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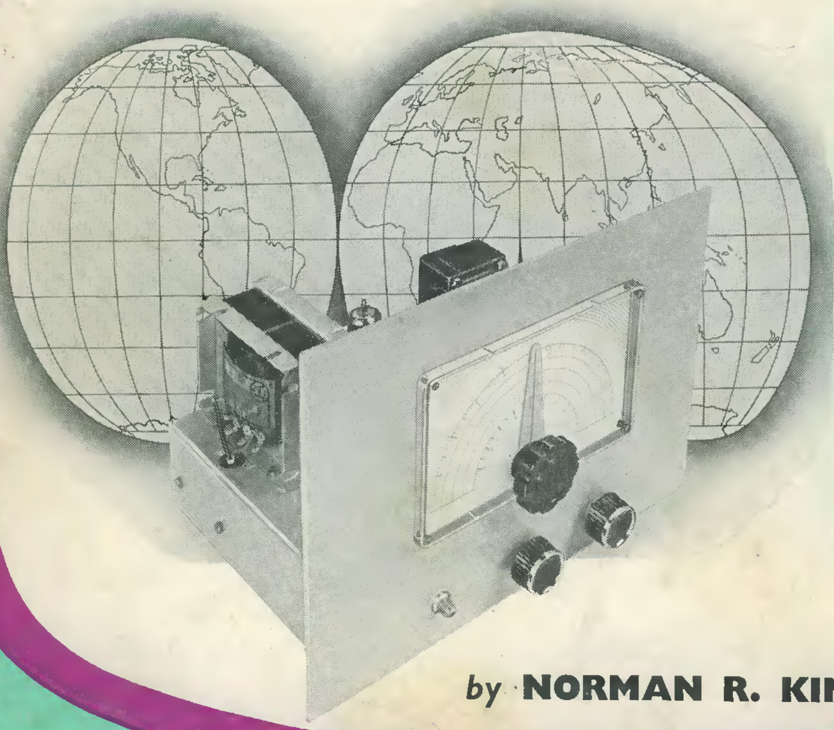

by NORMAN R. KING

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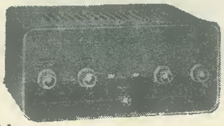

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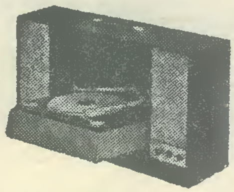

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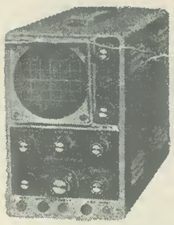

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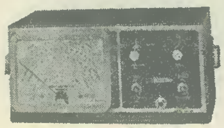

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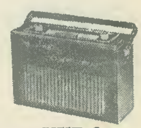

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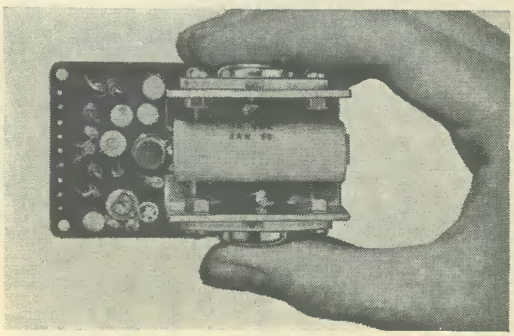

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Electronic D.C. Meter Amplifier/Converter

by W. KEMP

This transistor amplifier enables a 0-1mA meter to read currents as low as 5μA. The unit may also be used with the lowest voltage range of a testmeter (of the order of 2.5 volts or less) to provide an f.s.d. reading at a voltage of one-tenth that indicated by the meter

IN RECENT YEARS A NUMBER OF COMPANIES HAVE started importing low cost good quality moving coil meters into this country for sale on the amateur electronics market, and this has been a real boon to the do-it-yourself enthusiast, particularly as far as test-gear applications are concerned.

Unfortunately, however, the greatest sensitivity that is available in this range of low cost meters is 50μA f.s.d., and there are a number of applications, such as in high quality multimeter circuits and in d.c. bridge detectors, where sensitivities greater than this are required. In such applications, therefore, the constructor may be forced to resort to buying industrial meters, and these are prohibitively expensive. A 3in 10μA f.s.d. meter, for example, can cost over £14, and a 5μA f.s.d. type (the most sensitive type available) a good deal more.

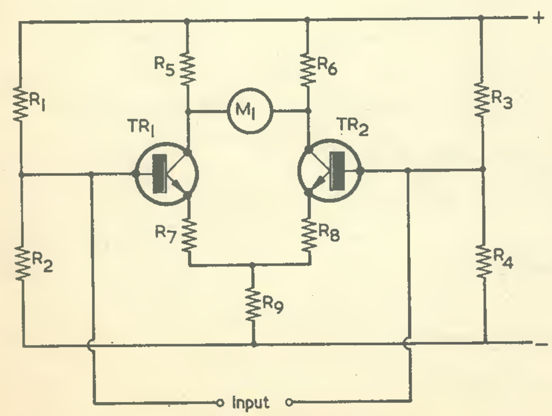


Fig. 1. A basic differential amplifier

It was with these problems in mind that the meter amplifier circuit described in this article was developed, and the final unit, which costs several pounds to build, enables the sensitivity of an existing meter to be increased by any amount up to a maximum of over 500 times without loss of linearity in the meter readings. Thus, an ordinary 1mA meter can be made to give an f.s.d. reading of 5μA or less, or a 250μA meter can be made to "do the impossible" and give an f.s.d. reading of less than 1μA.

Silicon transistors are used throughout the design so that, providing the unit is mounted in a suitable draught-excluding case, drift problems are minimised, and the design is such that calibration is virtually unaffected by variations in the battery supply potential.

The circuit can, if required, be used as a "range converter" on the "D.C. Voltage" ranges of an existing multimeter, since a voltage gain of up to approximately 21 times is available. This facility enables, for example, the 2.5 volt range of an ordinary multimeter to read (say) 250mV f.s.d.

The Circuit

The circuit is developed from the basic differential amplifier shown in Fig. 1. Here, both TR_1 and TR_2 can be regarded as normal common emitter amplifiers, but with an emitter resistor (R_9) which is common to both transistors and which thereby gives a self-balancing action to the circuit. Base bias to TR_1 is provided via R_1 and R_2, while that to TR_2 is provided via R_3 and R_4. R_5 and R_6, which are of equal value, are the collector load resistors of TR_1 and TR_2 respectively. The input to the circuit is applied between the bases of TR_1 and TR_2, and the output is measured between the two collectors.

COMPONENTS

(Fig. 2)

Resistors
(All fixed values 5% ½ watt unless otherwise stated. Further resistors, not listed here, are required for the setting-up processes of Figs. 4 (*a*) and (*b*))

R_1	27kΩ Hi-stab
R_2	10kΩ Hi-stab
R_3	33kΩ Hi-stab
R_4	12kΩ Hi-stab
R_5	12kΩ Hi-stab
R_6	12kΩ Hi-stab
R_7	2.7kΩ Hi-stab
R_8	1.2kΩ 10%
R_9	1.2kΩ 10%
RV_1	1kΩ potentiometer, carbon linear
RV_2	100Ω potentiometer, carbon linear
RV_3	See text

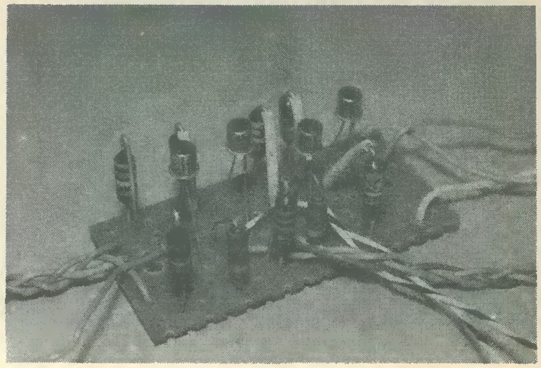
Transistors
TR_1—TR_4 ST141 (Sinclair)

Meter
M_1 Moving-coil meter in the range 250μA to 1mA

Switch
S_1 s.p.s.t. on-off switch

Battery
B_1 9-volt battery

Miscellaneous
Veroboard, 0.15in matrix, 1¼ x 2½in (see Fig. 3)
Draught-free case



The Veroboard panel allows a neat and compact assembly to be made up

In use, the values of the base bias resistors are adjusted so that, with no input signal applied, exactly the same voltages appear at the bases of TR_1 and TR_2. The values of R_7 and R_8 are then adjusted so that both transistors draw equal currents and there is zero difference in the potentials between the two transistor collectors. Zero current then flows in meter M_1.

When an input voltage is applied to the circuit the base current of one transistor is increased and that of the other is decreased; voltage amplification thus takes place in each transistor in the normal way, but with the transistors amplifying in antiphase to one another. Thus, a considerably amplified version of the input signal appears between the collectors of TR_1 and TR_2, and a current flows in M_1 which is proportional to the voltage amplification of the circuit and the d.c. resistance of the meter.

The major snags with the circuit described above are that, if a linear reading is to be obtained on the scale of M_1 the maximum current taken by the

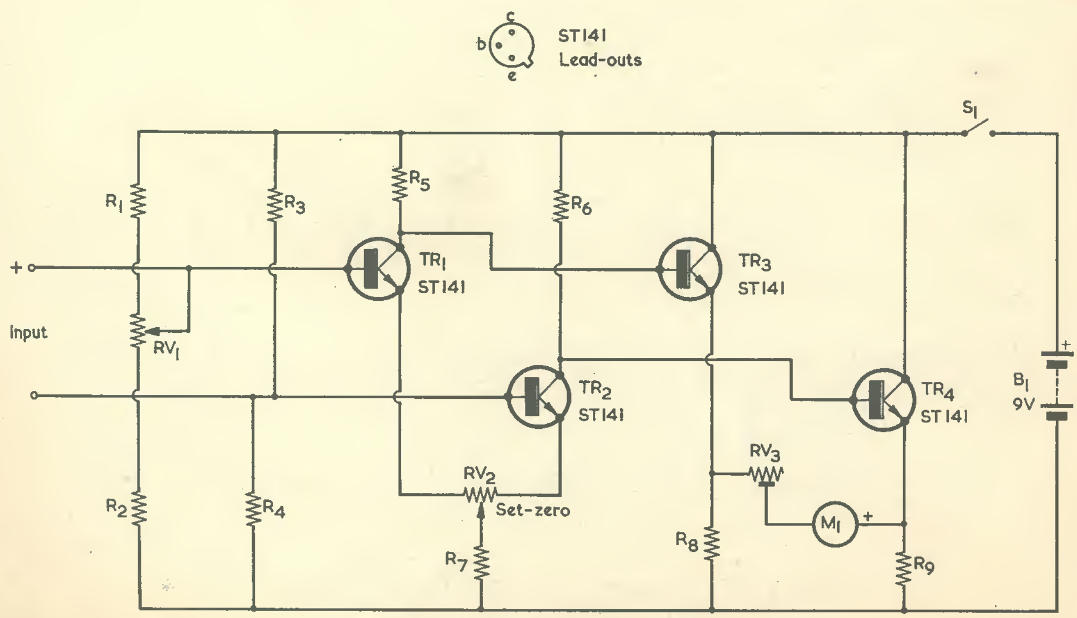


Fig. 2. The circuit of the meter amplifier/converter

meter must be small relative to the "standing" collector currents of TR_1 and TR_2, and that the maximum current gain available from the circuit is limited to less than 50 times.

