compared with a plain baffle or box. Accurate tuning is quite out of



not all at the same strength, some frequencies receiving undue emphasis.

A hole, or vent, bored in the side of the baffle does more than let air move freely through it. The box now acts as a resonator in the same way as a whistle is produced by blowing across the open end of a fountain-pen top. The latter resonates at a high frequency and the box at a low one; moreover the box can be tuned over a small range by altering the

the question for the average amateur, however, for it is futile to attempt to produce a reliable response curve in the absence of a completely "dead" room and very expensive calibrated equipment. The best that can be done is to take some measurements from which generalised deductions can be made to assist the production of good quality sound. So if the reader feels moved to experiment along the lines suggested here, more weight should be given to what

The sort of response to aim at is as shown in curve C, with a slightly higher peak at the higher frequency. This will result in sound being given where it can be heard and will limit the vibration of the cone at the lower less audible frequency.

A 10in speaker can be mounted in the enclosure by fitting it in one of the wider panels; results will be good but a larger speaker merits a larger enclosure. There is, after all, no substitute for a really large enclosure and this design is a compromise between size, cost and high quality from an 8in speaker. The writer would emphasise that the bass response with the present assembly is very good indeed and that the treble response is excellent though, naturally enough, very directional. (For example, needle scratch and tape hiss disappear when one moves to one side of the speaker.) For best results the enclosure should be near, or facing into, the corner of the room. This will further improve the bass and give a better distribution of treble.

Matching Transformer

The Axiette speaker is supplied with either 3 or 15Ω impedance. With equipment of the same output impedance there is no problem, but if, like the writer, you have a mixture there is a very simple solution. It is to fit an output matching transformer inside the enclosure with four terminals projecting through the base so that connection is easy. The Wharfedale matching transformer WMT1 used with the Axiette seems to produce no audible distortion or ill effects of any kind. (See Fig. 6.)

One final word. The bass efficiency of the enclosure is high and any hum in the amplifier will be revealed in good measure if it exists. So be prepared to carry out one or two overhauls if you are intolerant of hum.

Cambridge Underwater Research Expedition

Marconi Marine Equipment Chosen for "Titania"

Fifteen members of The Cambridge University Underwater Exploration Group, aboard the motor yacht *Titania*, will leave Poole Harbour within the next few days bound for the Mediterranean and four months of underwater archaeological research. The main scientific objective of the expedition is to make a new set of readings of the changes in the Mediterranean sea-level since the early ice age, using a new technique recently developed at Cambridge. All fifteen members of the expedition—geologists, archaeologists, zoologists and anthropologists—are fully trained and experienced divers.

A series of eight half-hour documentary films will be produced for B.B.C. television from a film which is to be made by three experienced underwater cameramen accompanying the expedition.

The *Titania*, which will be the home of the Group members for four months, is a 138-ton, twin-screw diesel yacht, of all steel construction, equipped with battery-operated radar and echosounding equipment. Marconi Marine's "Consort" radar and two Marconi-Ferrograph "Offshore" echometers will be used primarily in the navigation of the *Titania* on her passages to and from the Mediterranean, but one of the echometers is a portable model for use in plotting the cross-sections of underwater caves. Once accurately charted, the caves will be thoroughly explored by the divers, fully equipped with underwater scooters, diver-to-diver intercommunication equipment, portable decompression chamber and a zoological laboratory.

The Cambridge Underwater Group members hope to collect valuable scientific information from the exploration and excavation of more than forty sunken caves, diving to depths of up to 200 feet. They will seek specimens of ancient organic matter and evidence of early human occupation which, after suitable processing and testing with radioactive Carbon 14, may give a date when the caves were at the surface. It is hoped that the information about changes in sea-level over the ages will throw new light on the possibility of any future rise in sea-level which might affect low-lying countries.

The expedition—the fourth of a series of research projects organised by N. C. Flemming, B.A., F.R.G.S.—is sponsored and supported by a number of distinguished organisations including The Royal Geographical Society, The National Institute of Oceanography and The Department of Scientific and Industrial Research; and by many private individuals, among them Sir E. Bullard, F.R.S., Prof. H. Godwin, F.R.S. and Prof. J. Toynbee, M.A.

Television Society to organise Colour TV refresher course

Following the current interest in colour television which has been stimulated by recent Recommendations to The Pilkington Committee, and discussions in the press, it has become apparent that many people will, in the course of the next few years, become associated with the growth of this new medium.

Many people who are now familiar with black-and-white television may soon be facing unfamiliar techniques in colour television. With this in mind, The Television Society has organised a refresher course on Colour Television, details of which are given below:

A refresher course of six lectures on colour television will be given on the six consecutive Monday evenings between 18th September and 23rd October, 1961, in the large Lecture Theatre at the London School of Hygiene and Tropical Medicine.

The course of lectures will cover a description of the N.T.S.C. system, transmission problems and receiver problems. The lecturers will be Mr. S. N. Watson, B.B.C. Designs Dept., and Mr. G. B. Townsend and Mr. P. Carnt of the G.E.C. Hirst Research Centre.

It is hoped that practical demonstrations of colour television will be included during the series.

The lectures are being organised by The Television Society, the members of which will be charged £1 1s. 0d. for enrolling for the course, while non-members will be charged £2 2s. 0d. Early application for enrolment forms from The Television Society, 166 Shaftesbury Avenue, London, W.C.2 is advised.

COURSES OF INSTRUCTION

The following classes organised by the East London R.S.G.B. Group, in conjunction with the Essex County Council, are available for all those interested in amateur radio.

Radio Amateurs Examination Course

1. Wednesday, 7.15 to 9.15 p.m. 8 month course for those intending to take the examination.
2. Thursday, 7.15 to 9.15 p.m. This course is for those who possess a basic knowledge of electricity and magnetism—2 year course.

Morse and Codes of Practice

3. Monday, 7.30 to 9.30 p.m. 6 month course for those who wish to learn morse up to G.P.O. requirements for an amateur licence.

Venue for the above classes: The Ilford Literary Institute, High School for Girls, Cranbrook Road, Ilford. It is adjacent to Gants Hill Station on the Central London Tube, and buses pass the door.

Fees for those living in the Essex County Council area are: 30s. for the R.A.E. Courses; 20s. for the Morse and Codes of Practice; 35s. for both courses. Students from other parts of London will be admitted as out County students provided the local authority is notified.

Enrolment nights—4th to 7th September, 1961, 7–8.30 p.m. Classes commence week beginning 18th September, 1961.

Those interested should, in the first instance, write to: Mr. C. H. L. Edwards, A.M.I.E.E., A.M.Brit.I.R.E., 28 Morgan Crescent, Theydon Bois, Epping, Essex, for the reservation of a place. A stamped addressed envelope should be enclosed for reply.

A Crystal-controlled Oscillator for F.M.

by Sir John Holder, Bt. — Part 1

CRYSTAL CONTROLLING THE LOCAL OSCILLATOR OF a frequency-modulated broadcast receiver confers two great benefits on the amateur. Firstly, it makes alignment extremely easy and secondly, if properly arranged, it prevents crackling and "frying" noises which arise when switch contacts or variable condenser spindle contacts become oxidised or worn with use.

Alignment

When an amateur who has no access to a signal generator attempts to align a normal f.m. tuner, he encounters the difficulty that, theoretically at least, there are an infinite number of combinations of oscillator and intermediate frequency coil settings which will allow a signal to be heard, whereas only one pair of settings is correct.

A crystal oscillator is locked to the correct frequency so that, provided the oscillator circuit setting is somewhere within the range where the crystal can exercise control, a B.B.C. transmission will, after passing through the mixer, emerge at exactly 10.7 Mc/s (except of course, for the modulation swing on either side of this frequency).

The amateur, therefore, has only to align the intermediate frequency transformers so that they centre on this frequency. In fact, there are those who claim to be able to do this by ear, though it is better to measure the d.c. voltage of the automatic gain control. For this, a comparatively cheap voltmeter will suffice.

One can also dispense with the automatic frequency control valve, because such circuit variations which take place during warming-up are well within the limits of crystal control.

Freedom from Switch or Condenser Noise

In the case of a normal oscillator, slight momentary switch or condenser contact variations will cause a change in the conditions under which the oscillator valve is working. These will in turn cause frequency deviations which will be rendered audible by the discriminator or ratio detector.

A crystal will still hold the oscillator to the correct frequency even though these changes occur, so that no noises will be developed. In fact the author has successfully used a switch which, when employed with a normal oscillator, completely spoiled the enjoyment of broadcast entertainment.

Overtone Crystals

A crystal vibrates mechanically at a certain frequency. Hitherto, it has been too difficult and costly to make one which is small enough to vibrate at the high frequencies required for the reception of f.m. transmissions. Crystals vibrating at lower frequencies have been used in conjunction with frequency doubling circuits. With these, it is difficult to filter out unwanted frequencies. Messrs. Standard Telephones and Cables Ltd. have recently developed a quantity-produced crystal which will, if suitably encouraged, vibrate on its 5th overtone at 10.7 Mc/s below the radiated frequency of a B.B.C. f.m. transmission.[1] The encouragement consists in providing, somewhere in the oscillator loop, a coil-condenser circuit peak-tuning at approximately the required frequency.

Actually, the assembly contains three crystals contained in a valve envelope and combinations for the B.B.C. transmissions in each area can be obtained.

The Circuit

The S.T.C. crystals behave as series-resonant combinations of inductance and capacity, so that they will allow the desired frequency to pass through them but will exhibit a comparatively high degree of rejection to other frequencies.

Messrs. S.T.C. Ltd. suggest two alternative applications.[2] In the first, the crystal is interposed in the feedback from anode to grid of a normal type self-oscillating mixer, whilst in the second, a separate crystal-controlled oscillator is used.

In spite of its simplicity, the first circuit is a difficult one to "get working". With the second the constructor obtains, for the price of a double triode valve, something which, provided he grasps certain fundamental requirements, is remarkably easy to "get working". Reduced to its essentials, the second circuit is seen in Fig. 1.

It consists of a grounded-grid amplifier valve V_1, tuned anode coupled to a cathode-follower valve V_2, the output of the latter being fed back to the cathode of V_1 via the crystal. The tuned-anode circuit C_1, L, ensures that only regeneration on the correct overtone of the crystal can take place.

[1] This is the Standard Telephones & Cables crystal unit type 4434. A suffix letter corresponds to the B.B.C. transmitter with which the particular unit employed should be used.

[2] Leaflet MQ/104, *Quartz Crystals*, published by Standard Telephones & Cables Ltd.

The values of R_1 and R_2 are important. If regenerative conditions are sufficiently great any crystal oscillator will "spill over the top" and oscillate at a frequency which is controlled by the tuned circuit (in this case C_1, L) instead of by the crystal. By matching the output of V_2 and the input of V_1 to the crystal impedance, the maximum ratio of wanted frequency feedback to unwanted frequency feedback will exist.

For correct matching, R_1 and R_2 should each have a value of 150 ohms. Unfortunately this value of cathode resistor will not be high enough to prevent some valves from drawing more than their maximum rated anode current. Raising R_1 and R_2 to 220 ohms and raising R_3 from the suggested 27kΩ to 270kΩ was found to hold the valve within the rated anode current, provided that the h.t. voltage was not too great. R_4 was added to control the latter.

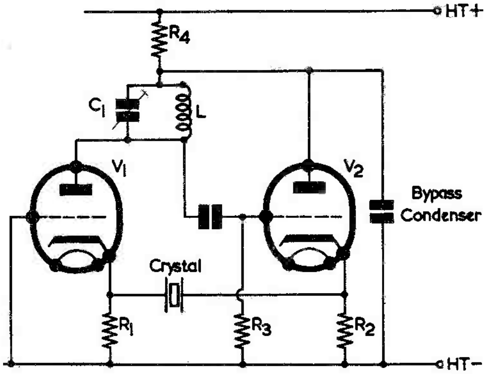


FIG.1 M87

Oscillator Voltage

So far we have only considered part of the story. In order to obtain maximum i.f. output for a given signal input, any mixer valve requires that the heterodyne be injected at a certain voltage.

An amateur will not normally have the means of measuring r.f. voltages. Fortunately trial-and-error will suffice. The voltage of the oscillator output is partly controlled by the applied h.t. voltage and partly by R_1 and R_2. Increasing R_4 reduces oscillator voltage and increasing R_1 and/or R_2 increases it, but, as we have seen, if these are made higher than 150 ohms, crystal control will be diminished.

A triode mixer requires that the oscillator injection takes place at about 2 volts and it is a question of choosing, by trial-and-error a suitable value of R_4, as indicated by results. A pentode mixer usually requires about 4 volts. Now the output of a crystal oscillator is one of quality rather than quantity, so to speak, and to feed a pentode satisfactorily, it must be worked at the upper limit.

By using a valve which has a high amplification factor and, moreover, one which will stand working at a relatively high anode voltage in conjunction with a relatively low cathode bias resistor, together with careful choice of value for the latter, the desired end can be achieved.