These difficulties are overcome in the final version of the unit, which is shown in Fig. 2. Here, TR_1 and TR_2 form the "long-tailed pair", which operate as already outlined. Now, however, the base bias voltage of TR_1 can be adjusted by means of RV_1 and the individual collector currents of TR_1 and TR_2 can be balanced by means of RV_2. Also, instead, of having the collectors of TR_1 and TR_2 connected direct to the moving coil meter they are now coupled to the bases of TR_3 and TR_4 respectively. These last two transistors are connected as emitter followers and act as impedance converters, giving a low output impedance at their emitters but unity voltage gain.

Finally, the meter is wired, via variable resistor RV_3, between the low impedance outputs at the emitters of TR_3 and TR_4, making a total overall current gain of over 500 times available on meters with an f.s.d. value of 1mA or less, and with perfect linearity of readings. RV_3 enables the current gain to be set to the required value.

Polarity indications are shown against the input terminals and the meter in Fig. 2, but these are intended merely as a guide for later testing and operation. The circuit will function equally well if both the input terminal and meter polarities are reversed.

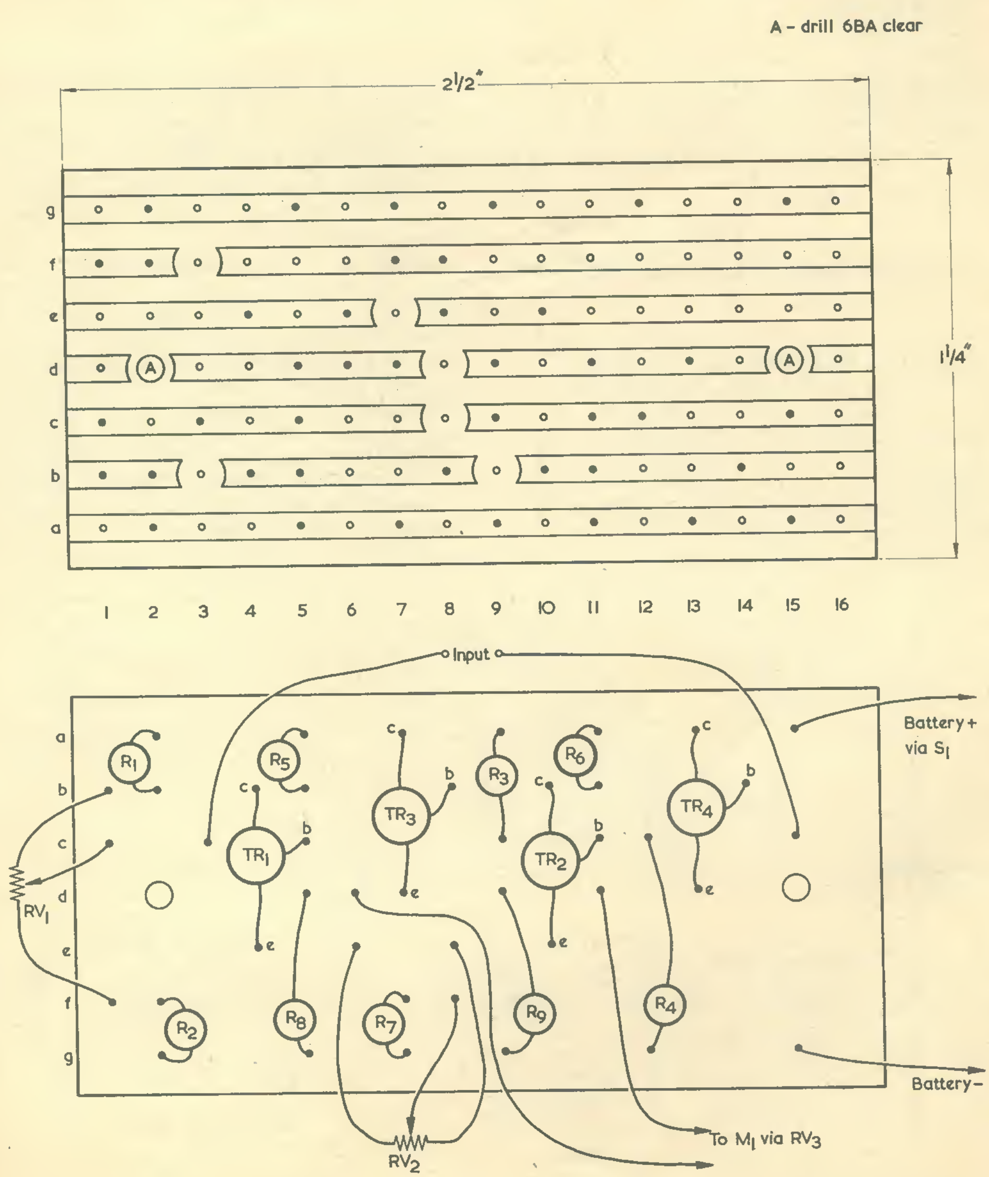


Fig. 3. The copper and component sides of the Veroboard panel on which the amplifier/converter is built

The circuit operates from a 9 volt battery, and draws a current of approximately 6.5mA.

Construction

The major part of the circuit is wired up on a small piece of Veroboard which measures $2\frac{1}{2}$ x $1\frac{1}{4}$in and has 0.15in hole spacing. Construction should be started by cutting this panel to size and then drilling the two small mounting holes, to clear 6BA screws, as shown in Fig. 3. Next, break the copper strips, with the aid of a small drill or the special cutting tool that is available, where indicated.

The components and leads can now be soldered in place on the panel, as shown in the lower section of Fig. 3. Note that all components are mounted vertically, and that insulated sleeving should be used where there is any danger of lead-outs short-circuiting against one another. All resistors other than R_8 and R_9 are 5% high-stability types. Variable resistors RV_1 and RV_2 should be connected to the appropriate connecting leads, but the meter and RV_3 should *not* be connected to the circuit at this stage. All three potentiometers are mounted external to the board, and can be positioned at convenient points in the case which will later be employed to house the unit.

When construction is complete the circuit can be given a functional check, in the following manner. Connect the supply leads to a 9 volt battery via S_1; set RV_1 and RV_2 to approximately mid-positions and close S_1, checking that a current of about 6.5mA is drawn from the battery. Now measure the voltage across R_8 and check that it can be varied by a substantial amount (between about 2 volts and 5 volts in the case of the prototype) by means of RV_1, but by only a relatively small amount (less than 1 volt) by means of RV_2. Now carry out a similar

Another view of the amplifier/converter components on the Veroboard panel

check on R_9, ensuring that a large variation can be obtained by means of RV_1.

Next, short-circuit the two input terminals together and check that the voltage across R_9 can be varied between approximately 5 volts and 3 volts by RV_2, but that negligible variation can be obtained by RV_1. Now carry out a similar check on R_8, but note that in this case the voltage should vary, due to adjustment of RV_2, between about 3 volts and 5 volts. That is, over the same range but in antiphase to that across R_9.

Finally, the circuit can be roughly set up, prior to use. Short-circuit the two input terminals together and connect a multimeter, on a 2.5 volt range or less, between the "meter leads" of the circuit; and adjust RV_2 for zero reading on the meter. Now break the connection between the input terminals

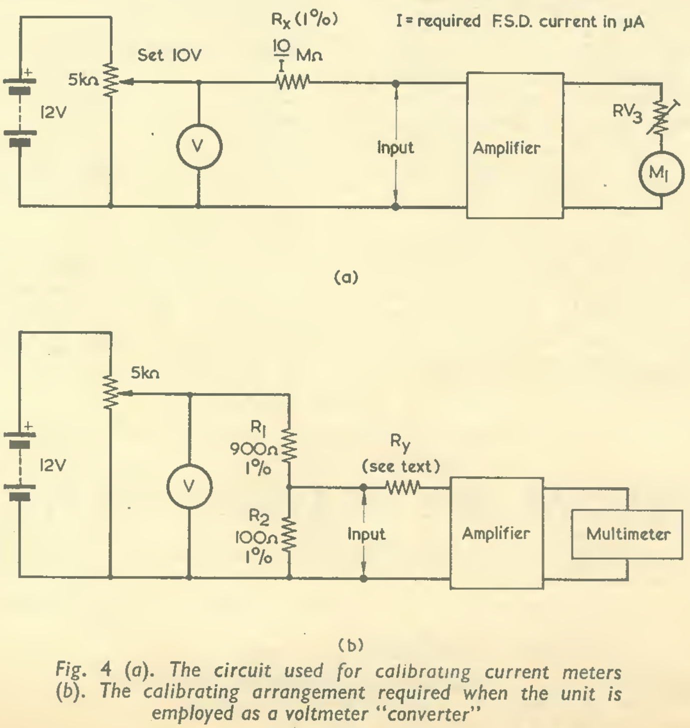


Fig. 4 (a). The circuit used for calibrating current meters (b). The calibrating arrangement required when the unit is employed as a voltmeter "converter" and re-set zero via RV_1. Reconnect the input terminals together and readjust RV_2 for zero reading on the meter. Continue with this procedure, alternately adjusting RV_2 and RV_1, until no further "zero adjustment" is required.

The circuit is now complete and tested, but it is very important to note that, before actually using the unit, the whole assembly should be mounted in a draught-proof box or case, since the circuitry is so sensitive that the slightest change in temperature *between* TR_1 and TR_2 will cause a shift in the zero balance conditions, and such a change in temperature can be caused by draughts, including those created by the action of breathing on or near to the circuit. Note that changes in *ambient* temperature do not create drift problems, since TR_1 and TR_2 are then heated or cooled by equal amounts.

Using The Unit

Once the unit has been mounted in a suitable container, and initially set up as just described, it is ready for use as a meter amplifier, and meter M_1 can be connected between the output terminals via RV_3. M_1 should have a sensitivity of between 250μA and 1mA f.s.d. The value of RV_3 will depend on the sensitivity of the basic meter and the overall sensitivity that is required, and must be found experimentally.

(For most requirements, M_1 may be a 1mA meter whereupon RV_3 could, initially, be a variable resistor of 5kΩ. With a 250μA meter RV_3 could initially, be a variable resistor of 20kΩ. Components with lower values may be fitted, after setting up, if the results obtained indicate that such values are required.—EDITOR.)

With meter M_1 in circuit the input terminals should be short-circuited together and the unit switched on. RV_3 should then be set to minimum resistance and RV_2 should be adjusted for zero reading on the meter. The circuit should then be "balanced" for zero reading once more via RV_1 and RV_2 in the manner already outlined. Once this balancing operation has been carried out, any change in the zero reading of the meter can be countered by short-circuiting the input terminals together and readjusting RV_2, the "set-zero" control. RV_1 should require little further attention throughout the life of the unit.

The circuit can now be adjusted to give the required value of f.s.d. current reading, using the set-up shown in Fig. 4 (*a*). Here, a 5kΩ variable resistor is wired across a 12-volt battery, so that a variable voltage supply is made available. The potential of this supply is monitored by voltmeter "V", and is used to feed a test current to the amplifier via series resistor R_x, which must be a 1% type. The value of R_x is equal to $\frac{10}{I}$ megohms, where I is the required f.s.d. current in μA. Thus, if an f.s.d. reading of 5μA is required in M_1, R_x should be given a value of 2MΩ.

First adjust the test potential to give a reading of zero volts in the voltmeter, and then set RV_3 for minimum resistance. Slowly increase the value of the input voltage until M_1 reads f.s.d., then increase the value of RV_3 to reduce the reading in M_1; further increase the input voltage, up to a final value of 10 volts, while at the same time increasing the value of RV_3 to keep the pointer of M_1 within the scale. Finally, with a reading of exactly 10 volts in "V", RV_3 should be adjusted to give a reading of exactly f.s.d. in M_1. Under this condition, an f.s.d. reading of 5μA is being obtained, and the test circuit can be removed, enabling the meter and amplifier combination to be used as a normal meter with a sensitivity of 200kΩ/volt.

Note that, during the above setting-up process, an occasional check should be made that M_1 sets to zero correctly with the input terminals short-circuited together, RV_2 being adjusted as required.

If the unit is to be used as a "converter" on the "D.C. Voltage" range of a multimeter, the calibration can be set up as shown in Fig. 4 (*b*). Here, a variable voltage supply is made available via a 5kΩ variable resistor, as before, and a fraction of this supply is tapped off by the R_1-R_2 voltage-divider network and fed to the input of the amplifier via R_y. The multimeter, set to a low voltage range, is connected to the output of the amplifier (i.e the upper ends of R_8 and R_9 in Fig. 2). RV_3 is not required for this application.

To set the unit up, the 5kΩ resistor is adjusted to give a reading in "V" which is equal to 10 times the required f.s.d. voltage reading for the multimeter, and the value of R_y is then adjusted, by trial and error, to give f.s.d. in the multimeter. Thus, if the multimeter is required to read 250mV f.s.d., a reading of 2.5 volts should first be obtained in "V", and R_y then adjusted as just described. Once the value of R_y has been determined, it should be wired permanently in position in series with the input lead of the amplifier.

A maximum voltage or "converter" gain of over 20 is available from the unit. If more than one range is required, a different value of R_y is needed for each of these. If desired, the different ranges can be selected by means of suitable switching.

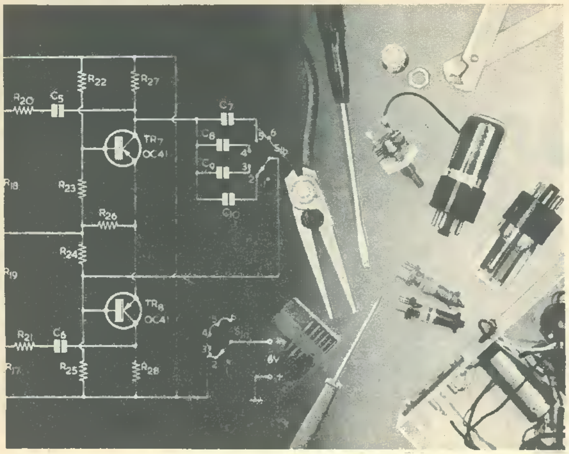
GB2LO AT CITY OF LONDON FESTIVAL

An unusual feature of the 1968 CITY OF LONDON FESTIVAL, July 8th–20th will be the Amateur Radio station installed and operated by the Radio Society of Great Britain.

The location is still under negotiation, but the station will be in a very prominent place within the 1.03 square miles of the City of London, and easily accessible to the public.

The G.P.O. have granted the use of the callsign, GB2LO.

Equipment will be loaned by Messrs. K.W. Electronics Ltd. and will be operated by volunteers on the amateur frequencies in the 10, 15, 20, 40 and 80 metre wavebands. The Society's Public Relations personnel will be on hand to explain the station and its function to visitors. Operation will be on single sideband only.



SUGGESTED CIRCUIT No. 209

REFERENCE VOLTAGE ZENER RECTIFIER CIRCUIT

by G. A. FRENCH

In mains operated equipment it is quite often necessary to fit a separate low voltage supply circuit to provide a reference voltage or to power one or more of the stages. Typical instances occur, for example, in valve equipment when it is desired to provide a fixed grid bias voltage or to incorporate a circuit employing transistors.

If the low direct voltage is to have a steady value, a normal approach is to employ a circuit of the type shown in Fig. 1. Here, a low voltage secondary winding on the mains transformer feeds a half-wave rectifier circuit, the voltage across the reservoir capacitor being applied to a resistor and zener diode. The voltage across the zener diode is then used as the reference, or to power the low voltage circuits.

When the current required from the low voltage supply is small (say, several milliamps only) it is possible to simplify the circuit of Fig. 1 by omitting the rectifier diode and using the zener diode both for regulation *and* rectification. The circuit then given forms the subject of this month's article. It has to be emphasised that the revised circuit is only suitable as a low current supply, and that for high currents the circuit of Fig. 1 is to be preferred.

Single Diode Circuit

The single diode circuit is illustrated in Fig. 2, where it will be seen to consist of a mains transformer secondary, a limiting resistor, the zener diode and an electrolytic reservoir capacitor. The rectified output voltage is taken direct from the reservoir capacitor. For the circuit to function correctly, the zener voltage of the diode should be somewhat higher than the alternating voltage peak value (r.m.s. value multiplied by 1.414) provided by the transformer secondary. This point is dealt with in more detail later. It is assumed, in Fig. 2, that there is a chassis connection into the rectifier circuit and that the required output voltage is positive of chassis. To obtain an output voltage that is negative of chassis, it is merely necessary to reverse the zener diode and the reservoir capacitor.

Let us commence an examination of Fig. 2 by assuming that the mains input is switched off and that the reservoir capacitor is discharged. When the mains supply is switched on, an alternating voltage is applied to the zener diode from the transformer secondary. During the first few cycles the zener diode functions primarily as a conventional rectifier diode, causing the reservoir capacitor to become charged and its upper plate to go positive. However, during the alternate half-cycles, when the upper end of the transformer secondary winding is negative, a reverse voltage is applied to the diode and its series resistor which is equal to the voltage across the secondary winding plus the voltage across the reservoir capacitor. When this reverse voltage exceeds the zener voltage of the diode, the diode passes zener current, causing the reservoir capacitor to discharge. The situation then arises that the reservoir capacitor is charged (by conventional rectifier diode action) on one half-cycle and discharged (by zener diode action) on the succeeding half-cycle. The system reaches equilibrium when both the charge and discharge periods are equal, whereupon the voltage across the reservoir capacitor becomes constant and is equal to half the zener voltage rating of the diode. The voltage across the reservoir capacitor may then be used as a reference or supply at low current drains, and is unaffected by changes in mains input voltage.

We have discussed the operation of the circuit in terms of what occurs immediately after the mains supply has been applied, and the impression might in consequence be given that the circuit takes a little time to reach equilibrium after switching on. In practice the time needed to reach equilibrium is of the same order as would be required for a conventional half-wave rectifier circuit to reach full output voltage if it had the same values of limiting resistance and reservoir capacitance.

Limiting Resistor Value

A disadvantage with the circuit of Fig. 2 is that the limiting resistor requires rather a high value in order to keep zener current flow within maximum rating. This enables satisfactory regulation to be provided at

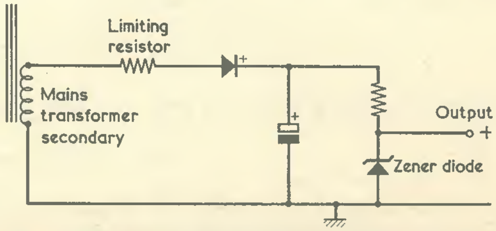


Fig. 1. A conventional method of obtaining a regulated low voltage supply. The mains transformer secondary winding could, in practice, be a heater winding or similar

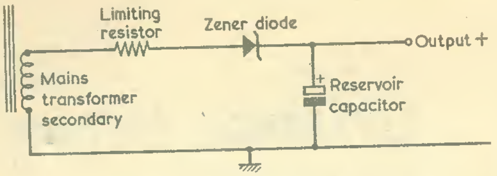


Fig. 2. A simpler circuit which may be used for low current drains. Output voltage is half zener voltage

low currents only, since the resistor also limits the forward current which charges the reservoir capacitor.

In Fig. 2, the maximum reverse voltage applied to the zener diode and its series resistor occurs when the upper end of the transformer secondary winding is at peak negative potential, whereupon the actual voltage applied is the peak secondary voltage plus the voltage across the reservoir capacitor (which is half the zener voltage of the diode). This maximum voltage may be expressed as ($V_p + 0.5V_z$) where V_p is the peak voltage and V_z the zener voltage. The voltage across the limiting resistor is then equal to this voltage minus the voltage across the zener diode, or:

$$(V_p + 0.5V_z) - V_z = V_p - 0.5V_z.$$

The value of the limiting resistor must then be equal to, or greater than:

$$\frac{V_p - 0.5V_z}{I_{max}}$$

where I_{max} is the maximum zener current specified for the zener diode used.

This expression tells us, incidentally, that the value of limiting resistor decreases as $0.5V_z$ approaches V_p, and advantage may be taken of this fact to operate the circuit with a low value of limiting resistor to enable it to offer better regulation. A good approach along these lines would consist of first selecting a zener diode whose nominal voltage is twice the rectified output voltage desired from the circuit and of feeding this from a transformer secondary whose peak voltage is just several volts greater than this output voltage.

It should be noted that if $0.5V_z$ is equal to or greater than V_p the regulating action disappears. The circuit then functions as a normal half-wave rectifier.

Practical Example

The writer checked the circuit in practice with a 12.6 volt mains transformer secondary winding and a ZL18 zener diode (available from Henry's Radio Ltd.). This zener diode has a nominal zener voltage of 18±5% and a power rating of 1.5 watts. The maximum zener current rating may then be inferred as 1.5/18, or 0.08 amps (=80mA).

The peak value of the alternating voltage given by the 12.6 volt secondary is 17.8, whereupon the minimum value required in the limiting resistor is:

$$\frac{17.8 - 0.5 \times 18}{0.08} = 110\Omega.$$

The circuit was set up with a 110Ω component in the limiting resistor position and gave an output of 9 volts, as predicted. This output was checked with reservoir capacitor values ranging from 50μF to 2,000μF, and remained unaltered. The value of reservoir capacitance required in practice is, therefore, mainly dictated by the hum level on the output which may be tolerated. The output voltage suffered no significant change at load currents up to 2mA, but it dropped by 0.4 volts at a load current of 5mA.

It will be noted that, in this practical example, the zener diode did not dissipate the full 1.5 watts for which it was rated in a normal d.c. regulating circuit, since the maximum zener current was only applied for a short period during each cycle. However, working from published zener diode characteristics it would appear somewhat safer to assume that the limiting factor for a zener diode is current rather than power. Experimenters might like to improve regulation by using a limiting resistor value lower than that given by the calculations just discussed, but the writer could not guarantee that this course of action might not result in damage to the diode.

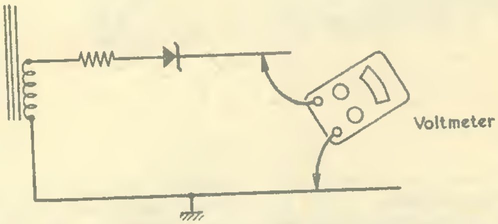


Fig. 3. To prevent mistakes, the rectified output from the zener diode may be checked for polarity with a voltmeter before connecting the reservoir capacitor into circuit

As a final point, it is quite easy to become confused as to the correct method of connection for the zener diode when employed in a circuit of this nature. If any doubt exists with the actual component employed, the circuit may be wired up without the reservoir capacitor and the output checked for polarity with a voltmeter, as in Fig. 3. If the voltmeter gives a reading of the desired polarity the reservoir capacitor may then be connected into circuit; if not, the diode should be reversed before the capacitor is connected. The reading given by the meter in the Fig. 3 circuit will, of course, be lower than is given after the capacitor has been connected into circuit.