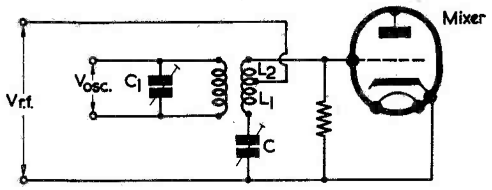


FIG.2a M88

One successful combination consists of a Mullard ECC85 valve using the following values: R_1 and R_2 200 or 220 ohms and R_4 omitted. With these values the circuit is brought to a kind of threshold condition where it will oscillate irrespective of the crystal with alien settings of L, C_1; but, if the latter is adjusted anywhere within a comfortably wide frequency band centred on the crystal frequency, then the crystal will take full control. The output will be higher than that which would be obtained with R_1 and R_2 adjusted for optimum crystal feedback and should be high enough for any requirements. Moreover, 200Ω is recommended by Mullard as a cathode bias resistor and there should be no danger of damaging the valve at the h.t. voltage which will be obtainable from the rail of any f.m. receiver.

Grid Resistor

The value of R_3 is not critical but should lie within certain limits. If it is as low as the suggested 27kΩ it will affect the L, C_1 circuit sufficiently to cause a loss of oscillator output. It can be made high enough to add additional grid bias to that given by R_2, if required; but if too high a value is chosen, C_2 will become charged highly negative and squegging will occur. The ECC85 will stand a value as high as 1MΩ, but for all-round work, 270 to 470kΩ is very satisfactory.

Injection

It only remains to feed the voltage developed across the tuned-anode circuit of the oscillator into the grid of the mixer by some method which will not either influence the tuning of the former or place such a load on it that the losses exceed the regeneration and cause the cessation of oscillation.

For this purpose, a bridge circuit which has been

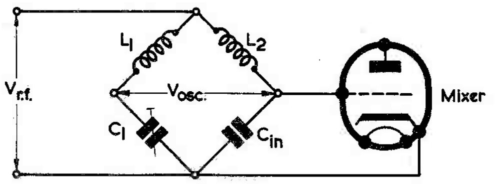


FIG.2b
Equivalent Bridge Circuit of FIG.2a
M89

described in *Wireless World*, and elsewhere, is ideal.[3] Fig. 2 shows the essential parts.

In Fig. 2, L_1 and L_2 are coupled to L of the oscillator tuned anode circuit, whilst C_{in} represents the grid-anode capacity of the valve plus strays. C is used to balance the bridge. Balance occurs when

$$\frac{C}{C_{in}} = \frac{L_1}{L_2}$$

An amateur may experience difficulty in adjusting a bridge and a simpler circuit will be described next month.

Oscillator Conditions

Apart from such things as faulty construction (causing i.f. feedback, etc) the oscillator can, if conditions be favourable, oscillate in three distinct ways:

1. *The correct way*

Characterised by complete silence of background and virtually no alteration in signal strength if the oscillator anode trimmer is rotated through several degrees.

2. *Oscillator tuned-anode takes charge*

As was mentioned previously, although the crystal exerts a strongly selective control on regeneration there is some regeneration at other frequencies and, if strongly selective conditions in other parts of the circuit are adjusted to a frequency other than the crystal frequency, they can override the later so that signals will be heard with other than the correct setting of the tuned-anode condenser.

The characteristics of this set of circumstances are: knife-edge tuning, great signal strength variation with only a small movement of the trimmer, the wrong programme for the particular switch setting may be heard (in fact a small trimmer movement will usually enable all three to be heard), "chirps" or whistles on one or more of the programmes, and microphonic noises when the tuner is touched.

3. *R.F. valve tuned-anode takes charge*

If the r.f. valve anode tuning slug is turned too far into the coil, or the condenser set to too high a value, the r.f. anode circuit may become tuned to oscillator frequency and take charge. The result is a howl which blots out everything. If this happens, the slug should be withdrawn (or tuning capacity decreased) to a position where a peak is found in the signal strength.

Adjustment

The foregoing description may sound, in the abstract, a bit frightening. Actually, the constructor will, after a little experimenting with the trimmers, very easily learn how to set up and recognise the three types of oscillation and, if he has constructed it properly, he will probably be surprised how "docile" the crystal oscillator is in comparison with others.

(To be continued)

[3] "Band II F.M. Unit", by L. Hampson, Mullard Ltd., *Wireless World*, August 1955.

The Vast-Rotor Story

A Ten-Year-Old Radar Secret Revealed

IN the immediate post-war years it became a matter of vital urgency to re-equip the Royal Air Force with new, ultra-sophisticated ground radar stations in order to bring Britain's air defences into a state of up-to-the-minute readiness.

The overall responsibility for the implementing of this colossal project was placed with the Marconi Company. Concealed in the code names "VAST" and "ROTOR", the task was carried out under conditions of absolute secrecy; only now, after ten years have elapsed, has it become possible to divulge some information on the circumstances under which the new chain of stations was built to cover the whole of the British Isles and their approaches.

In 1949 Marconi's were entrusted with the task of modernising a number of Air Ministry C.H. and G.C.I. stations as a matter of urgency. At the same time the Ministry put in hand a project which involved the design and construction of an entirely new radar chain employing the latest techniques and housed deep underground in concrete structures; this was to be backed by a large number of mobile radar convoys; the latter was concealed in the code name "VAST" and the former became "ROTOR".

In both these projects Marconi's were assigned the responsibility for the handling of the design of the radar equipment, the station planning, the installation and the testing, the whole to be carried out in the closest co-operation with the Air Ministry. The ROTOR stations were to be of three types—namely G.C.I., C.E.W. and C.H.E.L.

With the gigantic task of their design completed in record time the installation programme began in 1951, and whilst the number of stations involved still cannot be divulged it can be said that at one period up to 20 sites were in process of installation simultaneously with about 500 installation engineers working at capacity.

Further contracts followed as the magnitude of the project grew, with additional stations to give further cover to the approaches to the British Isles. Some of these, built on remote Scottish islands, posed considerable problems of transportation and access, but the whole of the VAST-ROTOR programme was completed in accordance with operational requirements.

With this unprecedented wealth of practical experience behind them Marconi's were well able to carry out subsequent major objects such as the design and layout of C.G.I. stations in Germany (again for the Air Ministry) and to cater for the very extensive radar requirements of friendly foreign powers as well as NATO. Currently a huge scheme for secret electronic equipment for the air defence of Sweden is among the many of the Company's commitments. This embodies ultra-modern techniques including the use of transistors, and colour and black-and-white television and, like the Bishop's Court installation, allows for the integration of military and civil flying requirements.

Transistor Power Supplies from Valve Equipment

by G. E. LEACH

HAVING RECENTLY BUILT A 3-TRANSISTOR PRE-amplifier for my audio system, I began to think of ways of powering it from the main amplifier rather than from batteries. Batteries are undesirable since either (*a*) separate on-off switches must be provided for main amplifier and pre-amplifier, or (*b*) a single switch must operate both mains and battery.

The pre-amplifier needs about 3mA at 9–12V d.c., the negative input lead being decoupled by a 1kΩ resistor and a 500µF condenser. The first idea is shown in Fig. 1. Since the h.t. supply would not be overloaded by an extra 3mA, a resistor R could

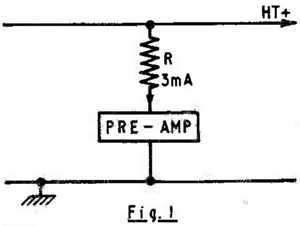


Fig. 1

E100

be provided to drop the h.t. to the required 12V, which would be smooth d.c. This idea was not tried because the transistor equipment needs a positive earthed supply.

In the circuit in Fig. 2, the normal connection of the transformer centre-tap to chassis was broken, and a resistor R inserted. The whole h.t. current of the amplifier flows through R, and a suitable choice of value gives the required voltage at the right polarity. When this circuit was tried it was found that the −12V point needed plenty of RC smoothing to reduce hum to an acceptable level. A moment's reflection showed that all the ripple current through the smoothing condensers flows through R, so that the −12V point has a high a.c. content.

The next step was to Fig. 3. Here, only smoothed d.c. flows through R, giving a smooth 12V across this resistor. To achieve this, the smoothing

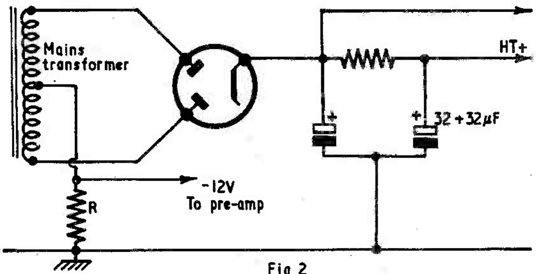


Fig. 2

E101

condensers must be isolated from the chassis. Since the case-chassis potential is only 12V, this is easily effected by means of a strip of "Sellotape" round the metal case inside the mounting clip.

For my amplifier, using two 6V6 valves in push-pull, a value for R of 150 ohms gave −10V. For

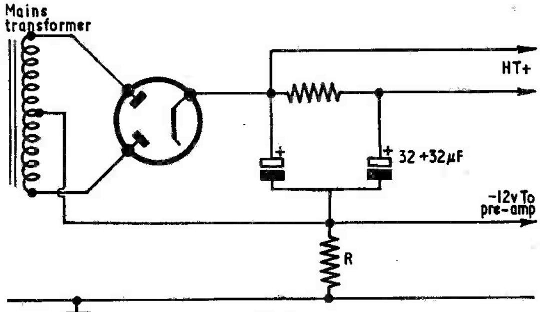


Fig. 3

E102

these operating conditions power dissipation in R is $\frac{V^2}{R}$ which equals 100/150 i.e. $\frac{2}{3}$ watt; so R should be at least a 1 watt resistor.

Two New TV Receivers by Stella

Flat screens with corners are a feature of two new t.v. receivers which have been released by Stella under the name STELLASCOPE.

Both the 19in model ST.1029U and the 23in ST.1023U have pre-set stops on the channel selector combined with pre-set automatic fine tuning, which enables quick and trouble-free switching to one or other of the local transmissions. Both cabinets have an African walnut veneer finish with a rich polyester protective gloss, and speakers located at the front.

The 23in model is 30½in wide, 18½in deep (including back plate) and 21in high. The 19in model is 25¾in wide, 15¾in deep (including back plate) and 17¾in high.

Optional extras for both receivers are a gold coloured stand with magazine rack and a telescopic aerial for strong signal areas.

An Inexpensive H.T. Unit

by
A. SPROXTON

THERE MUST STILL BE IN USE A LARGE NUMBER OF 4 valve portable receivers employing 90 volt h.t. batteries, as well as a considerable quantity of 1 and 2 valve Short wave battery sets. The most expensive item incurred in running these receivers is that of the h.t. battery, whose cost (for the cheaper types) is of the order of eight or nine shillings and whose life expectancy is around three months. Some small low cost mains transformers are currently available on the market and, since these offer a secondary voltage of some 135 volts, they are particularly well suited for use in mains units offering an h.t. voltage of 90 for battery receivers. Units of this type can, in consequence, obviate the expense of repeated battery replacements.

The mains transformers are small in size and can be mounted, together with the associated rectifier and smoothing components, in a small metal case measuring 3 x 3 x 2in. These dimensions compare favourably with those of a typical 90 volt h.t. battery such as the Ever-Ready B126 ($2\frac{3}{4}$ x 2 x $3\frac{7}{8}$in); whereupon the unit may be fitted inside the cabinet of a receiver in place of an h.t. battery of similar or

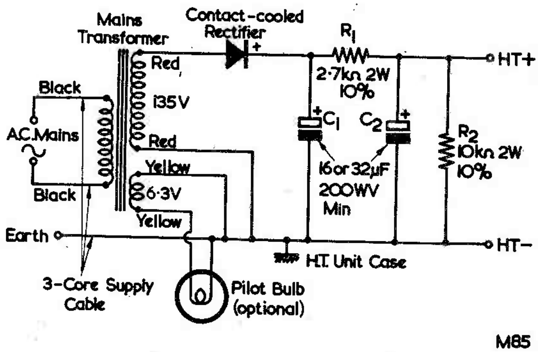


Fig. 1. The circuit of the h.t. unit. The contact-cooled rectifier should have a minimum current rating of 30mA. The diagram shows the colour coding of the fly leads from the mains transformer. The green lead of the 3-core supply cable should be that providing the earth connection

larger dimensions. Alternatively, the components required may be mounted in a larger metal box provided by the constructor, with a significant saving in initial cost.

The mains transformers also have a 6.3 volt secondary. This may be ignored for the present application, or it may be used to power a 6.3 volt pilot bulb.

The Unit

The circuit of the unit is given in Fig. 1. As may be seen, the mains input is applied to the primary of the transformer. The 135 volt secondary of the transformer connects, via a contact-cooled rectifier, to the smoothing circuit provided by C_1, C_2 and R_1. C_1, C_2 can be separate 16μF components, or they may consist of a special small size 32+32μF dual condenser if it is intended to build the unit into the small metal case previously mentioned. There is little difference in performance with either value of condenser. Resistor R_2 helps to maintain a steady potential at the output terminals, and the component values in the circuit are such that an output of 90 volts is provided at a current of 10mA.