ANNUAL CONVENTION — NORTHERN RADIO SOCIETIES ASSOCIATION

The Northern Radio Societies Association will again be holding their Annual Convention in the Kent Suite, at the Belle Vue Zoological and Exhibition Gardens, Manchester, on Sunday May 19th, 1968.

The Association comprises a number of Radio Societies from the North of England, who will be exhibiting, along with a number of commercial enterprises, at the Convention. The Convention will consist of a number of active displays and items of topical interest.

Inductance Test Unit

by

G. A. STANTON G3SCV

By taking advantage of the negative resistance offered by a transitron oscillator, this simple test unit is not only capable of finding the values of test inductances down to 1.5μH but can also give an approximate indication of Q. An external frequency measuring device such as a receiver or a signal generator is also required

THE MOST DIFFICULT MEASUREMENTS FOR THE amateur radio constructor to make are those concerned with inductance. An accurate inductance bridge is rarely seen outside the the professional laboratory. Likewise a good Q-Meter is neither easy to make nor cheap to buy and is not often available to the home constructor. Yet often in the course of experimental and constructional work it is desirable and sometimes essential to be able to make at least a rough estimate of both the inductance and the "goodness" of a particular coil.

The instrument to be described has been designed to help meet this need, and while no claim is made that it can replace the inductance bridge or the Q-Meter, it can still serve a very useful purpose on the test bench where more elaborate equipment is not available. It will enable, for example, the inductance of coils to be estimated down to values as low as 1.5 μH.[1] With its aid, inductors of similar value can be compared for relative "goodness" and can also be accurately matched for ganging purposes. It is particularly useful to the constructor who winds his own coils, for it enables these to be quickly checked before they are wired into a permanent circuit.

Basic Principles

The basic principles upon which the instrument operates can be understood from a study of Fig. 1. This shows a parallel tuned circuit comprising L and C connected to a device (block "A") capable of neutralising the losses involved in the circuit. When the losses are neutralised the tuned circuit will oscillate, and the frequency of oscillation will be mainly determined by the values of L and C and can be calculated from the well-known formula:

$$f=\frac{10^6}{2\pi\sqrt{LC}}$$

where f is in kc/s, L is in μH and C is in pF.

It follows that if either L or C are accurately known, the other circuit element can be found by ascertaining the frequency of oscillation. Seeing that our interest is in inductance, this can be calculated from the following:

$$L=\frac{10^{12}}{4\pi^2 f^2 C}$$

In this second equation, f, L and C are in the same units as before.

It may also be seen that the degree of loss-neutralising required to bring the circuit into oscillation will indicate the relative "goodness" of the circuit, for a low loss circuit will require less neutralising that one with high losses. If C is a high grade fixed component most of the losses will be in L so that the degree of loss-neutralising required will indicate the relative merit of the inductor itself. It must be emphasised, of course, that this will not be a direct measurement of Q but it does enable coils of the *same inductance* to be compared for relative efficiency.

Fig. 1. Illustrating the basic operation of the test unit. Block A is a two-terminal oscillator offering negative resistance to the tuned circuit

[1]This is, approximately, the inductance given by a short wave coil capable of being tuned up to 20 Mc/s (15 metres).—Editor.

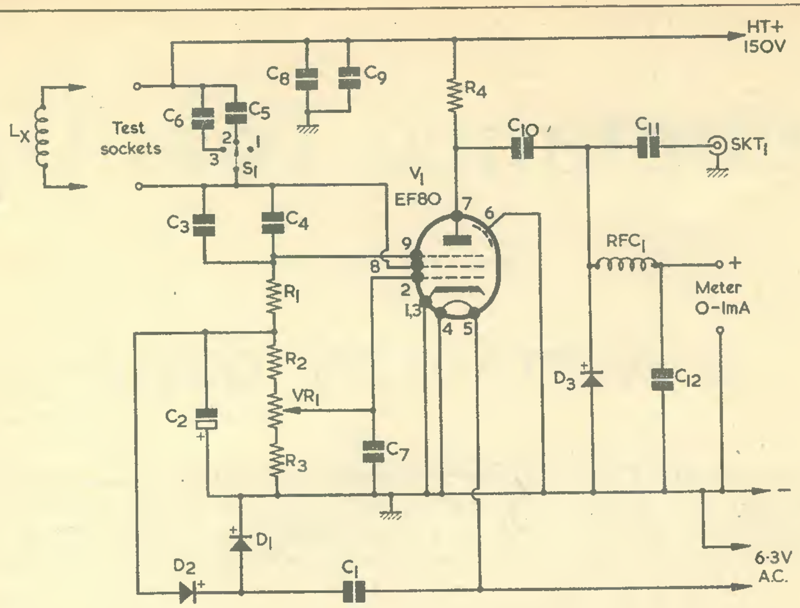


Fig. 2. The complete circuit of the unit. The coil to be checked is plugged into the test sockets

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)

R_1	750kΩ
R_2	180kΩ
R_3	1.5kΩ
R_4	10kΩ 1 watt
VR_1	50kΩ potentiometer, linear track

Capacitors

C_1	1μF paper, 150V wkg.
C_2	25μF electrolytic, 25V wkg.
C_3	0.1μF paper
C_4	1,000pF ceramic
C_5	82pF silver-mica
C_6	230pF silver-mica
C_7	0.01μF paper or ceramic
C_8	1μF paper, 200V wkg.
C_9	1,000pF ceramic
C_{10}	1,000pF ceramic
C_{11}	100pF ceramic
C_{12}	1,000pF ceramic

Inductor
RFC_1 2.6mH, type RFC5 (Denco)

Valve
V_1 EF80

Diodes
D_1, D_2, D_3 OA91

Sockets
SKT_1 Coaxial socket
B9A valveholder, low-loss type, with skirt
4 wander plug sockets

Miscellaneous
4 wander plugs
2 crocodile clips
2 pointer knobs
Tagboard, tagstrip (see Fig. 4)
Material for chassis, wire, etc.

The "neutralising device" represented by block "A" in Fig. 1 could take the form of any two-terminal oscillator. Of these the most convenient for the purpose in hand is the transitron and the practical circuit given in Fig. 2 is based upon this.

Circuit Operation

A full explanation of the working of the transitron oscillator is beyond the scope of this article and the interested reader is referred to a standard radio text book, such as *Radio And Electronic Laboratory Handbook* by M. G. Scroggie, published by Iliffe Books, Ltd. It is sufficient for our purpose to say that the transitron belongs to the negative resistance class of oscillator and its operation is due to interaction between the suppressor and the screen-grid in a pentode valve. The valve used in Fig. 2 is an EF80 which, for optimum results as a transitron oscillator, requires a negative bias of approximately 17 volts on its suppressor grid. This, it will be seen, is provided by two small diodes, D_1 and D_2 connected in a voltage doubler arrangement across the heater supply. In the original D_1 and D_2 were OA91's but any similar type could be substituted. Bias for the control grid of the valve is also provided by the same network and by means of VR_1, can be varied from about 3.5 volts down to 0.1 volts. R_3 prevents the control grid bias from dropping to zero, and it not only protects the valve but also prevents instability.

The bias control, VR_1, is used in the instrument to indicate the degree of loss-neutralising required by a particular coil in order for it to oscillate, the degree of neutralising being inversely proportionate to the bias. For example a coil with high losses will require the valve to operate with a lower value of bias than a low loss equivalent.

The inductor under test is connected in the screen-grid circuit of the valve and S_1 enables a choice of capacitance to be connected across it. In position 1 of this switch, the capacitance presented is made up of the strays in the circuit together with the inter-electrode capacitance of the valve. In the layout to be suggested this was found to total 20pF. This switch position is intended for use when an external capacitance is in parallel with the inductor under test—as, for example, occurs in an i.f. transformer. In Position 2, the capacitance presented is made up by C_5 to approximately 100pF. In the third position the total becomes 250pF. The round figures make any necessary calculations that much easier.

For the purpose of detecting the oscillations, use is made of the fact that an output can be taken from a transitron without unduly affecting either the frequency or the stability of the oscillatory circuit itself. In Fig. 2 an output is taken from the anode via C_{10} to a diode, D_3. This diode rectifies any oscillations presented to it, and the rectified current is fed via a filter choke to a milliammeter. Thus oscillations occurring in the screen-grid circuit will be indicated by a meter which is completely isolated from it. The meter can be external to the test unit and could consist of an ordinary testmeter switched to a 0–1mA range.

In use the inductor to be checked is connected to the test terminals of the unit, S_1 set to the appropriate position, and the bias control adjusted to the position where oscillation commences. At this point the valve will be supplying the minimum power necessary to neutralise the losses of the oscillatory circuit. If desired, VR_1 can be provided with a simple scale calibrated in arbitrary units (say from 0 to 10) to enable approximate comparisons of tuned circuit "goodness" to be made. It only remains to find the frequency of the oscillations for the value of the inductor to be estimated.

Evaluating Frequency

Three methods of finding the frequency can be suggested. With the first, use is made of an accurately calibrated receiver which is simply tuned until the "signal" from the test unit, at SKT_1, is picked up. If, however, the receiver is a superhet care will be needed not to confuse the genuine signal with spurious responses caused by image reception and the like. The second method uses a signal generator, the output of which is fed to socket SKT_1. Headphones are then substituted for the milliammeter and the diode D_3 functions as a mixer. When the signal generator is tuned through the frequency

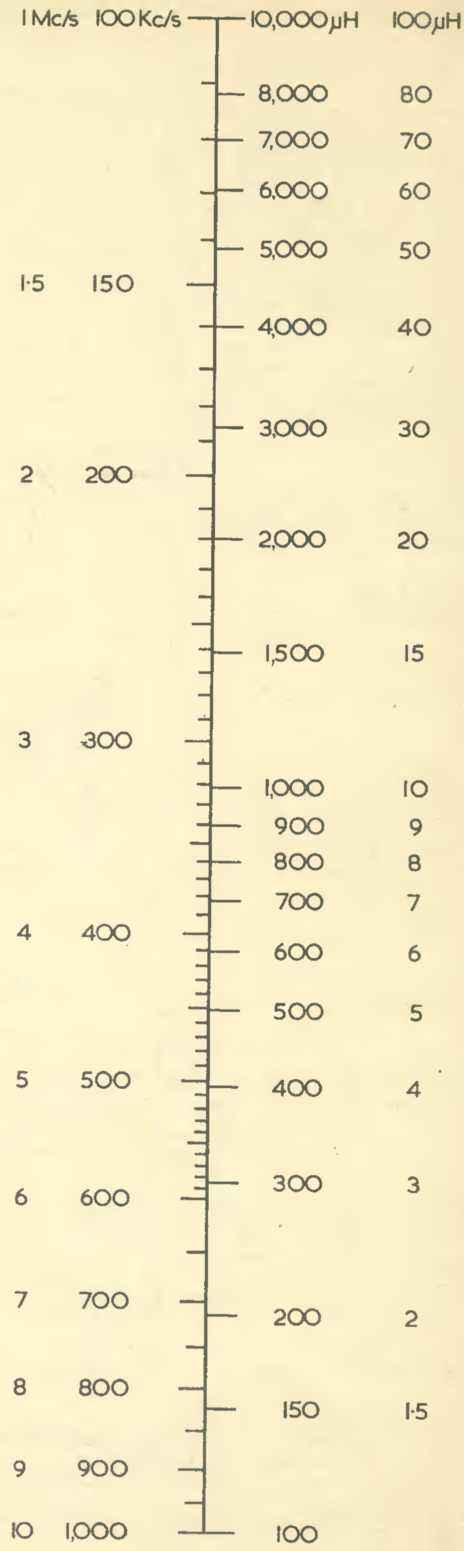


Fig. 3. Chart showing relationship between frequency and inductance with 250pF capacitance. The left hand outer column corresponds to the right hand outer column, and the left hand inner column corresponds to the right hand inner column

being generated by the unit a beat note will be heard in the phones. Zero beat will indicate the frequency of the oscillations. This method allows accurate