Fig. 2 illustrates the components fitted into the 3 x 3 x 2in metal case. Four rubber feet may be fitted at the base of this case, whereupon the screws securing two of these can be employed to anchor the mains transformer as well, using the lugs at the top of the shroud. The contact-cooled rectifier has to be bolted to the side of the case in order to allow dissipation of heat from this component. A chassis tag is fitted to one side of the case to take the negative connection of the dual electrolytic condenser, together with the earth lead of the three-core

Components List

Essential Items

1 Mains transformer, 135 and 6.3 volt secondaries. (Surplus Radio Supplies.)
1 Contact-cooled rectifier. (Surplus Radio Supplies.)
2 16μF electrolytic condensers, 200W.V. or greater.* (Surplus Radio Supplies.)
1 Resistor, 2.7kΩ, 2W, 10%.
1 Resistor, 10kΩ, 2W, 10%.

Additional Items

1 Metal case, 3 x 3 x 2in. (Home Radio, Mitcham, Ltd.)
1 Signal-lamp holder, type D.675/1. (Bulgin.)
1 L.E.S. bulb, 6.3 volts.
2 yds lightweight 3-core mains cable.
1 32+32μF electrolytic condenser, JF185F.* (Home Radio, Mitcham Ltd.)
1 3-way output socket. (Home Radio, Mitcham, Ltd.)
Rubber feet, Paxolin, solder tags, nuts, bolts, grommet, etc.

* The 32+32μF condenser is required instead of the two 16μF components when the unit is built into the 3 x 3 x 2in box.

mains lead. A second chassis tag is mounted under one of the nuts securing the output socket.

If the 6.3 volt winding is to be used, this may be connected to a pilot bulb mounted on the lid of the case, as shown. A Bulgin fitting type D675/1 provides a useful bulb mounting for this application.

Some of the connections to the transformer are not anchored to component tags. Such connections should still, nevertheless, be soldered, and they may be insulated by sleeving or good quality tape.

Metal boxes other than that shown in Fig. 2 may be employed, as the layout required is not critical. (A useful, and inexpensive box would be provided by an Oxo tin.) It is essential, however, that the contact-cooled rectifier be bolted to the side of the box employed.

Operation

It will be found that the unit offers a steady and reliable source of supply. The h.t. negative output is common to the metal case in which the components are housed. In many battery portables, the receiver chassis is not at h.t. negative potential and care should be taken to see that the chassis and power unit case do not come into contact with each other. It may be found helpful, in some instances, to reverse the mains connections to the unit in districts where mains-borne interference is prevalent. It may also be desirable to earth the metal case of the unit via the three-way mains cable employed.

Cost

The function of a mains h.t. unit is to obviate the expense of continual h.t. battery replacement. With this unit a further saving is effected by the initial low cost of the mains transformer. If the constructor provides his own metal case, together with the essential components given in the Components List,

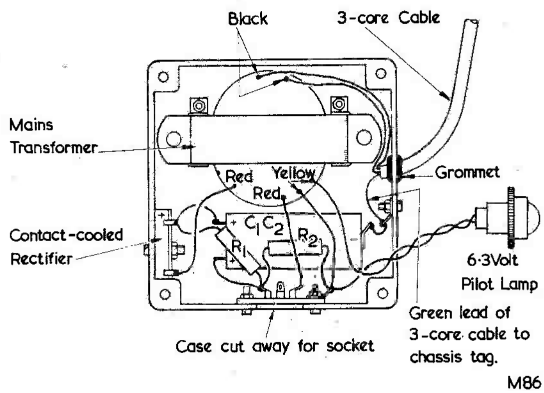


Fig. 2. How the h.t. unit components are fitted into the 3 x 3 x 2in metal case. The contact-cooled rectifier is secured by two bolts, one being below that shown. The centre tag of the socket is not used. The 3-core cable enters the box at a point approximately ⅝in up from the base, whilst the adjacent chassis tag is 1in up from the base. The top of the rectifier (excluding its tags) is some ¾in below the top of the case

the total cost would be approximately equivalent to that of two h.t. batteries, whereupon the unit would pay for itself within six months.

Pye receive contracts from Iraqi Ports Authority and . . . B.B.C.

A contract to the value of approximately £100,000 has been signed by the Iraqi Port Authority and Pye Telecommunications Limited of Cambridge for the supply and installation of a v.h.f. and u.h.f. radiotelephone network for the following services:

(*a*) V.H.F. telephone services at Margil for Basrah Airport; the Ports' Ambulance; Fire-fighting Units; Electricity Distribution Department and the Maritime Services.

(*b*) Four other v.h.f. communication systems for the Maritime Services at Al-Wasillah, Fao, the Deep Water Berth and Um Qasir.

(*c*) A u.h.f. telephone link between Fao and the Deep Water Berth and a v.h.f. telephone service aboard the Ports' Maritime vessels is also included.

It is anticipated that the entire scheme will be fully operational early in 1962 and will be one of the most modern in the whole of the Middle East.

The contract was officially signed in Basrah by Colonel Khedar A. Abduljalil, D/Director General of the Iraqi Ports Authority and Mr. H. W. Woolgar, Sales Director of Pye Telecommunications Limited.

The British Broadcasting Corporation has awarded a contract to Pye Telecommunications Limited, of Cambridge for the supply of four microwave links.

The Pye links will operate in the 7,000 Mc/s band and each will consist of a transmitting terminal, with two transmitters, and a receiving terminal, with two receivers. Automatic changeover facilities will be provided.

The equipment will be used to convey programmes to certain new low-power satellite television stations which are being set up to extend the coverage of the B.B.C.'s Television Service.

Pye Telecommunications Limited are supplying also to the B.B.C. a duplicated microwave transmitting terminal for installation at their North Hessary Tor station.

A Signal Tracer for Transistor Portables

By G. SHAW

Our contributor gives details of a simple signal tracer which has been designed especially for use with transistor portables

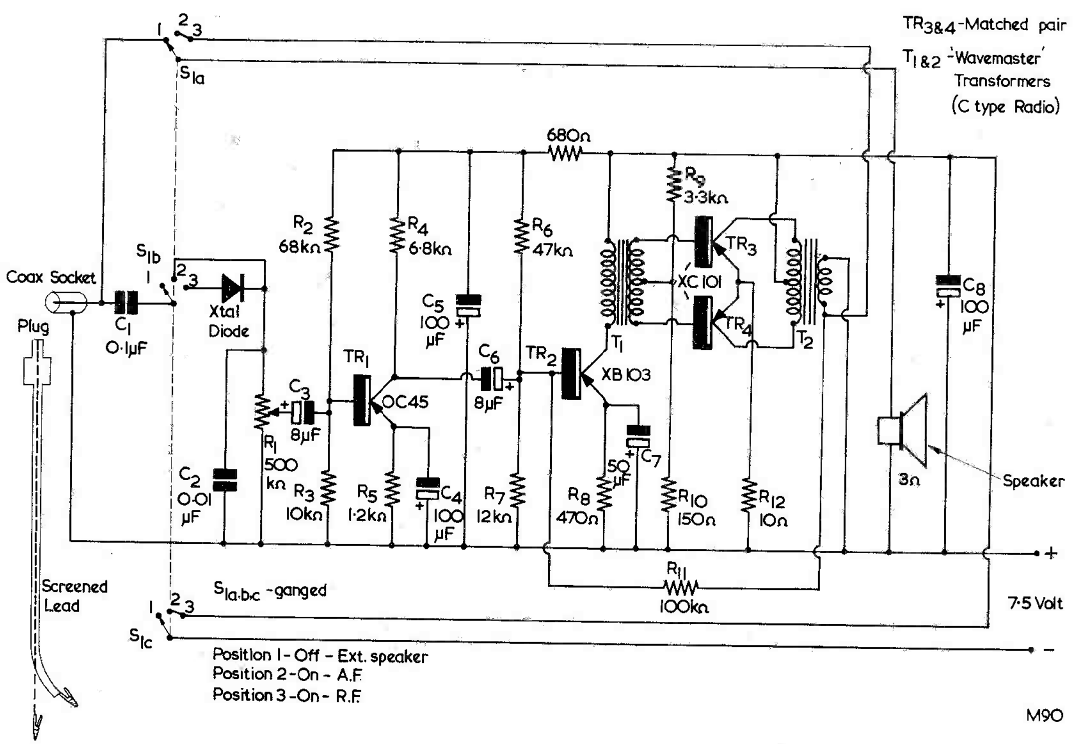
Some time before Christmas our service department, normally overworked, became even more so, with quite a few stock transistor sets sent in from our branches. Some of these were quite easy repairs, but one or two refused to yield their secrets. These were put on one side.

The fault in one set was found by the "stethoscope" principle; that is, by sensitive earphones and a diode probe. This method of testing would have been more satisfactory, however, if I could have had the department to myself. The competition from tape recorders, radios and t.v. sets, etc., made the weak sounds in the earphones almost inaudible.

It followed that I wanted something with which the wick could be turned up, so, on the following Saturday morning, I devised and built up the signal tracer whose circuit accompanies this article.* This proved to be so successful that I have not since attempted any improvements.

The Circuit

As may be seen from the diagram, the tester employs a three stage transistor a.f. amplifier. When S_1 is in position 1 the amplifier section is switched off, and the coaxial input socket connects direct to the 3Ω speaker fitted in the tracer. When S_1 is set



to position 2 the amplifier is switched on, the speaker is connected to the output transformer T_2, and the input is coupled, via C_1, to the volume control R_1. In this condition, the signal tracer functions as a straightforward a.f. amplifier. In position 3 the amplifier is switched on as before, but the input signal is now applied via a crystal diode. The unit is now capable of detecting any r.f. signal applied to it, the detected signal being fed, via volume control R_1, to the three stage amplifier.

The test input lead is a short length of thin screened microphone cable fitted with a coaxial plug at one end and crocodile clips at the other. The tracer has sufficient gain to enable a good signal to be obtained from the collector of a receiver mixer.

Application

The following offers a typical instance in which the tracer may be used with a conventional transistor portable which gives no output.

First check battery voltage and supply voltages to transistors. Then, with S_1 in the off position, connect the tracer input leads across the speaker. Next switch the tracer to position 2 (a.f.) and check for signal, working backwards, at the output transistor collectors, the output transistor bases, the driver transistor collector, the driver transistor base, the volume control, and the a.f. side of the crystal detector. Next switch to position 3 (r.f.) and check at the r.f. side of the crystal detector, and at the collectors and bases of the i.f. transistors back to the collector of the mixer transistor.

If signal appears at any point during the check just detailed the location of the fault will be obvious. If no signal is present, even at the collector of the mixer, the fault lies at a point in the circuit before this collector.

Other Uses

Apart from its function as a signal tracer, the unit has been found useful for other purposes as well. It can, for instance, check for equal a.f. drive and output voltages on the bases and collectors of push-pull output transistors. It has also been of considerable help in providing a quick check for microphones, crystal pick-ups, and similar equipment.

EDITOR'S NOTE

The circuit originally sent to us by our contributor employed transistors and transformers in the driver and output stages which may not be readily available to the home constructor. We have, in consequence, modified this part of the circuit to employ available components. There should be little difference in the gain offered by the two versions of the tracer. If the negative feedback signal, provided via R11, is in incorrect phase the amplifier will oscillate when it is first switched on—correct phase may then be obtained by reversing the connections to any winding of T1 or T2.

An OC45 is specified for the TR1 position, but it is probable that any small a.f. transistor would function adequately in its place.

Book Reviews . . .

HI-FI YEAR BOOK, 1961 Edition. Edited by Miles Henslow. 256 pages (including 69 pages advertising), 5½ x 8¾in. Published by Miles Henslow Publications Limited. Price 10s. 6d.

The Hi-Fi Year Book for 1961 provides a valuable source of information on audio equipment currently available, and will prove as useful to the professional engineer as it is to the amateur enthusiast. The book fully lists items of audio equipment, giving a detailed and concise description of each, together with its price. There are numerous illustrations.

An attractive feature is the manner in which items have been tabulated, the equipment having been divided into various categories according to type and function. Thus one "directory" of equipment is devoted to Pick-ups and Arms, another to Speaker Drive Units, and so on. Manufacturers are listed alphabetically in each directory, and a single manufacturer's name may appear in several parts of the book if the products cover different categories.

Before each directory appears a short article on the appropriate subject by a specialist contributor, and these articles provide an authoritative background to the lists which follow.

J.R.D.

TELEVISION RECEIVER SERVICING, Volume One, Second Edition: Time-Base Circuits. By E. A. W. Spreadbury, M.Brit.I.R.E. 362 pages, 5½ x 8¾in. Iliffe Books Ltd. Price 25s. net.

This is volume 1 of a comprehensive book (published in two volumes) covering the field of television servicing. This volume is concerned with timebase stages, whilst volume 2 covers all the other sections of the receiver. The second edition of volume 1, now under review, has been completely revised and rewritten where necessary, and the subject-matter includes short-necked 110° cathode ray tubes and their deflection assemblies, together with desaturated and 3rd harmonic line output transformers.

The volume is written for the service engineer and it assumes a reasonable knowledge of radio principles. The contents deal with all points in the timebase stages of British television receivers, from the sync separator to the line and frame deflector coils. A useful chapter describes flywheel sync line oscillator circuits, and gives examples of commercial circuits and techniques. Also of interest is the material describing the development of line output transformers from "narrow angle" to 110° circuits.