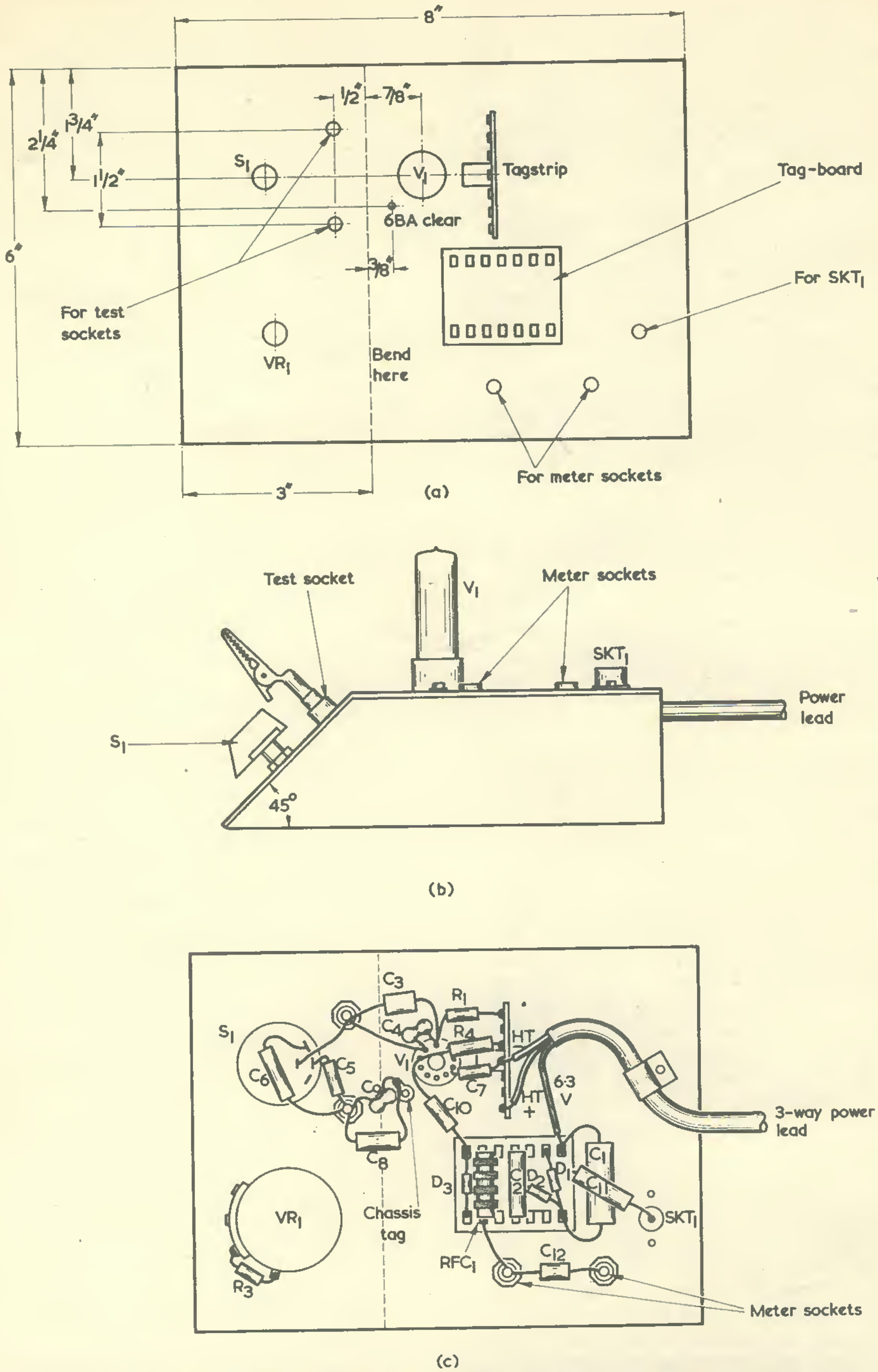


Fig. 4 (a). Dimensions of the chassis plate, illustrating the positions taken up by the major components. Note that a 7-way tagboard and 7-way tagstrip are fitted. V_1 valveholder should have the orientation shown in (c)
(b). Side view of the chassis plate after bending, with components mounted. Side plates, and an end plate for the rear, may be made of wood or metal
(c). The positions of the components under the chassis plate when assembly is completed. Wiring should follow the circuit diagram of Fig. 2

measurements to be made, but again care must be taken not to confuse beats caused by harmonics with that due to the fundamentals. In general it can be expected that a beat due to the latter will be much stronger than those due to the former. The third method suggested is perhaps the easiest of all, the frequency being determined by means of an absorption wavemeter. While this method may not be so accurate as the others suggested no confusion is likely to arise over harmonic responses.

Having ascertained the frequency of oscillation, the inductance of the coil under test can be found by calculation. Alternatively if a rough estimate will suffice, the chart given in Fig. 3 can be used. This has been prepared for use with the 250pF parallel capacitance.[2]

Constructional details of the unit are given in Fig. 4. All the components easily fit on to a piece of 16 s.w.g. aluminium measuring 8 x 6in and bent as shown. The only critical part of the wiring is that relating to the oscillatory circuit itself, and the connections here should be as short and direct as possible. If the valveholder is orientated as shown in Fig. 4 (*c*) no difficulties should be encountered. Capacitors C_3 and C_4 should be mounted as close to the valve pins as possible and the earthy wires of C_8 and C_9 should be connected to a chassis point near the valveholder.

In order to enable firm connections to be made to the coil under test, two crocodile clips are soldered to standard wander plug pins, which then fit into the test sockets.

Power requirements for the unit are modest, 6 volts at 0.3 amp being all that is needed for the valve heater, and 10mA at 150 volts for the h.t. supply. If the latter is stabilised so much the better, but this is not absolutely essential. Most workshops will already have a suitable supply available on the bench.

While the unit is primarily intended for use with radio frequency inductors, it can also be be used for checking audio frequency types. For example, if the primary of an output transformer is connected to the test terminals, audio frequency oscillations will be produced. Again, the frequency generated can be used to calculate the inductance of the transformer.

A further use for the unit is as a signal source. By connecting a suitable value of inductance, signals from the low audio range up to some 20 Mc/s have been produced on the prototype. Careful adjustment of VR_1 ensures good wave form. The unit is, in fact, a very useful accessory for any workshop.

[2]With a parallel capacitance of 250pF, the inductance (in μH) is approximately equal to 10^8 divided by frequency (in kc/s) squared.—Editor.

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

Oscilloscope Type CT52 and CT84.—L. C. Chandless, 43 Maryatt Avenue, South Harrow, Middx.—loan or purchase of circuit diagram or any other information.

* * * *

Test Set Type 253.—B. A. Manning, 14 Tredown Road, London, S.E.26—handbook, circuit diagram or any other information—loan or purchase.

* * * *

Ace "Richmond" A.M./F.M. Receiver.—B. Dunn, 8 Lancaster Drive, Clayton-le-Moors, Accrington, Lancs.—manual or circuit diagram of this receiver (type No. 3458)—loan or purchase.

* * * *

Crystal Calibrator No. 10.—F. A. Chidgey, 94 Tachbrook Street, London, S.W.1—manual or circuit diagram—loan or purchase.

* * * *

"Fountain" Home/Office Intercom.—WO686311 Cpl. Hall, Dominie Rects, R.A.F. Stradishall, Suffolk—circuit diagram or any information on this Japanese-made equipment.

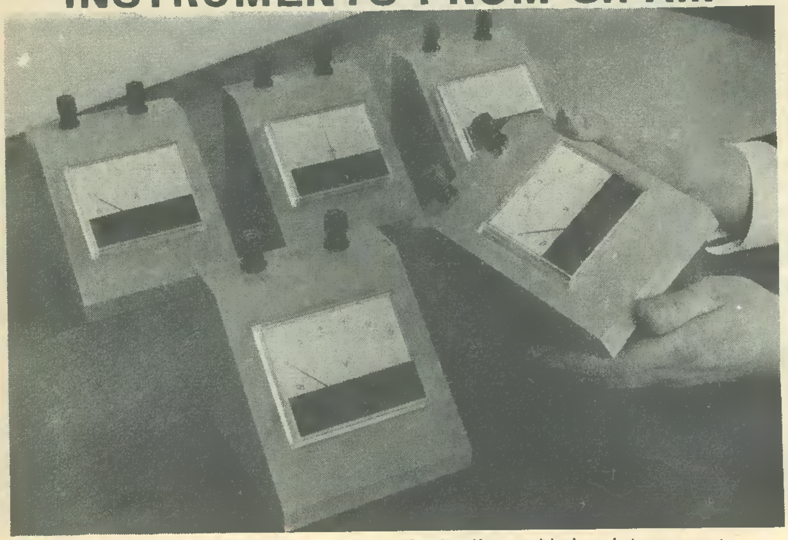
NEWPORT MODEL ENGINEERING EXHIBITION

The Blackwood Amateur Radio Club (GW6GW) are to present a Stand at this Exhibition—to be held at Duffryn Junior School, Stow Hill, Newport, Mon. from 13th to 20th April (except Sunday) 10 a.m. to 9 p.m.

The Exhibition will feature all the various aspects of model engineering—flying model aircraft, traction engines, miniature railways, etc. The Club Stand will include a working transmitter, receiver, teletype equipment and a display of home constructed units.

NEWS . . . AND .

NEW SET OF PORTABLE BENCH INSTRUMENTS FROM SIFAM



A selection of the new range of Sifam "Student" portable bench instruments which, housed in strong and resilient, grey "ABS" plastic material, have been manufactured to meet the special requirements of schools, colleges, universities and industrial laboratories, with scale ranges as recommended for Nuffield Physics Courses

A new range of portable, electrical measuring bench instruments, housed in tough "ABS" plastic cases, to meet the special requirements of schools, colleges, universities and industrial laboratories, has been introduced by Sifam Electrical Instrument Co. Ltd., Torquay.

The complete matching "set", to be known as the Sifam "Student" range, comprises seven instruments with scale ranges as recommended for Nuffield Physics Courses: 0–1A, 0–5A, 0–5V, 0–15V, 0–1A and 0–5A dual range, 0–5V and 0–15V dual range and a 3–0–3mA galvanometer.

Moulded in grey, the ABS plastic material used for the stand is exceptionally strong and resilient. It is noted for its resistance to most alcohols, oils, acids, salts and alkalis. The fine surface finish will resist scratching, is non-hygroscopic and, of course, is electrically insulating.

Two terminals are fitted (three on dual-range instruments) suitable for wire, spade connectors and standard 4mm. plugs.

The standard Sifam "Student" range is fitted with the company's "Clarity 32" movement, with transparent front, knife-edge pointer and fine-line scale. Accuracy is to B.S. 89: 1954 industrial grade; sensitivity is 100 millivolts (ammeters) or 1000 ohms per volt ± 2% (voltmeters).