An attractive feature of the volume is the easy, down-to-earth style in which it is written; and it will be of especial value to the busy service engineer who works in a practical service shop.

J.R.D.

VALVE CODES

What do they mean?

THE EXTREMELY LARGE NUMBER OF TYPES OF valves which are now on the market make it extremely desirable that the code for each type should not merely distinguish that type from others, but should also convey certain information about the valve to any person who is familiar with the coding. The amount of information carried in a valve code is limited only by the desirability of keeping the code short so that it can easily be memorised. A system of letters and numbers is memorised rather more easily than a system consisting entirely of numbers. In addition there are 26 letters but only ten digits; codes employing letters therefore tend to be more flexible.

The information selected for the code should be that which any designer will wish to know when he is considering the possibility of using the valve in an item of equipment, for example: (*a*) heater voltage or current; (*b*) number and arrangement of electrodes; (*c*) type of base; (*d*) type of envelope; (*e*) high or low anode resistance.

Quite a number of methods of coding valves have been used in the past, but most new valve types now on sale in this country are coded under either the American or the Mullard (or "European") system. The Mullard system carries much useful information and has a great deal to commend it. It is also desirable that provision should be made for certain other electronic devices to be coded under normal valve codes; for instance, transistors can be coded using the Mullard valve code. The meaning of some of the more commonly used valve codes will now be considered in detail.

Mullard Code

Table 1 shows the meaning of the Mullard method of coding valves—a system which is also being used by some other manufacturers. The code commences with a letter indicating the heater voltage or, in the case of valves intended for use with their heaters connected in series, the heater current. If a person is designing a piece of equipment using a 6.3 volt heater supply, he need only consider using valves whose Mullard coding begins with the letter E. A good system of valve coding therefore helps to save the time of the equipment designer.

The letter or letters following the first show the general arrangement of the electrode structure. The

TABLE 1
The Mullard Valve Code

	First Letter (Heater)	Subsequent Letter
A	4 volts	Diode
B	—	Double diode
C	200mA, series connected	Triode
D	Battery, 0.5–1.4V	Triode Output Valve
E	6.3 volts	Tetrode (not output)
F	—	Pentode (not output)
G	5 volts	—
H	150ma, series connected	Hexode
K	2 volt (Accumulator)	Heptode or Octode
L	—	Output Tetrode or Pentode
M	—	Cathode ray indicator
N	—	Thyratron valve
O	Semi-conductor	—
P	300mA, series connected	—
Q	—	Nonode
U	100mA, series connected	—
X	—	Full wave rectifier, gas filled
Y	—	Half wave rectifier
Z	—	Full wave rectifier (but OAZ is zener diode)

Figures

1 to 19 various	50 to 59 B9G
20 to 29 B8G Loctal	60 to 79 sub-miniature
30 to 39 Octal	80 to 89 B9A (Noval).
40 to 49 B8A Rimlock.	90 to 99 B7G miniature.

meaning of the letters used is shown in the third column of Table 1. If two or more letters follow the first letter, the valve contains more than one section in a single envelope (e.g. the ECH35 is a triode hexode).

The first digit of the number following the letters shows the type of base (see bottom part of Table 1) but the second digit is merely a sequential number which is given to distinguish between valves which would otherwise have identical coding. If the number of the valve pins was used as the first digit of the number in an uncoded form, it would not distinguish between octal and B8A bases or between B9A and B9G bases.

The new Mullard "frame grid" pentodes have the usual coding, but, in the cases of the EF183 and the EF184, the code has to be extended by placing a figure 1 between the letters and the number because there are already a large number of 6.3 volt pentodes with B9A (noval) bases.

TABLE 2
Summary of the Modern American Valve Code

First Number

0	cold cathode	6	5.6 to 6.6 volts
1	Up to 1.6 volts	7	6.3 volts loctal
5	4.6 to 5.6 volts	12	12.6 volts approx.
		14	12.6 volts loctal
		35	35 volts approx.

Letters
Carry little or no information. (See text)

Final Number
Indicates the number of useful electrodes brought out to a separate external connection.

Suffix (if any)

G	Large glass bulb on octal base.
GT	Small glass bulb ("T9").
M	Metallised envelope on octal base.
X	Low loss base.
Y	Intermediate loss base.
W	Military type.
A to F	Modified versions of the valve; the letters are allocated in order to each modified version.

Mullard semi-conductor valves have codes commencing with the letter O (no heater). The second letter follows the usual coding, i.e. an A for diodes or a C for transistors. A serial number follows. Modern Mullard voltage stabiliser tubes have codes commencing with the burning voltage (e.g. 150B2). The letters AW or MW followed by a serial number represent, respectively, electrostatically and magnetically focused cathode ray tubes.

American Code

Almost all American valve manufacturers use the same (R.T.M.A.) valve code. In addition a number of valves made by certain British manufacturers (such as some of those made by Mullard and Brimar) are also marked in the American coding.

TABLE 3
The Marconi-Osram Valve Code

Letters

A	Valve with special industrial applications.
D	Diode or double diode.
GU	Gas filled rectifier.
GT	Thyratron.
H	High impedance triode.
KT	Kinkless tetrode or pentode.
L	Low impedance triode.
M	Metallised valve (usually at end of code).
N	Output pentode.
U	Rectifier.
W	Variable-mu pentode.
X	Frequency changer.
Y	Tuning indicator.
Z	Sharp cut-off pentode.

The letter(s) are followed by a serial number.

The code commences with a number which gives the heater voltage to within −0.4 to +0.6 volts, some typical values being shown in Table 2. The 7 and 14 volt loctal types are mainly intended to be used in car radio equipment. They have a higher heater maximum operating voltage than the normal 6.3 and 12.6 volt valves so that they will not be damaged by the higher voltage which is applied to their heaters whilst the car battery is being charged. It is unfortunate that the American code does not give the heater current instead of the heater voltage in the case of valves intended for series heater operation.

The first number is followed by one or two letters, these being allocated in sequence beginning with A. In the case of power rectifiers, however, the sequence commences with Z and proceeds backwards. When all of the letters have been used singly, two non-identical letters are then employed commencing with AB. If the number is followed by the letter S, the valve is a single-ended type (i.e. it does not have a top cap connection).

TABLE 4
The Ediswan-Mazda Valve Code

Number

1	1.4 volt	10	0.1 amp.
6	6.3 volt	20	0.2 amp.
		30	0.3 amp.

Letters

C	Frequency changer.
CRM	Television tube.
D	Diode or double diode.
F	Tetrode or pentode voltage amplifier.
K	Small thyratron.
L	Triode, tetrode or pentode voltage amplifier.
M	Cathode ray indicator.
P	Power amplifier.
U	Half wave rectifier.
UU	Full wave rectifier.

The above is followed by a serial number.

A further number comes next in the code. It shows the number of useful electrodes which are brought out to separate external connections. The heater counts as one electrode (unless it is tapped at a place other than the centre). An internal or external screen which is brought out to a separate connection counts as one electrode. If two electrodes are brought out to one valve pin (e.g. suppressor grid and cathode), the two together count as only one electrode for coding purposes. In almost all octal valves, pin 1 is connected to the screening, which counts as one electrode. For example, the 6J5 is a triode with a 6.3 volt heater, the five electrodes being: anode, grid, cathode, heater, screening. The information carried by the second number in the American code is certainly much less useful than that carried by the letter or letters following the first in the Mullard code.

Sometimes one or more additional letters are placed after the main part of the coding of octal valves, but they are often omitted. The purpose of these letters is to give some information about the external construction of the valve. For instance, the 6K8GT is a 6.3 volt heated triode-hexode with a small bulb having straight sides, whilst the 6K8G has the same electrode structure placed in a larger glass envelope with curved sides. Providing enough space is available, the two valves are interchangeable. Many American octal valves have been made with two or more different kinds of envelope including all-metal envelopes. The meaning of any suffix placed after the main part of the coding is shown in Table 2.

Gas filled voltage regulator tubes have a code commencing with VR followed by a number indicating the normal running voltage. The final number when added to the first number gives the approximate striking voltage, e.g. VR105/30 which strikes at 135V and stabilises at 105V.

Generally it can be said that the American code gives little useful information other than the heater voltage and possibly the external construction. Sometimes valves coded under the old American system are still found, especially in surplus equipment. In this code each valve is merely allocated a number which conveys no information whatsoever about the valve itself. Typical examples are the power tetrodes known as the 1622 and the 807—the latter being a valve much used in amateur transmitters.

Marconi-Osram Code

This code commences with one or more letters which are followed by a number. The letter(s) indicate the electrode structure of the valve and have the meaning shown in Table 3. Generally no further information whatsoever is given by the code, although in some cases the number following the letters indicates the approximate heater voltage or current. It is one of the few codes giving information as to whether a pentode is variable-mu or sharp cut-off.

Ediswan-Mazda Code

The system is very similar to the Marconi-Osram code except that it contains information about the heater. The code commences with a number indicating the heater voltage or current by means of the coding shown in Table 4, but in the case of rectifiers (e.g. UU5), this number is omitted. A letter indicating the general class of valve follows the number. The meaning of the letters is also shown in Table 4.

Brimar Codes

Most small Brimar valves used in ordinary radio work are coded in the American system, but two other codes are used:

(1) One or more figures followed by a letter and finally a serial number. The meaning is as follows:

1—half wave rectifier	A—4 volt heater
8—r.f. pentode	B—2 volt heater
9—variable-mu pentode	D—indirectly heated valve (not a 2 or 4 volt heater).
20—triode hexode	

(2) A complicated code for special valves giving very full information.

Services Codes

The armed forces use a very great number of valves and have their own coding system. Up to 1941 the three branches of the services used valves with different codings. Those used by the Army commenced with A, the Navy with N and the Air Force with V. In surplus equipment we still find valves with such a coding as ARDD5 (Army receiving double diode number 5) or ARP31 (Army receiving pentode number 31)—an equivalent of the Mullard EF39. The NR49 was the Naval equivalent of the EF36. The much used EF50 was known in the Air Force as the VR91 and in the Army as the ARP35.

Since 1941, however, all valves (and certain other electronic devices) used by the armed forces and government research stations have been coded under the CV system. This coding consists of the letters CV followed by a number which is allocated in sequence and which gives no information whatsoever about the valve. For instance, the CV140 is a double diode whilst the CV148 is an infra red image converter. Two or more CV numbers may be allocated to one type of valve if there are extremely slight differences in the specifications. Further letters may be added to indicate the date of manufacture.

Surplus valves which were intended for use by the American services are often marked with the normal American coding and a service coding. They usually bear the letters JAN (joint Army-Navy).

It is to be hoped that in future all valve manufacturers will mark their small radio valves with the same coding—probably the Mullard or European coding. Then it will no longer be necessary to remember that the EF91, Z77, 6AM6, 6F12 and the 8D3 all have virtually the same characteristics. Nevertheless the services will no doubt continue to know these same valves as the CV138 and its "reliable" version as the CV4014.

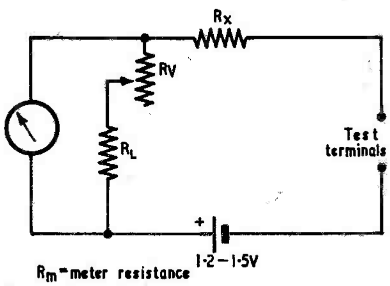
Readers may like to practice and improve their knowledge of the Mullard, Mazda, Marconi and American codes by writing down all of the information which can be obtained on the following valves from their coding. The answers may be found on page 40 of this issue. GZ32, X78, 1T4, 6D2, PCF80, UU8, 12AX7, KTW61M, EABC80, 6SK7G, N66.

An ACCURATE OHMMETER

By A. L. SHEPPERD

It is usual, in simple ohmmeters, to assume that the energising battery has either constant voltage and varying internal resistance or constant internal resistance and varying voltage. In the simple design described here, the latter is assumed.—Editor.

The usual form of simple ohmmeter suffers from an excessive error due to battery voltage variation. Such an ohmmeter usually consists of a fixed resistor, a variable (zero set) resistor, a 1.5 volt cell and a milliameter. With a 0–1mA meter having a resistance of say, 100 ohms, the combined series resistance would be 1,400 ohms when the battery



E110

voltage is 1.5. Half-scale deflection would then correspond to the insertion of a test resistor of 1,500 ohms. When the battery voltage falls to 1.2 the total series resistance would have to be reduced to 1,100 ohms. Half-scale deflection would then correspond to 1,200 ohms. The error is therefore 10% although this could be halved if the meter were calibrated at a battery voltage of 1.35.

A modified circuit, described here, will reduce the error to less than 0.5%.

The Modified Circuit

Consider the circuit of Fig. 1. R_x is the series ballast resistor, R_L the fixed shunt resistor and R_V the variable (zero-set) shunt resistor. Taking the meter resistance (R_m) as 40Ω, R_x as 970Ω, R_L as 80Ω, and R_V as 120Ω at a battery voltage of 1.2, and zero ohms at a battery voltage of 1.5, the total circuit resistance can be calculated as follows:

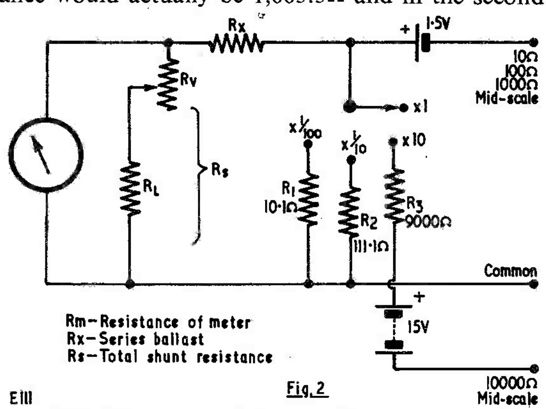
For a battery voltage of 1.2

$$\text{Total } R = 970\,\Omega \frac{40 \times 200}{240} = 1{,}003.3\,\Omega$$

For a battery voltage of 1.5

$$\text{Total } R = 970\,\Omega \frac{40 \times 80}{120} = 996.6\,\Omega$$

In both these instances half-scale deflection corresponds to 1,000Ω. In the first case the resistance would actually be 1,003.3Ω and in the second



E111 Fig. 2

case 996.6Ω giving a total circuit error of less than 0.5%. The lower the meter resistance the lower the error. In the case of R_m being 100Ω the circuit error would be a little less than 1%, which is still ten times the accuracy of the simple ohmmeter. Many

0–1mA meters have an internal resistance of less than 50Ω, in which case the total error is likely to be mostly due to error in the test resistor used for initial calibration and scale error in the meter.

The ohmmeter of Fig. 1 would be adjusted in practice by setting-up R_V, the zero set rheostat. Setting-up can be done in one of two ways. The first is the obvious one of short-circuiting the test terminals and adjusting R_V to read full scale (zero ohms). Alternatively a 1,000Ω resistor could be connected across the test terminals and R_V adjusted to read half scale.

With this ohmmeter the only calibrating device required is a 1,000Ω resistor of as high an accuracy as possible, certainly as good as 1%. 100Ω and 10Ω resistors of equivalent accuracy would also be needed if range extension is required.

TABLE

R_m	R_L	R_V	R_s	R_x
40	80	120	200	970
50	100	150	250	962.5
60	120	180	300	955
70	140	210	350	947.5
80	160	240	400	940
90	180	270	450	932.5
100	200	300	500	925

The Complete Ohmmeter

Fig. 2 shows the complete circuit including range extension. The total series resistance required must be such as to allow at least 20% more current to flow than is required for f.s.d. of the meter when the cell voltage has dropped to 1.2V. With a 1mA meter, allowing a current of 1.2mA at a cell voltage of 1.2 will give a half scale deflection resistance reading of 1,000Ω. R_s has to carry the excess current over 1mA throughout the life range of the battery. This is 0.5–0.2mA.

$$\frac{R_m}{R_s}=\frac{I_s}{I_m} \quad \therefore R_s=\frac{R_m\, I_m}{I_s}$$

At 1.5 cell volts R_s passes 0.5mA

$$R_s=\frac{R_m \times 1\text{mA}}{0.5\text{mA}}=2R_m$$

At 1.2 cell volts R_s passes 0.2mA

$$R_s=\frac{R_m \times 1\text{mA}}{0.2\text{mA}}=5R_m$$

Therefore $R_L=2R_m$ and $R_V=3R_m$.

It follows that at 1.5V, $R_V=0$ and at 1.2V, $R_V=3R_m$. Below 1.2V, the meter will fail to set to zero thereby indicating an exhausted battery.

To find the value of R_x connect up the meter with R_L and R_V in shunt and add in series a new 1.5V battery, a 1,000Ω resistor of 1% accuracy or better, and a 1,000Ω rheostat. Set R_V to zero. Reduce the value of the rheostat until the meter registers half-scale. The rheostat is then set to the value of R_x. This can be checked by substituting a cell which is worn and which has a voltage of 1.2. It should be just possible to obtain f.s.d. with the test terminals short-circuited and R_V at maximum. The accompanying table gives values of R_L, R_V, R_s and R_x for different values of R_m.

Range Extensions

To extend the range shunts may be used across the meter and R_x.

For the 100Ω range (mid-scale) R_2 is switched in shunt with the total resistance offered by R_m, R_a, R_V and R_x. This total resistance is 1,000Ω, and the shunt value required to reduce this to 100Ω is 111.1Ω.

For the 10Ω range (mid-scale) the shunt resistor required (R_1) is 10.1Ω.

It is not necessary in practice to obtain resistors of 111.1 and 10.1Ω, as the values can be adjusted in the following manner. Connect up the circuit as in Fig. 2 and check the accuracy on the x1 range using the 1,000Ω 1% resistor. Now connect the 100Ω resistor across the test terminals and connect in the R_2 position a resistor or combination of resistors such that the meter reads mid-scale, i.e. the 100Ω point. Similarly with the 10Ω range and R_1. R_1 and R_2 can now be permanently wired into circuit.

10,000Ω (Mid-scale) Range

To obtain a x10 range it is necessary to employ a higher voltage battery. This is shown in Fig. 2. As a mid-scale reading of 10,000Ω is required and the resistance of the instrument with open circuit test terminals is already 1,000Ω an additional 9,000Ω is needed. This is inserted, as shown, in series with the 15 volt additional battery, to be used with the "common" terminal.

Zero Adjustment

As stated above zero adjustment is normally obtained by adjusting R_V with the test terminals short-circuited. When the instrument fails to zero by this means, the battery voltage has dropped beyond its useful range and should be renewed. If it is desired to use the 100Ω and 10Ω ranges the battery should be of as large a capacity as possible. On the 10Ω range the zero may tend to wander owing to the relatively high current passing. It is recommended that the zero setting of the 10Ω range be made and the test carried out as rapidly as possible.

A T.R.F. Radio Feeder Unit

By K. Benny

THE EMPHASIS THESE DAYS IS ON F.M. RADIO FEEDER units which will, of course, give superlative results, but have the disadvantage of being more complex (and more expensive!) than Long/Medium wave t.r.f. feeder units. It is also necessary to remember that all areas do not yet have v.h.f./f.m. coverage. The feeder unit described in this article will give quite good results with B.B.C. stations in most areas and is very simple. It has the further advantage that it requires no alignment whatsoever!

Circuit

The circuit consists of an untuned, high gain, pentode r.f. amplifier stage, inductively coupled to an infinite impedance detector, which is a triode connected pentode (EF91 or 6AM6). The use of an untuned r.f. stage results in freedom from a common bugbear of t.r.f. receivers, namely, self-oscillation. The resultant loss of gain due to the lack of an aerial input transformer is partially counteracted by using a high slope pentode amplifier. In areas where there is a local transmitter providing a very high signal strength, it may be necessary to include a parallel tuned circuit to act as a rejector for that station.

Performance

The output of the unit was measured across the 470kΩ resistor in the cathode circuit of V_2 with a valve voltmeter, and the input r.f. voltage modulated 30% at 1kc required to give an output of 0.1 volt at this point was noted.

f (ks/s)	V_{in} (μV)	V_{out} (mV)
1,500	0.88	100
1,000	1.0	100
650	1.42	100
200	0.76	100

Construction

The circuit shown is that of a fixed tuned switched receiver providing two Medium wave and one Long wave stations, but could be variably tuned on Medium wave only as required. The tuning coil used in the prototype receiver was a high-"Q" coil consisting of Litz windings in a dust iron "pot", but any reputable make of coil will be suitable. Dual waveband coils sold singly for use with crystal sets should prove eminently suitable.

When S_1 is in either of the two left-hand positions it short-circuits the lower section of the tuned

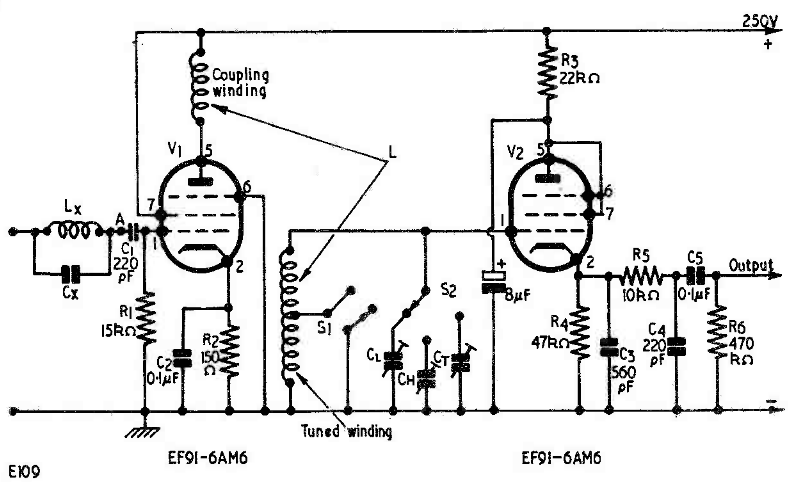


Fig. 1. Circuit of the t.r.f. feeder unit. Note that the combination L_x, C_x, forms an optional rejector for the local station. The switches S_1, S_2, should be a ganged 2-pole, 3-way type. Coils L and L_x, the variable trimmer condensers C_L, C_H, C_T, and the fixed value condenser C_x to suit chosen frequencies

winding, thereby providing reception on Medium waves. In the right-hand position, S_1 allows the complete coil to be connected to the appropriate tuning condenser, thereby enabling the Long wave band to be received.

The tuning capacities switched in by S_2 are those needed to cause the desired station to be received, and it may be necessary to use fixed condensers paralleled by trimmers in order to obtain the required capacity. The fixed condensers used for tuning purposes should be silver mica types.

The use of two separate valves is not strictly necessary, and one of the current B9A triode-pentodes such as the ECF80 should prove eminently suitable; unfortunately one was not available at the time the receiver described here was made.

Power Supplies, etc.

The power supplies required for the feeder unit are 6.3V 0.6A l.t. and 250V 12mA (approx.) h.t. The heater supply should preferably be balanced, though this may prove to be unnecessary. It is necessary to ensure that the smoothing condenser connected across the h.t. line is positioned close to the anode load of V_1.

There is little to be said concerning the operation of this unit. Once constructed, it requires only to be connected to a power supply, an amplifier and an aerial. Just one word of advice—do not expect this tuner to give its best performance on 10ft of aerial! A reasonable aerial is required if the best results are to be obtained.

Dealing with Perspex

By D. Myddleton-Evans

PERSPEX IS A VERY GOOD MATERIAL for cases containing small "plug-in" units or radios. It is light, is a good insulator, is inexpensive and has an extremely attractive appearance. These features make it especially useful for small units; for instance, many of the "Suggested Circuits" series could easily and compactly be built into such cases. A large variety of suitable cases already manufactured is usually to be found in local hardware stores; highly recommended are the "Elevenses" type made by Stewart Plastics. Dealing with Perspex may cause some difficulties to those without experience in this field, and it is hoped that this article may be of use to them.

Drilling Perspex

The correct method of drilling Perspex to prevent cracking is to put a drop—no more—of turpentine on the spot to be drilled, and then proceeding with a durium tipped drill. In practice, however, the author finds a normal drill to be as satisfactory as the durium tipped drill, if a gentle pressure only is applied. Whichever drill is used the case should be held with one side in a vice, the jaws of the vice being as near as possible to the point of drilling. A drill should never be forced or an unsightly crack may be made. When drilling holes of about $\frac{1}{4}$in diameter, it is best to use a small drill ($\frac{1}{16}$in) first, drilling through with this and then using the larger drill. This method prevents the larger drill from wandering and also helps to prevent cracking.

Enlarging holes of $\frac{1}{4}$in, the normal maximum drill size, to $\frac{3}{8}$in, a popular size for small switches, variable condensers, etc., can be done in several ways. It is possible to obtain the large drill required and to make the hole with this. More easy, perhaps, is to find a tapering metal object, (a pair of old scissors would be excellent!), and twist this round in the hole, applying a *very* gentle pressure forwards. This is a somewhat unprofessional method, and leaves a rough finish, but it is satisfactory for any component with a fixing nut on the outside which hides the slight unevenness and chipping.

Larger holes may be made by drilling a hole big enough to take a saw blade and then sawing out the hole and filing the edges. This usually requires some experience if it is to be done without cracking. Like the drill the saw should never be forced.

Mounting Components

Printed circuit boards may be mounted by using small metal brackets which fix to the sides of the case and to the board. They may also be mounted by using long bolts fixed into one side of the Perspex with the board bolted to the ends. Heavy components, such as transformers, may be mounted directly to the Perspex, employing a washer on the side opposite to the component. Normally, the washer will be under the bolt head. Using a washer reduces the pull of the bolt against the Perspex. It should always be remembered that if a Perspex case having a heavy component mounted to it is dropped, the case is almost certain to crack.

As when using metal chassis, component layout should be planned before drilling an holes in a Perspex case.

Soldering

Perspex has a low melting point so care is necessary when soldering components in these cases. The soldering iron must not touch a side, and neither must solder run off the iron on to the side or base or an ugly brown mark will be the result. The best plan is to solder as many connections as possible before fitting the components into the case. A Perspex case should not be left on hot surfaces, such as the flat top of a heater, or it may bend or distort.