Other Sifam instruments can be mounted in the stand if required.

"CONSTRUCTOR" ON THE AIR

We were very gratified when, recently, in the Overseas Service of the B.B.C., favourable mention was made of this magazine.

The speaker's theme was that everyone is aware that electronics is at the heart of numerous industrial processes but not so many realise that, in the hands of amateur experimenters, electronic gadgets are invading domestic life. As evidence of this he quoted the contents of our February issue.

It was pointed out that there were seven articles on making units of electronic gear as distinct from pure radio, and that a quick glance showed how far do-it-yourself electronics have penetrated the domestic sphere.

Electronics and home wine making was instanced. The main difficulty is getting the brew to ferment properly. Special wine-making yeasts can be bought, but these come in dried form and have to be "activated" first. This entails putting the yeast in a bottle with a nutrient, sugar, and water and keeping it for 48 hours at a fairly precise and even temperature (24–27°C). Problem: British homes are too cold, especially at night. Solution—the Temperature Controlled Container article.

The Automatic Parking Light Operator article consisting of a light dependent resistor and a handful of transistors was mentioned, and it was pointed out that if the car only had a 6 volt battery then the Miniature 2 Volt Power Supply feature would remedy the position.

For the more adventurous electronics enthusiast there were the details of the Long Range Light Modulator—"very handy for private chats with a girl friend across the street".

The talk concluded "Home electronics is certainly extending its frontiers".

EXPORT ORDER FOR HEADPHONES WITH NOISE PROTECTION

Amplivox Limited of Wembley have just been awarded a valuable Overseas contract from the Royal Dutch Army for several thousands of their Ampligard Type Ear Defender Headphones. These Headphones have been specially designed to considerably reduce high ambient noise and provide highly intelligible communications. Anyone wearing the Ampligard Headphone is able to clearly receive important messages even in conditions of very high noise.

Similar Amplivox products have previously been supplied to the British Armed Services and for other Industrial applications at home and abroad.

. . . COMMENT

WATCHING THE WINNERS

Three Marconi V322A closed-circuit television cameras assume a supervisory role in the final coupon-checking room at Littlewoods Pools Ltd., Liverpool.

The cameras, all with remote pan and tilt heads, remote control panels and a remote zoom and focusing facility, are capable between them of observing all activity in the room in detail. The two cameras in the background of the photograph produce pictures of the operators of two Optical Reading and Sorting machines which, in conjunction with a computer, select those coupons with maximum points, while the third camera scrutinizes the operation of semi-automatic machines employed to determine the exact number of minor dividends.

The control room, housing the control panels and three Marconi 23in. V6211 Video Monitors, is sited close to the checking room, and is normally manned by one operator.

RADIO CONTROL SYMPOSIUM

The Esher Model Flying Club, following upon the outstanding success of the symposium they held last year, are to hold their 1968 Symposium on 19th, 20th and 21st April, at the Brooklands Technical College. The 19th is reserved for trade buyers, but the other two days will be open to the public. In addition to the interest provided by the comprehensive display of r/c equipment and accessories, there will be flying displays and lectures.

STEREOPHONIC TRANSMISSIONS —A POINT OF VIEW

A reader has written to us expressing a point of view regarding the stereo transmissions of the B.B.C., which seems to have some justification. The relevant part of his letter is as follows:

Stereophonic transmissions to the extent of about 25 hours weekly are now put out by the B.B.C. and the whole of this new service is devoted to minority interests of serious music listeners and includes those particularly small sections of taste who like ancient organs, electronic music, etc.

There can be no valid reason why the B.B.C. is so completely biased and prejudiced in its approach to the new service. It is certainly no excuse to use the fact that transmissions are on Radio 3 only, which already provides more than an equitable share of time to minority music interests as well as the extension into Radio 4 of serious music.

In fact no minority interest is so generously catered for as that of the serious music listener.

I believe the B.B.C. to be confusing the serious music listener with the high fidelity enthusiast.

High fidelity enthusiasts are found from all musical interests but the greatest potential audience is without doubt the lighter music listener.

A glance through the high fidelity press will indicate just how much equipment tuners and amplifiers, are being sold but no coverage is given at all in the stereo broadcasts to cater for the largest audiences.

I cannot protest strongly enough at this flagrant misuse of licence money to satisfy such minority interests at the expense of all other high fidelity enthusiasts.

Stereophonic time should now be divided proportionately between the various musical interests and a due proportion of time at week-ends and in the evenings should be given to the more popular light music tastes and to the whole audience who are interested in stereo transmissions.

SOCIETY FOR AMATEUR RADIO ASTRONOMERS

Soon after the formation of the above society, we referred in these notes to our pleasure that such an organisation had been formed, particularly as we had pioneered the subject of radio astronomy for amateurs in the popular radio press.

It is therefore pleasant to record that the society is flourishing and now has a world-wide membership. Many members are now either operating or building their own equipment spanning the whole range from audio frequencies (to detect whistlers) up to 3cm microwave wavelengths. A journal *Radio Sky* is published approximately three times a year and contains articles of both a practical and theoretical nature.

Where geographical conditions permit members are encouraged to form groups so that information, talents, and resources can be pooled.

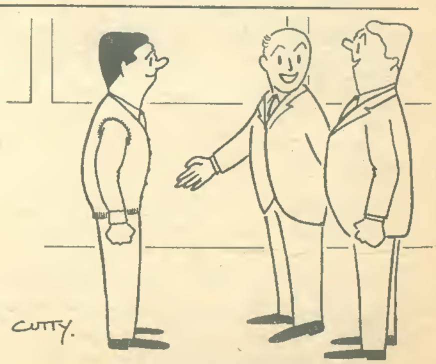
At the present time several groups are hoping to correlate solar activity with whistlers and possibly radio emission from Jupiter.

Any readers interested should write to the Society for Amateur Radio Astronomers, 80 Greenford Gardens, Greenford, Middlesex.

QUOTE

"Outside their business, their knowledge is often negligible. I once sat next to a radio-valve tycoon at lunch. He talked about radio valves through soup, fish, meat and cheese—it was his only subject."

Anne Scott-James commenting in The Daily Mail *on the idea of forming a government made up entirely of business men.*



"Meet our Welsh wizard of the valve section, Dai Ode."

Increasing Projector Lamp Life

by

T. R. BALBIRNIE, B.Sc.

By carrying out some simple modifications it is possible to extend the life of a slide projector lamp by a very considerable extent

SINCE SLIDE PROJECTOR LAMPS ARE DESIGNED FOR high efficiency they are necessarily expensive items and have rather a short life. Any method by means of which the life of such lamps can be extended without undue loss in efficiency seems, therefore, to be worthwhile.

The short life is due to the lamp being operated at a higher filament temperature than a household lamp. This is brought about by applying a voltage in excess of that which would normally be applicable to the household lamp. The graph in Fig. 1 shows that the efficiency, expressed in lumens per watt, increases sharply as the overvoltage is increased above 100% (the arbitrary "normal" value). The life of an overrun lamp can also be seen to drop steeply under these conditions. It will be noted that a 5% increase or decrease in applied voltage causes a corresponding halving or doubling of the average life.

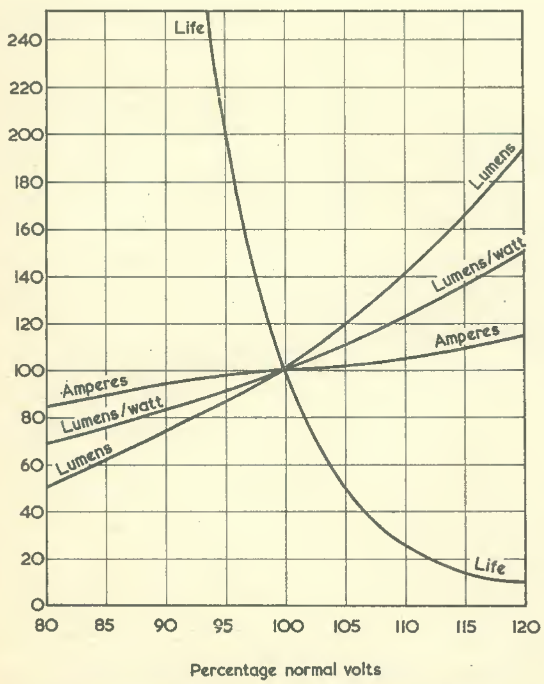


Fig. 1. Illustrating how a variation in applied voltage affects the light output (lumens), efficiency (lumens/watt), current and life of a tungsten lamp. All units are expressed as percentages of the normal rated values. (Courtesy, Philips Electrical Limited)

Life Shortening

As far as slide and filmstrip projectors are concerned, life shortening of the bulb is aggravated by repeated switching on and off, tilting and vibrating the apparatus. Most people avoid these last two mistakes but the first is often overlooked. It is certainly bad practice to switch off between boxes of slides as the extra shortening in life will offset the cost of electricity saved. When the bulb's filament is cold its resistance is very low and a powerful surge of current will flow at the instant of switching on. The current will only fall to its normal value when operating temperature has been reached a short while later. On switching on, there will also be a strong magnetic attraction between adjacent strands of filament, which will momentarily pull towards one another. In an older lamp the filament will be

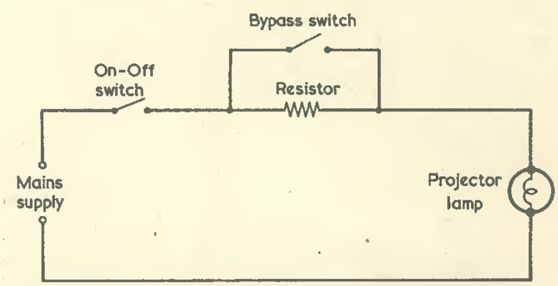


Fig. 2. Inserting a resistor in series with the projector lamp to reduce the switch-on current surge. The bypass switch is closed several seconds after switching on. It is important to open the bypass switch again after use of the projector, or the benefit given by the resistor will be lost when switching on the next time

(continued on page 543)

RADIO CONSTRUCTORS DATA SHEET 5

CAPACITIVE REACTANCE—AUDIO FREQUENCIES

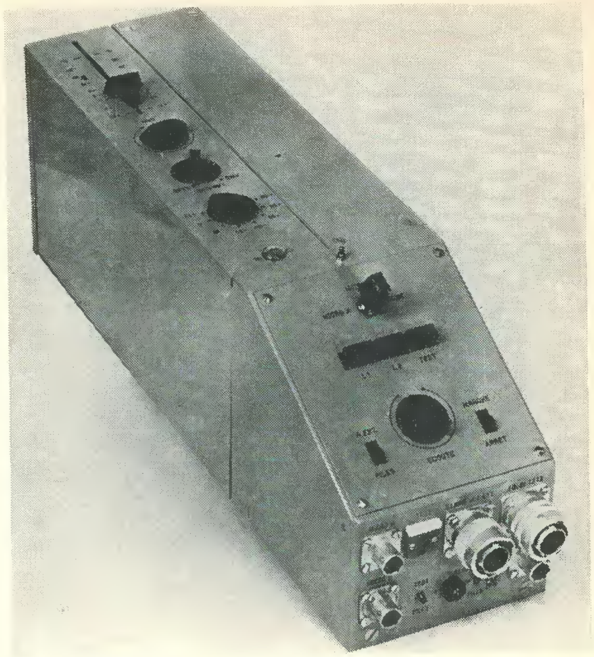
The Table gives reactance in ohms at the capacitances and frequencies indicated. $X_C=\frac{1}{2\pi fC}$.

Capacitance	25 c/s	50 c/s	100 c/s	400 c/s	500 c/s	1 kc/s	5 kc/s	10 kc/s
50pF						3,180,000	637,000	318,000
100pF				3,980,000	3,180,000	1,590,000	318,000	159,000
250pF				1,590,000	1,270,000	637,000	127,000	63,700
500pF			3,180,000	796,000	637,000	318,000	63,700	31,800
1,000pF		3,180,000	1,590,000	398,000	318,000	159,000	31,800	15,900
2,500pF	2,550,000	1,270,000	637,000	159,000	127,000	63,700	12,700	6,370
5,000pF	1,270,000	637,000	318,000	79,600	63,700	31,800	6,370	3,180
0.01μF	637,000	318,000	159,000	39,800	31,800	15,900	3,180	1,590
0.02μF	318,000	159,000	79,600	19,900	15,900	7,960	1,590	796
0.05μF	127,000	63,700	31,800	7,960	6,370	3,180	637	318
0.1μF	63,700	31,800	15,900	3,980	3,180	1,590	318	159
0.2μF	31,800	15,900	7,960	1,990	1,590	796	159	79.6
0.5μF	12,700	6,370	3,180	796	637	318	63.7	31.8
1μF	6,370	3,180	1,590	398	318	159	31.8	15.9
2μF	3,180	1,590	796	199	159	79.6	15.9	7.96
5μF	1,270	637	318	79.6	63.7	31.8	6.37	3.18
10μF	637	318	159	39.8	31.8	15.9	3.18	1.59
20μF	318	159	79.6	19.9	15.9	7.96	1.59	0.796
50μF	127	63.7	31.8	7.96	6.37	3.18	0.637	0.318
100μF	63.7	31.8	15.9	3.98	3.18	1.59	0.318	0.159

CUT ALONG THIS LINE

TRADE NEWS . . .

ALKALINE BATTERY POWER



Manganese alkaline batteries were supplied from Britain for the French Broadcasting and Television Service for use during this year's Winter Olympic Games at Grenoble.

Fourteen thousand Mallory MN1300 alkaline batteries were used to power S.A.F. recording units, Swiss made Magna and Perfectone portable tape recorders and connecting interphone system at temperatures down to minus 20°C.

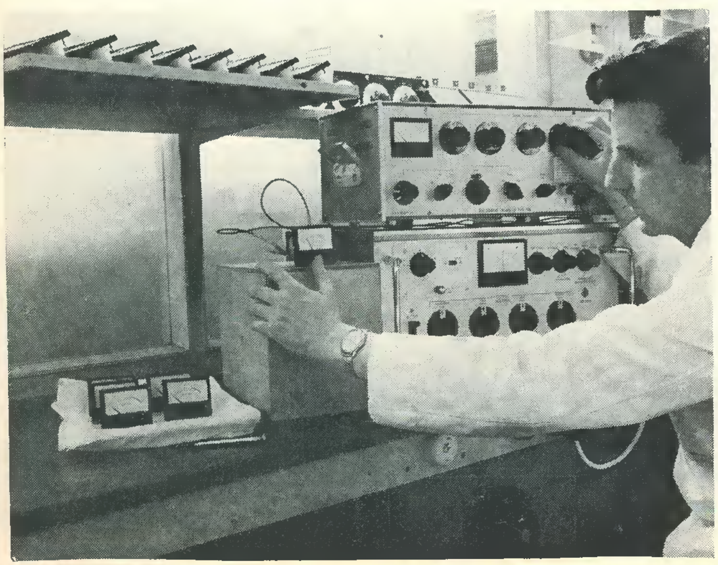
The applications will have high current drains and each unit will be powered by a set of twelve batteries. Tests have shown that even at temperatures between minus 10° and minus 20°C there is still sufficient service to make efficient operation practicable. Because of the low temperatures it was found that several sets of twelve MN1300's were used each day. The Mallory MN1300 is equivalent in size to the standard U2 torchlight cell with a nominal voltage of 1.5V and a capacity of 10,000 mAh. Normal applications are portable tape recorders, radios, clocks, distress beacons, army transceivers and portable lighting.

The illustration shows the S.A.F. recording units powered by sets of twelve Mallory manganese alkaline batteries.

SIFAM VOLUME LEVEL METERS

Special "vu" meters for use in a new, portable professional tape recorder being tested at the Torquay factory of Sifam Electrical Instrument Co. Ltd.

Sifam have received a large initial contract from Ampex Electronics Ltd., Reading, Berks., for these meters for fitting to the new Ampex AG-20 battery-operated audio recorder. Built into a modified Sifam 'Director 24" instrument case, the meter movements have specially designed ballistics based upon the stringent U.S.A. Standards Institute Specification for volume measurement of electrical speech and programme waves.



Selected for their reliability under rugged conditions, the meters were subjected to severe tests both in the U.K. and by the Ampex parent corporation in the United States. The most dramatic of these was an environmental test of the recorder in which an interview was taped by skydivers from the British Green Jackets Parachute Club during free fall from an altitude of 12,000 feet.

INCREASING PROJECTOR LAMP LIFE

(continued from page 540)

permanently stretched, anyway, and visibly sagging on its supports, whereupon there is a possibility, on switching on, of a short-circuit bypassing a portion of the filament. The life of the lamp will then end in a rather unimpressive blue flash.

There seems a lot to be said for preventing the initial surge of current which causes so much trouble, and this can be done in two inexpensive ways. The first is to place, in series with the lamp, an additional resistor which can be short-circuited with a suitable switch a few seconds after switching on. See Fig. 2. An Ohm's Law calculation and a

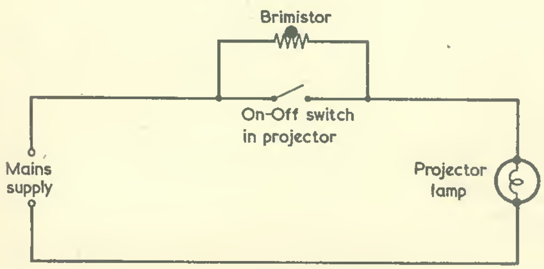


Fig. 3. The switching circuit using a Brimistor which is employed by the author

little trial and error will soon find a suitable value for the resistor, and it should be such that the filament slowly comes up to a dull glow. The wattage rating need not be as high as for continuous rating, provided of course, that there is no possibility of the projectionist failing to switch the resistor out of the circuit quickly. A suitable resistor could be bought or home wound. The best position for it is within the projector body, but placed well away from anything which could be damaged by heat. The series resistor is probably the best method for the higher powered lamps of, say, 500 or 1,000 watts.

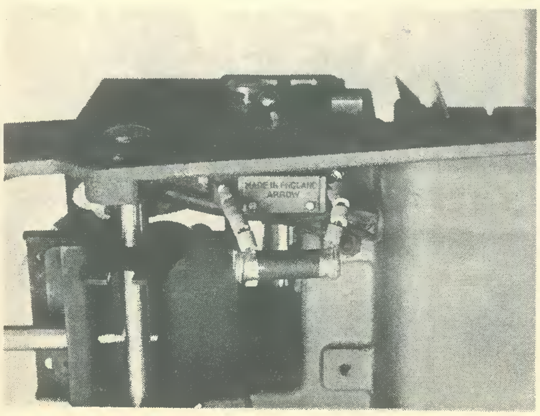


Fig. 4. Illustrating the manner in which the Brimistor is mounted inside the projector

Using A Brimistor

For the more popular lamps of 250 or 300 watts a better plan is to use a thermistor, and a suitable component is the Brimistor type CZ11. This compact device, with its negative temperature coefficient of resistance, is very well suited to the application. Connected in series with the lamp, it offers a high resistance when switched on from cold and this smoothly reduces in a second or so as it heats up. If the Brimistor is left in circuit permanently its low resistance when hot will cause a slight dimming of the bulb but, as has been mentioned, this can be regarded as beneficial as there will be a useful increase in life on account of this. Alternatively the Brimistor can be bypassed with a switch and so put out of circuit after it has done its duty, as with the resistor.

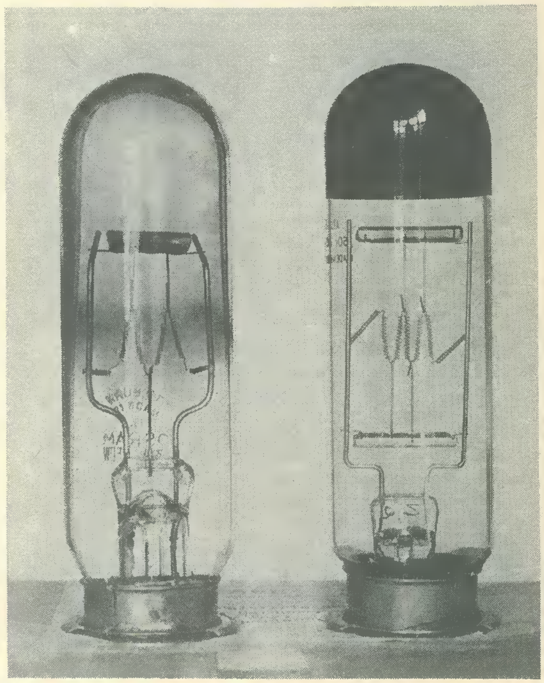


Fig. 5. The result of carrying life extending too far. The lamp on the left shows marked blackening of the bulb, as compared with the new lamp on the right

The author has soldered his Brimistor directly across the terminals of the internal on-off toggle switch. See Figs. 3 and 4. The normal function of the switch is then, of course, lost. It could be replaced by one in the mains lead if desired but this seems hardly worthwhile. With the switch in the off position, current flows through the lamp via the Brimistor. Normally it is left like this for the duration of the show but under special circumstances, when a slight increase in brightness is thought to be necessary, it is bypassed by closing the switch. The advantage given by connecting across the switch is that good secure mounting of the component is possible. Heat resisting beads have been threaded on the wire ends and full use has been made of these to keep the Brimistor in a clear position within the body of the projector. If a similar plan is adopted remember to keep the Brimistor away from the cooling effect of any blower which may be fitted, as it will not then reach a satisfactory temperature.

Remember, also, that a Brimistor takes some time to cool down and present a high resistance for its next period of use. If it is short-circuited by the switch after reaching operating temperature it will have ample time to cool down, and will be ready for instant use when next required.

The CZ11 may be obtained at low cost, and that used by the author drops about 4 volts at operating temperature. If it is left in circuit after warming up there will be a significant increase in lamp life on this count alone.

One final point needs to be emphasised. With either of the schemes described here, the life of the lamp may possibly be prolonged to such an extent that its useful life will be ended when blackening of the bulb spoils light transmission. See Fig. 5. This blackening is a very gradual process and the benefit of a new lamp can only be assessed by having a spare and trying its effect every now and again. Recently the author was becoming disappointed with his slides, only to find that the bulb was so blackened that it should have been discarded long before. Brightness measurements made with a Weston light meter showed a remarkable increase in light when a new lamp was fitted.