Painting

If desired, Perspex may be painted with any lacquer paint, but the paint should be used sparingly. So far as the applications mentioned in this article are concerned cases are best painted on the inside; though the only painting necessary would normally be rough calibration of dials etc., for which "Panel Signs" transfers are far better. One last point is that most cleaning fluids, especially those containing carbon tetrachloride, tend to melt Perspex. Petrol, however, may safely be used for cleaning purposes.

Marconi Underwater TV for Cray Fishing?

Successful Tests Carried Out in Australia

Harbour officials and shipping representatives who watched recent demonstrations of Marconi-Siebe, Gorman underwater t.v. equipment in Australia were most impressed and it is thought the cameras might have uses for the Australian cray-fishing industry.

One camera, used from a control boat, could serve a fleet of fishing boats. The camera would show good reefs and whether the fish were plentiful, and a marker buoy transmitting a v.h.f. signal would direct catcher boats to a productive area.

The recent tests, both at Sydney and in Western Australia, were carried out by Amalgamated Wireless (Australasia) Ltd.

At a demonstration at Blues Point, New South Wales, Police department skin divers located Postmaster-General's department submarine telephone cables running between North Sydney and the city. The condition of the cables could be seen on two monitor screens on shore.

This demonstration was seen by the Managing Director of A.W.A., Sir Lionel Hooke, the N.S.W. Director of Posts and Telegraphs, Mr. J. R. Hutchinson and P.M.G. department engineers.

At a subsequent trial the equipment was taken outside Sydney Heads on a trawler and the sea bed examined at a depth of 180 feet.

At one of the Sydney demonstrations onlookers inside a cabin were able to see a worm crawling on the reef (at a depth of 40 feet), and to read writing on a milk bottle lying on the reef.

The Marconi-Siebe, Gorman equipment is primarily a hand-held apparatus with overall dimensions, including casing and lamps, of only 3 feet x 2 feet 3 inches.

The camera can be buoyancy-adjusted for virtual weightlessness under water. A similar camera is now being used by the North of Scotland Hydro-Electric Board for research into fish and hydraulic problems on Scottish lochs.

RADIO topics

By RECORDER

A MINOR REVOLUTION HAS TAKEN place in the manufacture of domestic radio and television receivers over the last eight or nine years. Unlike many of the revolutions which occur these days, this one has been relatively bloodless. Whenever skirmishes have taken place they have been entirely verbal in character, consisting mainly of propaganda by some set manufacturers and of indignant counterblasts from service engineers.

The revolution referred to is, of course, the replacement of hand-wired chassis by printed circuit boards. The changeover is now virtually complete, and printed circuit receivers are currently accepted in the domestic electronics field as being reasonably reliable and capable of service, bearing in mind the new techniques involved.[1]

How It Started

It was in 1947 that John Sargrove, in this country, proposed the advantages of printed circuit manufacture. John Sargrove also developed a complete automated plant for manufacturing sound receivers, descriptions of this plant and the processes involved being given in the technical press at that time. For some reason, interest in the plant died away, despite the potential advantages it offered in so far as the saving of direct assembly labour was concerned.

Interest in printed circuits themselves did not, however, die, and research on materials and techniques continued. I would guess that it was around 1952 or so that the first trickle of printed circuit assemblies into domestic radio and television receivers commenced. The first boards consisted of small sub-assemblies, such as printed i.f. filters and the like, these gradually increasing in size and detail as time went by.

The major changeover to printed circuits took place in 1955 to 1958. During this time *complete* printed circuit chassis appeared, and manufacturers found themselves closer to the dream wherein a whole production line of factory operators fitting and soldering components could be replaced by a super-machine which automatically inserted the components into a printed circuit, and then soldered all the joints underneath in one fell swoop. Unfortunately, automated production did not advance as rapidly as had been hoped and there tended to be initial snags, particularly where automatic soldering was concerned. On a conventional production line each joint is made with a normal soldering iron, and it is an almost unconscious human reaction to lightly rub a joint with the bit whilst solder is being applied.

[1] This is how I understand the situation from my own contacts, but I would be interested in comments from service engineers and others who have different opinions.

The rubbing breaks through the oxides on the surface of the connecting wire and gives good thermal contact to the joint. With automatic soldering there is no similar abrasive action, because the boards are dip-soldered or passed over a "wave" of molten solder. The consequence was that, in some cases in the earlier days, component lead-outs which soldered perfectly on a hand production line obstinately refused to "wet" at all when passed through the automatic process. As a result there would be blobby and unsatisfactory joints, joints which had obviously not "taken" and, worst of all, joints which *looked* all right but in which the lead-out wire was surrounded by solder without being "wetted" by it.

About this time service engineers began to object strongly to printed circuit boards, their main complaint being against some of the more complex boards used in television receivers. The objections were raised partly because some of the initial designs were flimsy and difficult to get at, and partly because the manufacturing quality of some of the assembled boards was significantly lower than the hand-wired versions the engineers had grown used to handling. Such objections were valid, and were not eased by statements from some manufacturers that the new printed circuit receivers were as easy, if not *easier*, to service than their hand-wired predecessors!

It is interesting to note that a similar situation appears to have arisen in America. I have beside me four copies of the American magazine *Radio-Electronics* which were published in 1958, and each of these carry double-page advertisements by Zenith Radio Corporation. Half of the space in the June advertisement is devoted to the following message: "YES! WE HAVE NO PRINTED CIRCUITS IN ZENITH TV CHASSIS—ZENITH HANDCRAFTED STANDARD CIRCUITRY COSTS MORE BUT IT MEANS MORE SATISFIED CUSTOMERS FOR ZENITH DEALERS AND SERVICEMAN". The May advertisement devotes almost the same space to: "Even though the Daddy of printed circuitry is head of Zenith's Research Dept., there's NO PRINTED CIRCUITRY IN ZENITH TV CHASSIS".[2] The last seven words of this message are in heavy ¾in type. The remaining two advertisements for February and April are slightly more subdued so far as the question of printed circuits is concerned, but they still state: "Out of consideration for servicemen we use NO PRINTED CIRCUITRY".

These advertisements must surely reflect the attitude of American service engineers in 1958 to the printed circuit television receivers then being produced in that country.

Over the last few years further development seems to have made complete printed circuit chassis much more acceptable to the service engineer. Automatic soldering problems should now be almost completely cleared up. Also, many printed circuit boards now carry component identification and other servicing aids to overcome the disadvantage inherent in an assembly where the components are on one side and the connections on the other. And so the printed circuit is now with us, and has become an accepted part of the domestic radio and television scene.

Savings

Apart from the cost factor, printed circuits can offer a valuable contribution in two alternative ways, these being saving of weight and saving of space. The reason for the saving of weight is fairly obvious, and it arises from the fact that the weight of a unit in excess of its components is the weight of the printed circuit board itself. It is rather ironic to think that printed circuits can also cause a saving in space because the inherent design limitation of a conventional printed circuit is that all component connections must be made in one plane only. Nevertheless, a saving in space is possible, if only because bulky tag-strips and anchoring lugs can be eliminated.

The approach of the home-constructor to the printed circuit is, of course, quite different to that of the receiver manufacturer. The equipment built by the amateur is normally of the "one off" variety, and so the question of production cost saving does not arise. It is possible for the home-constructor to build a printed circuit unit completely from scratch, drilling and etching the board himself before fitting and soldering the components. This is a fascinating exercise, and the result can look very smart indeed. I don't know how the time involved would compare with that taken up in constructing a hand-wired equivalent, but it should be comparable if no involved layout design for the copper pattern has to be undertaken initially. At the same time, a number of excellent home-constructor kits currently advertised include a printed circuit board which is ready for immediate use. In this instance all the amateur has to do is to insert components and solder, whereupon a significant saving in time can result. Fortunately, the constructor knows that there is no *necessity* to use printed circuit construction, because the units he makes will work just as well if they are mounted on a chassis and wired up conventionally as they will if fitted to a printed circuit board. In the first instance the components are connected together by pieces of copper wire; and in the second they are connected together by pieces of copper foil!

Codes

A fascinating aspect of human behaviour is the aptitude to form codes when communication media are limited. There is, for instance, the unofficial night-time headlight code in which a single flash of the headlights tells a vehicle in front that the person flashing wishes to pass. The driver in front then flashes his own headlamps if he is ready to be overtaken. The overtaken vehicle flashes its headlamps when the passing vehicle is sufficiently far advanced to be able to pull in and, finally, the overtaking vehicle flicks its tail light as a token of thanks when the operation is complete. I should add, of course, that unofficial headlamp signals are *not* approved by the motoring organisations and that motorists should follow the Highway Code.

Another unofficial code I heard about recently is practised by two teenagers. One of these youngsters rings up the other at a pre-arranged time and then listens to the "burr-burr" of the ringing tone in his own receiver. After a sufficient number of ringing tone signals have taken place he then hangs up. The recipient of the call merely counts the number of times the bell rings and translates this into information concerning when the pair will next meet, or any other similar message. Since the recipient does not take his phone from its hook no "official" connection is made, and so there is no charge for the call!

Colour TV

According to newspaper reports, the Russians should have trebled their colour television service in June, extending this from 90 minutes of colour a week to 4½ hours. It is stated that the programmes may be seen in Moscow and Leningrad and that the Russians have long passed the experimental stage.

[2] This statement carries an asterisk against the word Dept., and refers to the fact that "even though Dr. Alexander Ellett, head of Zenith's research department, is recognised as the daddy of printed circuitry through his work on radio proximity fuses, still Zenith uses no printed circuitry in its t.v. chassis because it means more service headaches and often causes service delays".

U.S.A., Cuba and Japan already have colour television, whilst Britain who, in 1936, started the first high definition television service in the world, now crawls along at the end of the line with an outmoded scanning system that is employed nowhere else in the world.

The Report of the Television Advisory Committee 1960 states that "the existing 405-line standards will not be adequate for all purposes for the next 25 years", and that "extension of television into Bands IV and V would offer the last opportunity for making a change in line standards". The situation is clear enough. We cannot start colour television until a decision has been made on future line standards. If the decision to introduce 625 lines (which may then include compatible colour transmissions) is made, then we must go into Bands IV and V.

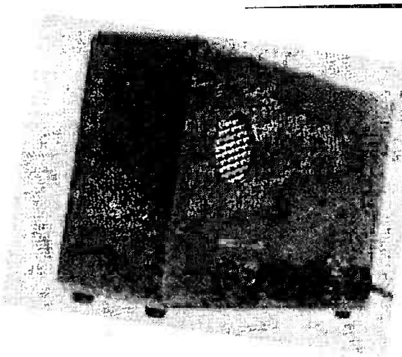
Is it the step of moving up into Bands IV and V which is currently paralysing official thinking? The expansion of radio communication will inevitably cause these Bands to be used by *some* services in the future; why not, therefore, take a decision and earmark them for television now?

News in Brief

English Electric Valve Co. Ltd. have introduced a range of high vacuum variable condensers for transmitters. The condenser plates consist of two sets of concentric cylinders whose intermeshing is controlled by the expansion or contraction of metal bellows. The metal bellows can be adjusted from outside the condenser. One of these condensers, the U200/10, has a range of 5.5 to 206pF, together with maximum r.f. voltages and currents of 10kV and 20A respectively, and has replaced a physically larger 5 to 37.5pF air dielectric condenser at one of the B.B.C. Daventry transmitters.

The R.A.F. is on the air on 41 metres with Radio Sharjah in the Persian Gulf. This spare time 7 to 11 p.m. station, housed in the wings of the camp cinema, was originally intended to cover R.A.F. Sharjah only, with the hope that signals would be picked up at Bahrein to the north and Masirah Island to the south. In practice, letters have poured in from such places as Bombay, Okinawa, Texas, and the U.K., and the station now has a fan club of listeners all over the world. Programmes put out are mainly record requests plus tapes of "The Goon Show" and "Hancock's Half-hour".

More t.v. Dx: this time from Mr. R. J. Ringrose of Ipswich, Suffolk. Mr. Ringrose uses a 12in Pye FV1 receiver whose tuner stage has been replaced by an EF80 extra i.f., this being preceded by a switch tuner employing an ECC84 and PCF80. The only modification for reception of Belgian 625-line positive modulation signals on 48.25 Mc/s (vision) is a change in line oscillator grid condenser from 250 to 200pF. French 819-line signals on 185.25 Mc/s (the highest t.v. Dx frequency I've reported yet) are also received, but it is necessary to resolve the pictures side by side as e.h.t. is lost if the line timebase is run too high. Both Belgian and French signals come in most evenings, and I would guess that the 185.25Mc/s transmission (vision, French Channel 8a) is radiated from Eiffel Tower. Continental reception is obtained with a Channel 1 vertical dipole. By combining his Channel 1 aerial with a Channel 3 "H", Mr. Ringrose has also obtained B.B.C. pictures on all five B.B.C. Channels.



A versatile VOICE OPERATED SWITCH

By K. MEREFIELD

THE CIRCUIT DESCRIBED HERE WAS DEVELOPED FOR use as a baby alarm. The usual baby alarm consists essentially of a microphone placed in the nursery which picks up the crying of the child and passes this to a loudspeaker via an amplifier. The disadvantage of this system is that monitoring entails the use of fairly high output power if the loudspeaker is in a room where, say, a television set is in use. The voice operated switch described here, however, is noiseless, giving visible warning with the facility of being able to hear if required. The provision of a visible warning system makes this device particularly suitable for those who are hard of hearing.

Another direct use of this circuit is for the switching or carrier control circuit with a voice operated transmitter in which the r.f. carrier is transmitted only when there is modulation. It may also be used as a signal tracer or high gain amplifier.

Circuit Description

The circuit, shown in Fig. 1, is quite straightforward. It comprises a three stage resistance capacity coupled amplifier (TR_1, TR_2, TR_3) with a gain of about 90dB. The signal at the collector of TR_3 is passed to a rectifier (MR_1) and the rectified signal is used to charge the RC network, R_9 C_9. The voltage across this network is applied to the base of TR_4, which is an emitter-follower and is d.c. coupled to the output transistor TR_5. When the potential across the RC network R_9 C_9 exceeds about −0.2 volt, TR_4 is turned on and a similar p.d. appears across the emitter load R_{10}. This turns on the output transistor TR_5 and the relay in its collector circuit energises, thus causing the alarm lamp to operate.

The loudspeaker shown in the collector circuit of TR_3 is an ex-Government balanced armature earpiece of the low resistance type, and enables a listening check to be made. Alternatively, a "break" jack could be wired into the circuit enabling headphones to be plugged in if required.

Components

Although Mullard OC71 and OC72 transistors are specified in the circuit any audio frequency transistor should prove suitable; likewise any germanium diode should suffice for MR_1.

The relay should operate at 5 volts and must not have a resistance of less than 100Ω for use with an OC72 or OC71. The relay used in the prototype had a resistance of 720 ohms.

It is possible to construct the alarm without using a relay. If a 6V 0.04A pilot bulb is used, this can be put into the collector circuit of TR_5 in lieu of the relay and will work just as well. (See Fig. 2.)*

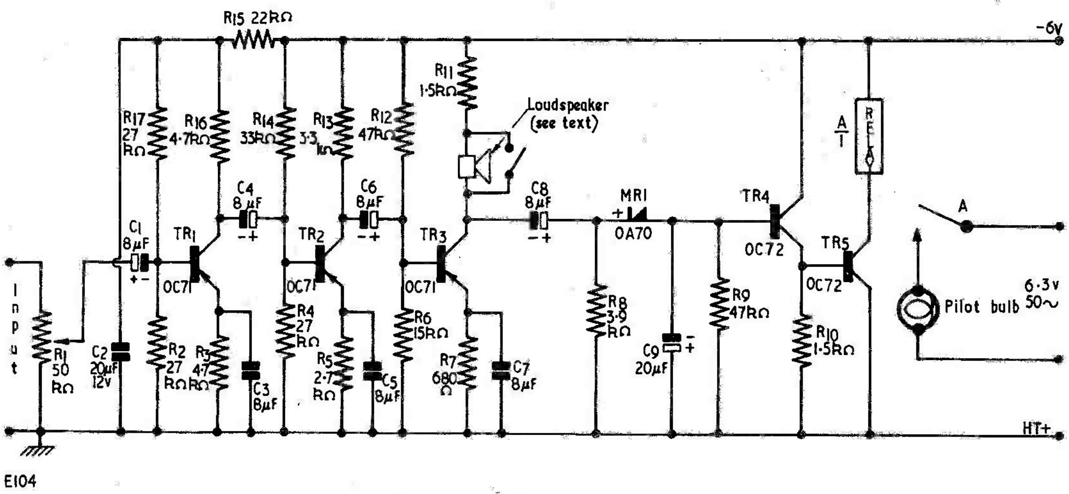


Fig. 1. Circuit of the Versatile Voice Operated Switch

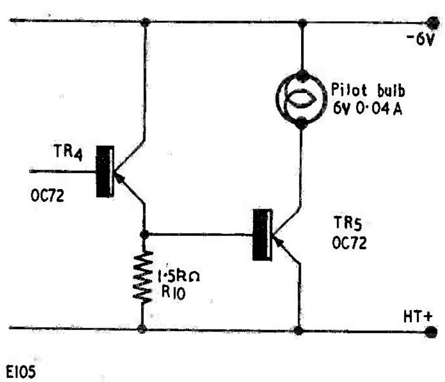


Fig. 2. Method of using the alarm without a relay

Power Supplies

The equipment may be run from any 6 volt battery or from the mains via a transformer and rectifier assembly as shown in Fig. 3. It should be noted that the circuit shown here will only supply a few mA of d.c. If a heavy duty relay or a lamp is used in the collector circuit of TR_5 then point contact germanium rectifiers are *not* suitable, and either junction diodes or a selenium rectifier capable of supplying the current required should be used.

Operation

Having wired the unit, connect it to a suitable supply and switch on. To check that the unit is working correctly, switch the loudspeaker into circuit and, with the gain control set for maximum, touch the input connection with a finger. A loud hum or "squeal" should be heard in the loudspeaker. Next, switch the loudspeaker out of circuit and once more touch the input connection. The relay should now operate, thus causing the alarm lamp to illuminate. If it does not, connect a high resistance voltmeter across the rectifier load (R_9, C_9) and ascertain whether there is a d.c. output when the base of the first transistor is touched. Assuming that a d.c. voltage of about 0.5 volts (or more) is measured at this point, the voltmeter can now be connected to measure the voltage at the collector of the output transistor TR_5. This should normally be about 6 volts, falling to about 0.3 volt when the unit has an input. If these voltages are not given, then either TR_5 or the emitter follower TR_4 are defective and should be replaced.

* The author states that he has taken measurements to ensure that operating the pilot bulb directly from the transistor does not cause excessive dissipation in the latter. We would class this particular application as being experimental.—EDITOR.

All that is needed now is a suitable microphone connected to the input. The microphone used should have a reasonably high output voltage and must be of low impedance. A crystal microphone will therefore *not* be suitable, since it is a high impedance device. Equally unsuitable would be a moving coil microphone, since this type normally has rather a low output. The best type of microphone is the moving iron or balanced armature reed such as the ex-Government D.L.R. earpiece. Although normally used as earpieces they work well as microphones and are in fact used as such in "sound powered telephones". This, incidentally, is the same type that is recommended for use as the internal loudspeaker; thus, the acquisition of a pair of ex-Government balanced armature headphones will provide both the requisite microphone and "loudspeaker"

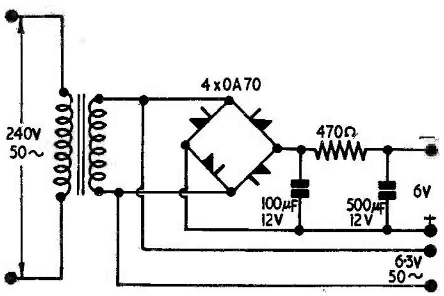


Fig. 3. Switch power supply using a mains transformer and rectifier assembly

The impedance of the balanced armature insert is about 120Ω and this can be matched to the input impedance of the voice operated switch (about 5,000 ohms) by means of a transformer (ratio 1:7 or thereabouts) if so desired. The insert will, however, be quite satisfactory for normal use if directly connected to the input. A carbon microphone could be used, but it is not recommended in view of the need for a polarising voltage, which could take more current from the supply than the rest of the circuit! But it may be worthy of consideration if a fantastic sensitivity is required.

Construction

The original voice operated switch shown in the accompanying photograph was mounted in an Eddystone die-cast box 7½in long x 4½in high x 2in deep. Small rubber feet were fitted to the underside of the box to prevent it scratching polished surfaces. All the components are fixed to the "lid" of the box so that, when the six screws holding the lid in place are removed, the lid comes away with all "the works" mounted on it, thus saving the need for unsoldering leads to components mounted on the case.

Using a Grounded Grid PA STAGE *for CW or RTTY*

By J. B. TUKE (G3BST)

IT WOULD APPEAR FROM INFORMATION DERIVED from many contacts on the amateur bands, that a certain amount of stagnation exists in the design of power amplifier stages for amateur transmitters. While endless variations of band coverage, exciter circuits, power supplies, etc., exist, when the p.a. stage is considered it is a pretty sure bet that this will consist of one good sized tetrode (e.g. the 813) or two smaller tetrodes (e.g. 807s in parallel), and that pi-coupling to the aerial will almost certainly be used.

This stereotyping of design is probably due to three main reasons—one, this type of p.a. requires very little drive, two the pi-coupling is more or less a "must" in areas covered by television (and that means almost everywhere these days) and, three, the circuitry and adjustment is simple since no neutralising is required. Since this type of p.a. has performed satisfactorily in many stations for a number of years, it is pertinent to enquire whether there is anything wrong with it and if there is any need to look for an alternative. In order to consider this question, the disadvantages of the circuit should be studied. These are: poor d.c.-to-r.f. conversion efficiency (in the order of 65–75%); the production of a fair amount of heat in the vicinity of the valve due to this poor anode efficiency and also to screen dissipation; the necessity for "screen-dropping" resistors together with clamping or stabilising circuits; the ever-present threat of instability unless great care is taken with construction (how many 2–807 power amplifiers can be tuned up with no antenna load and reduced grid bias without oscillating!); and the ease with which parasitics appear, leading to the further complication of stoppers in practically every electrode lead. It is surely worthwhile looking for an alternative circuit not having these disadvantages.

An Alternative P.A. Circuit

Since the amateur licence limits the input power, any replacement circuit for the above must improve on the anode efficiency as a first requirement, and this automatically leads to consideration of the triode. Before readers raise their hands in horror at such an "old-fashioned" idea, let us discuss the triode amplifier in more detail. Its anode efficiency will be at least 80% and may well be nearer 90%, and there is no power wasted in the screen, with its associated resistor networks. There is no need for clamping under key-up conditions—if a triode is biased to cut-off, then it is cut-off and that is all there is to it.

What about the amount of drive required? Agreed, this will be a good deal greater than that required for the tetrodes—but must exciters be designed so that, with everything running flat out, the bare minimum grid current appears in the p.a.? Is it any more difficult to design an exciter unit with an output of 30 watts instead of 3 watts? It might be suggested that t.v.i. problems will arise, but if the transmitter can be run at around 100 watts without trouble, then surely so can a 30 watt exciter. Let us not be prejudiced about the increased drive, but rather approach the problem with an open mind. The final objection to the use of a triode will be the necessity for neutralisation which, if the pi-coupled anode circuit is to be retained, will necessitate a split grid coil. There is, fortunately, a simple answer to that one—use the triode in a "grounded grid" circuit.

Some use is already made of this circuit by s.s.b. operators, but few stations use it for c.w. or r.t.t.y. The difference between s.s.b. and c.w./r.t.t.y. conditions is simply one of grid bias—the former being class B and the latter class C. The writer has found that few amateurs have considered the use of the grounded grid stage in class C, having thought

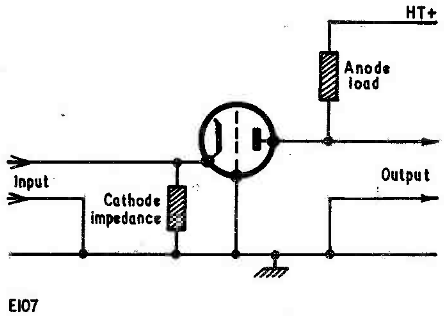


Fig. 1. Basic circuit of a grounded grid p.a. stage

that it was restricted solely to class B. This is most definitely not so. The grounded grid amplifier is a most useful circuit since it is completely stable without neutralisation providing the most elementary constructional precautions are taken.

The basic circuit is shown in Fig. 1, where it will be seen that any positive feedback can only take place by capacitive coupling between anode and cathode (providing, of course, that there is no external coupling between input and output circuits). The anode-cathode capacity of a valve is normally quite small with the grid earthed (much less than that between the grid and anode of a tetrode), and, anyway, the gain of a triode is so much smaller than that of a tetrode that the small amount of feedback occurring will cause no trouble and probably cannot even be detected. Since the r.f. drive is applied between cathode and earth, there is a large degenerative feedback. If the cathode is driven positive, then this is the same as making the grid negative, anode current is therefore reduced. This reduction of anode current will lower the voltage which it develops across the cathode impedance, thereby making the cathode less positive—i.e. a voltage is produced across the cathode impedance in opposition to the drive voltage, so that a larger amount of drive will be required to operate the valve in grounded grid mode compared with that of a conventional earthed cathode. However, this additional drive is not wasted, it augmenting the r.f. power in the anode circuit. This can be considered as power being "fed through" from cathode to anode, where it becomes added to the r.f. output power available in the normal way.

Plate Efficiency

Since the plate efficiency of a triode is high to start with, say 80% at least, the addition of the feed-through power results in an effective plate efficiency of 90–95% without difficulty! The additional power is, of course, really obtained from the driver stage so that the overall efficiency of d.c./r.f. conversion remains the same, but the grounded grid circuit does result in more r.f. appearing at the anode for a given input to the final.

The full mathematical formulae for computing the operating conditions of any particular valve can be obtained from text-books—the *ARRL Handbook* is one example—there being no point in repeating them here. It is interesting, however, to compare two typical p.a. stages, one consisting of two 807's and another consisting of a 35T in grounded grid mode, both running at 120 watts input. Typical operation of the 807's may be considered as 600 volts on the plate and 200mA total anode current. The rated efficiency of an 807 is 66.6% so that there should be 80 watts of r.f. at the anode. There will be 40 watts of heat from the anodes alone to be disposed of, together with about 5 watts from the screens. More watts will be dissipated in screen supply resistors, together with clamping or stabilising tubes, but since these can be placed in a different part of the transmitter we will not include them in the heat problem. A similar grounded grid stage running at 1,200V at 100mA should have a plate efficiency of about 85% (perhaps higher), producing therefore 102 watts of r.f. at the anode and 18 watts of heat. To be completely fair when dealing with the heat question, the total heat produced by the 35T will amount to 38 watts, since the heater is rated at 20 watts. If the heater power of the two 807's is also included (11 watts) the total heat to be dissipated by the double tetrode p.a. is 56 watts compared to the 38 watts of the grounded grid stage. And this is not all. To the 102 watts r.f. produced by the triode valve must be added the feed through power (about 10 watts in this case) making a total r.f. power of 112 watts. It should now be noted that in order to produce 112 watts r.f. from a pair of 807's, the input would have to be increased to

168 watts (G.P.O. on the warpath?) and the heat dissipated by the anodes alone would be 56 watts! Clearly there is something in the grounded grid business after all.

The drive requirements are, of course, very much greater than for a tetrode p.a. but it is surely worthwhile to bear with this in order to achieve a high r.f. output, so easily. The drive requirements can be taken as roughly 2.5 times that required to drive the same triode in the conventional manner—but the excess drive over the normal requirements is that which appears at the anode in the form of additional r.f.

Choice of Valve

To come down to practical details—the choice of valve would appear to be limited. Obviously the triode must be an r.f. type or some of the efficiency expected will be lost. At present, the 35T seems the best choice. It is obtainable fairly inexpensively on the surplus market, requires a modest h.t. (1,200–1,500V) and is extremely tough electronically. It is possible to run tetrodes as triodes by strapping screen and anode. The writer has no experience of this, it being used by some s.s.b. stations and therefore there is room for experiment along these lines. It should be noted at this point that the over-running of valves, often resorted to in grounded grid s.s.b. (p.a.'s) is not permissible in c.w. class C conditions.

A Working Stage

A typical working grounded grid stage is shown in Fig. 2—and the values given are suitable for a 35T. One particular method of feeding power to the cathode circuit is shown, but there are others—such as using r.f. chokes in both heater leads and coupling the r.f. to the cathode capacitively, or winding the cathode tuning inductance with double wire. Whichever method is employed, allowance must be made for a certain amount of filament voltage drop, and the supply arranged to give 5 volts at the filament pins. The heater choke shown consists of 80 turns of 20 s.w.g. wire close wound on a 1½in former. The cathode tuning coil, L_1, is wound with 14 s.w.g. silver-plated wire on a similar former. It may be tapped as shown, or a plug-in coil could be used. The voltage drop across L_1 is negligible on the h.f. bands and in order to prevent an appreciable drop developing at 3.5 Mc/s, a relatively small coil with large capacity is used.

The bias voltage on a grounded grid stage is that normally used for the valve in class C conditions and, as usual, it may be obtained partly from fixed supplies and partly from grid current. In the latter case, the voltage developed across R_1 (Ig x R) may be added to the fixed bias. Total bias should be about 110 volts, of which at least 70 should be fixed in order to keep the valve cut-off when drive is removed. The grid condenser should be a high quality mica component, any reactance at this point introducing positive feedback.

The anode circuit uses conventional pi-coupling with tapped coils. Increased efficiency on the h.f. bands can be obtained by using a number of coils rather than a single tapped coil, but a discussion

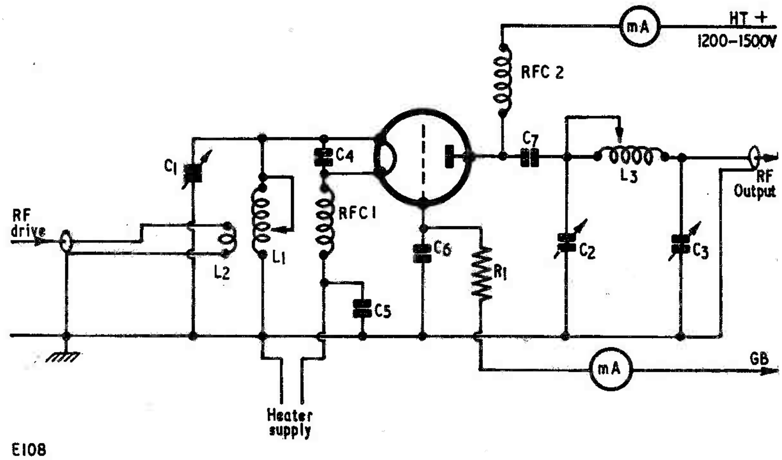


Fig. 2. Complete circuit of the grounded grid p.a. stage

Components List

Condensers

- C_1 500pF variable (receiving type)
- C_2 50pF variable (transmitting type)
- C_3 1,000pF variable (2 x 500pF receiving type)
- C_4 0.01μF mica
- C_5 0.01μF mica
- C_6 0.01μF mica
- C_7 0.01μF mica

Resistor

- R_1 1.5kΩ 3 watts

Coils

- L_1 Input tuning (see text)
  - 3.5 Mc/s 16 turns on 1½in former
  - 7 Mc/s 8 turns (tapping)
  - 14 Mc/s 3 turns (tapping)
- L_2 Input link (2 to 3 turns)
- L_3 Tapped anode coil, pi type

Chokes

- RFC_1 See text
- RFC_2 Transmitting type (conventional)

about this is not appropriate here since it applies to p.a. circuits in general.

While there is no set type of construction to follow, a good scheme is to mount the valve so that it passes through a metal screen, all anode components being mounted on one side of the screen and all cathode components on the other. This is not, however, essential and, providing normal construction practices are observed, no trouble will be experienced with instability.

Tuning Adjustments

The tuning adjustments of a grounded grid stage are quite straightforward, though at first some unusual effects are evident. If drive is applied to the stage without any h.t., then appreciable anode current will flow if the anode tuning is off resonance. This is the "power fed through". This current will, of course, flow through the h.t. power pack because a d.c. circuit exists even though it is not delivering voltage. It should be noted that if mercury vapour rectifiers are in use these will strike, do not, therefore, attempt drive adjustments while waiting for the rectifiers to warm up, or damage will result! With drive applied, the anode circuit can be tuned to resonance when most of the phantom anode current will disappear. Limited h.t. may now be applied and the circuit tuned in the normal way. It will be found that loading the circuit increases the drive requirements, which, with full power should be in the order of 35–40mA. It will also be seen that if the anode circuit is tuned across the resonant point the dip in anode current corresponds exactly to the rise in grid current—an indication of complete stability. It is important that drive is maintained at the correct value under full load if anode efficiency is to remain high. With the 35T, any increase of plate dissipation is promptly indicated by increased brilliance of the anode!

The owner of a transmitter with tetrode(s) in the final may feel curious to know just how much extra r.f. would be obtained by converting to grounded grid and yet hesitate to completely reconstruct the p.a. stage. The answer, in this case, is to build the grounded grid stage as an "add-on" unit, and use the present transmitter as a driver. The grounded grid stage can be built as a completely separate self-contained item, and fed by coaxial cable from the main transmitter. The only modification necessary to the main transmitter will be reduction of its h.t. voltage and, possibly, the removal of one of the p.a. valves if two in parallel are in use, since it will now only be "loafing along" as an exciter unit. This scheme is excellent in practice and extremely versatile.

Having experienced the pleasure of using a grounded grid amplifier, the writer will certainly never return to tetrode or tetrodes p.a.'s in a high power transmitter; and it is felt that this circuit is worthy of serious consideration by r.t.t.y. stations in particular, since these operate for long periods in the "key-down" conditions when the power appearing as heat in the final is not only extremely wasteful but can be an acute problem in itself.

A Constructor visits the 1961 R.E.C.M.F. EXHIBITION

THERE IS A VERY IMPORTANT difference between the R.E.C.M.F. Exhibition and the National Radio Show at Earls Court. In the latter, products are displayed not only for the technically-minded but also for the lay public. At the R.E.C.M.F. Exhibition, on the other hand, the components presented find a market only amongst set-makers and other manufacturers of electronic apparatus. It is an Exhibition in which engineer sells to engineer, and products are displayed on their technical merits alone, with a minimum of window dressing.

The Radio and Electronic Component Manufacturers Federation held their Exhibition this year in the Grand Hall at Olympia. This is, of course, a much larger hall than that used at Grosvenor House in previous years, and the change was welcomed by every person to whom the writer spoke, exhibitor and visitor alike. Stands were comfortably large and roomy, there was adequate space between displays, and it was possible to discuss components at any part of the Exhibition without having to undergo the Rugby scrum conditions prevalent at previous Shows.

Miniaturised Components

The trend towards miniaturisation continues, and a large number of very small components were to be seen at the Exhibition. Many of these components are low-cost designs aimed specifically at the transistor radio market.

Notable in this category is the edge-controlled potentiometer type 56 which has just been released by Morganite Resistors Ltd. This component may be supplied with or without a single pole switch rated at 50 volt (max.) and 250mA (max.), and adjustment is effected via a milled edge plastic ring having a diameter of 0.8in. The internal mechanism is largely contained inside this ring and overall depth, excluding tags, is just in excess of 0.2in. The tags are designed for direct mounting to a printed circuit panel. An ingenious design feature

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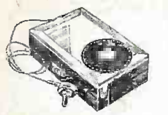

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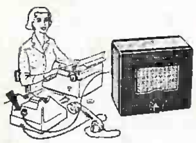

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No more "Holding Up" wasting time waiting for your call to come through. When it does the amplifier can be switched off if required. **No** connections, just Sellotape the pick-up coil to back of phone as above.

BUILT, TESTED, READY TO USE

£5. 10. 0. P.P. 2/6

5" speaker; 3 months' battery life. Now with 400mW output

Portable 4-transistor Baby-Alarm as previously advertised. But now with 400mW output on 5" speaker. Can be used up to 200 yards, **£5.10.0.** P.P. 2/6. Including battery and microphone. Battery life 3 to 4 months used every day. Very sensitive.

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6 - TRANSISTOR RADIO

Fidelity

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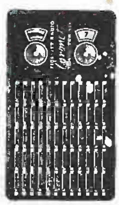

6-TRANSISTOR MEDIUM & LONG WAVE POCKET RADIO

- Size 2¾" x 4¾" x 1¼"
- Quality Push-Pull Speaker Output
- Guaranteed for 12 months
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- Carrying Case

ALL BRITISH DESIGN AND CONSTRUCTION

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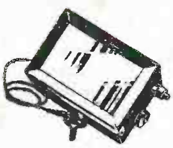
Incl. Battery

3-TRANSISTOR AND DIODE PERSONAL POCKET RADIO

SUPER - 3



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

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NO EXTRAS TO BUY
Size 4⅜" x 3 x 1¼"

Quality output on personal earphone

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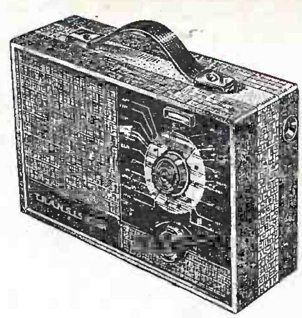
- New Type Printed Circuit with all Components marked
- Full Medium & Long Wave Tuning
- High "Q" Internal Ferrite Aerial
- Car Radio Adaption and AVC
- Slow Motion Fingertip Tuning with Station Names
- "Hi-Fi" Quality Speaker
- Attractive Rexine Covered Cabinet. RED/WHITE or BLUE/WHITE

TOTAL COST OF ALL PARTS
£10. 19. 6 P.P. 3/6
LEAFLET ON REQUEST

COMBINED PORTABLE AND CAR RADIO



JUST RIGHT FOR A DAY OUT—ANYWHERE!

AVO-METERS

AVO — MODEL 8
Multi-Meter. (List price **£24.10**)

£17. 10. 0 Regd. P.P. 5/-.

Complete with Avo Test Leads and Batteries. Fully guaranteed new condition.

AVO — MODEL 7
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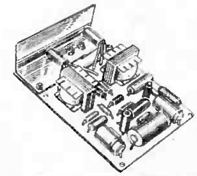
¾ WATT 4 TRANSISTOR AMPLIFIER



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

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

Kit of parts 62/6, P.P. 1/6

A printed circuit high gain amplifier size 4" x 2¾" x ¾" using Mullard OC71/OC81D and 2-OC81 Transistors. Ideal for Intercomm., Record Player, Tuner Amplifier or any application requiring a quality and reliable amplifier.

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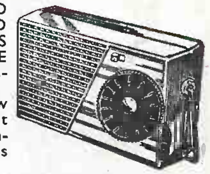
"PW" 6 TRANSISTOR MEDIUM & LONG WAVE POCKET SUPERHET



- 6 MULLARD TRANSISTORS AND DIODE
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