Audio Frequency Substandard

by **A. D. WILLIAMS, B.Sc.**

This substandard audio frequency generator employs a standard tuning fork as the frequency-determining element. Since the coils required at the tuning fork tines may need to be home-wound or adapted from other components, we present this design as an experimental project; but the experienced constructor should find little difficulty in making the circuit function satisfactorily

Many sources of r.f. signals of accurately known frequency are available to the experimenter. For instance, a radio receiver may be used to calibrate an r.f. signal generator very accurately. For a.f. work, however, the amateur usually has to rely on one or more of three sources, these being standard frequency broadcast signals, such as the B.B.C. tuning notes, the 50 c/s mains frequency, or highly divided r.f. signals from a crystal controlled oscillator. Unfortunately, broadcast-band a.f. signals are usually available only at certain times of the day, and in many parts of the world cannot be received at all. The mains 50 c/s frequency, although having good long-term stability, may present quite large short-term variations. Divided r.f. signals require a very large number of binary dividers, or a smaller number of, say, denary dividers, and these require great care in construction and use to maintain the division ratio constant.

This article describes a constant frequency source with its fundamental in the audio range, so that for many purposes the complications of divider and multiplier stages are not needed. Apart from its uses in a.f. variable frequency oscillator calibration and amplifier measurements, it could also be used as a constant frequency source for inductance bridge measurements. Twelve such sources could be used to provide a basic octave in an electronic musical instrument, other octaves being obtained by multiplier and divider stages. By use of a suitable tuning fork and frequency division stages, 1 second pulses may be obtained to synchronise an electronic clock with an accuracy of better than 10 seconds per day. Although not an exceptionally high accuracy, this is still very good for the cost of the components used.

The Circuit

The circuit, shown in Fig. 1, is that of a 2-stage amplifier whose

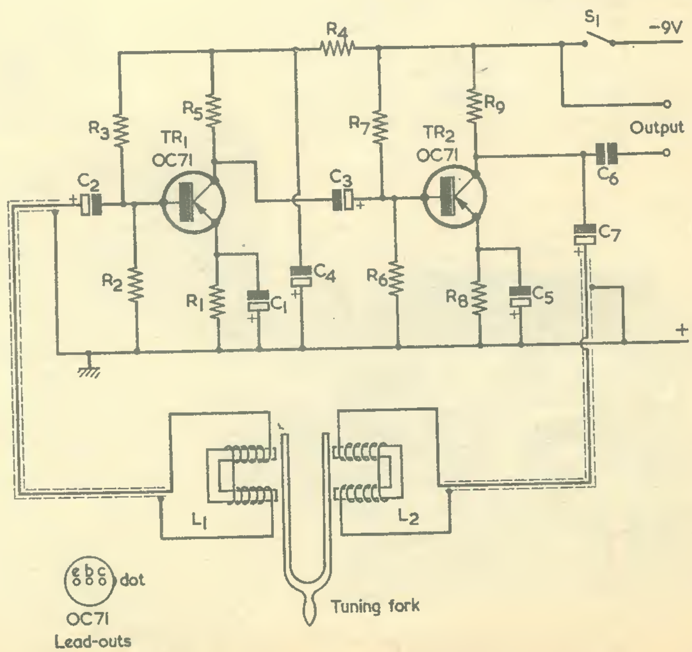


Fig. 1. The circuit of the audio frequency substandard

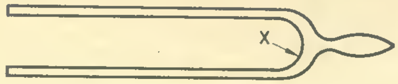


Fig. 2. Small adjustments in tuning fork frequency may be obtained by careful filing at point X

Tuning Fork Frequencies

Fork	c/s
C	262
D	294
E	330
F	349
G	392
A	440
B	494

output passes into a coil, L_2, which excites a tuning fork, and whose input is obtained from a coil, L_1, excited by the same tuning fork. The original model used an A fork, but any other will work just as well. The fork selected will, or course, determine the frequency (see the accompanying Table).

For generation of 1 second pulses a C fork could be adapted by careful filing at the point X (Fig. 2) to reduce the frequency to 256 c/s, whereupon 8 binary divider stages may then be used to give a 1 c/s output. The filing must be carefully done with constant checking of oscillator frequency, preferably by means of a digital frequency meter. Not a great deal of filing is needed to change the frequency by the required amount.

Construction

Disregarding coils L_1 and L_2 the construction of the amplifier requires no more care than that of any other 2-transistor small signal amplifier. One method of construction shown in Fig. 3 and the photograph, is on a length of tagstrip. Although OC71 transistors were used in the prototype, these were later replaced by cheap "surplus" transistors with no noticeable deterioration in performance.

The tuning fork and bell assembly follows the general layout shown in the photograph, with the two coils for L_1 being alongside one tine of the fork and the two coils for L_2 alongside the other tine. The coils shown in the photograph were taken from German-manufactured electric bells intended for operation from the mains, but such coils are not generally available in the U.K. Details of alternative coils are given later in this article.

Whatever coils are used, construction is simplified if these have soft iron cores. Magnetised cores make positional adjustments difficult, as they deflect the tines of the tuning fork and can cause trouble when oscillations build up in amplitude. It will be noted that the circuit functions despite the fact that the cores of the pick-up coils, L_1, are not intentionally magnetised.

The tuning fork must be mounted securely by the handle, so that the tines are quite free to vibrate, and it must be possible to remove the fork from its mounting for testing purposes. The constructor with mechanical skill may wish to mount the coils so that the air gaps between coils and fork are adjustable, and if a pure sinewave output is desired such a mounting will help very much. In the prototype the coils were cemented in place with Araldite so that there was a 0.02in gap (measured by a feeler gauge) between the cores of the coils and the tines of the fork. The tines of the fork must be completely free to vibrate, without touching the cores or any other part, or oscillations will not start.

Operation

After the amplifier has been completed and the coil and tuning fork assembly fixed in place, the coils are connected to the amplifier by screened wire, and the tuning fork removed. The amplifier output is taken to a high impedance earphone, and the amplifier is switched on. If oscillations take place *without the tuning fork in position*, the connections to L_2 must be reversed, whereupon oscillations should cease. If they do not cease then unwanted feedback is taking place which must be corrected before satisfactory performance can be obtained. The amplifier is then switched off, and the tuning fork replaced. If the amplifier is switched on again, and providing the fork handle is secure and the tines are free, oscillations should build up at the frequency of the fork over about 5 seconds.

COMPONENTS

Resistors
(All resistors ¼ watt 10%)

- R_1 1kΩ
- R_2 10kΩ
- R_3 39kΩ
- R_4 3.9kΩ
- R_5 2.2kΩ
- R_6 10kΩ
- R_7 39kΩ
- R_8 1kΩ
- R_9 2.7kΩ

Capacitors

- C_1 100μF electrolytic, 12V wkg.
- C_2 10μF electrolytic, 12V wkg.
- C_3 10μF electrolytic, 12V wkg.
- C_4 100μF electrolytic, 12V wkg.
- C_5 100μF electrolytic, 12V wkg.
- C_6 0.002μF paper
- C_7 10μF electrolytic, 12V wkg.

Inductors

- L_1, L_2 See text

Transistors

- TR_1 OC71
- TR_2 OC71

Switch

- S_1 s.p.s.t. switch

Battery

- 9-volt battery

Miscellaneous

- Tuning fork
- Output sockets or jack
- Material for baseboard, etc.

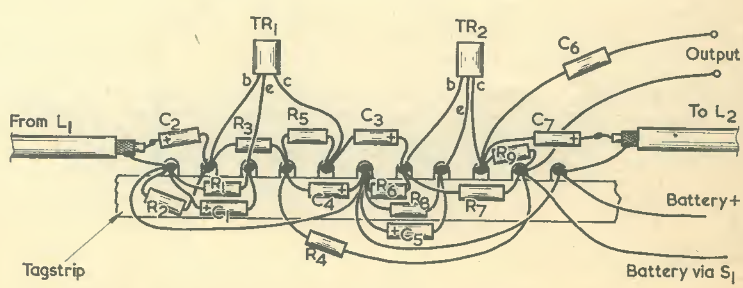


Fig. 3. The amplifier components can be fitted to a tagstrip, as here. For clarity, some of the components are shown smaller than they would be in practice

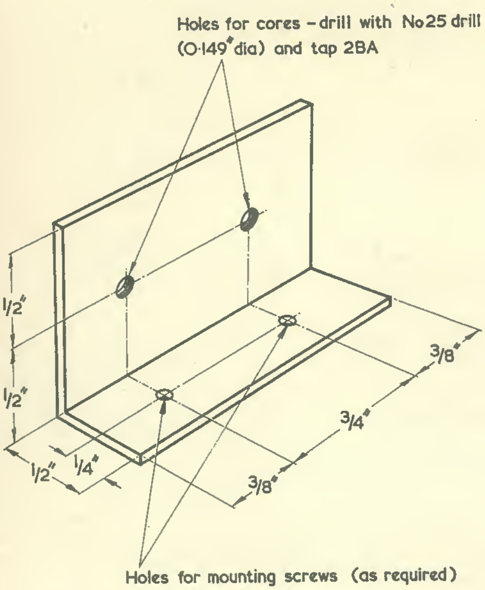


Fig. 4. The coil mounting bracket. Two are required

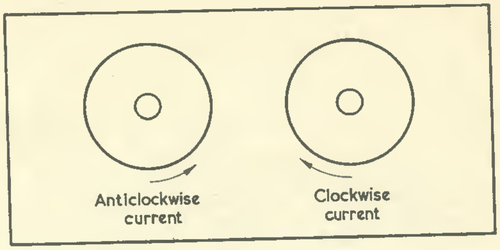


Fig. 5. Direction of current in each coil assembly

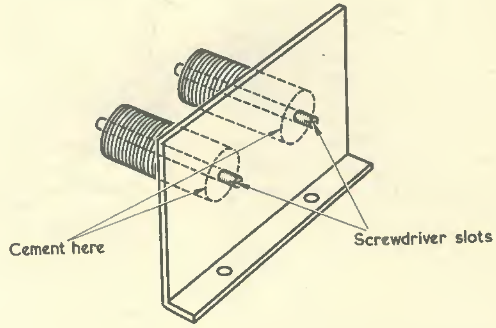


Fig. 6. Two coils and their cores mounted on a bracket

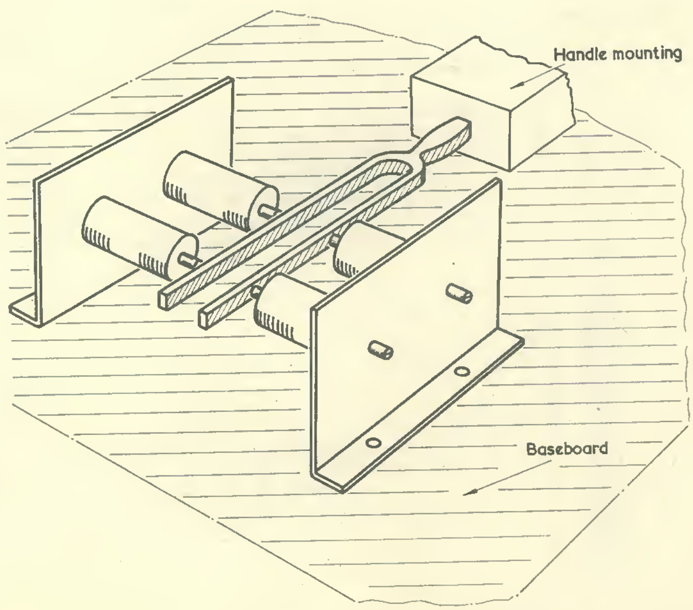


Fig. 7. The tuning fork appears between the coils as illustrated here

If they are slow to start the fork may be lightly flicked with a finger.

Performance

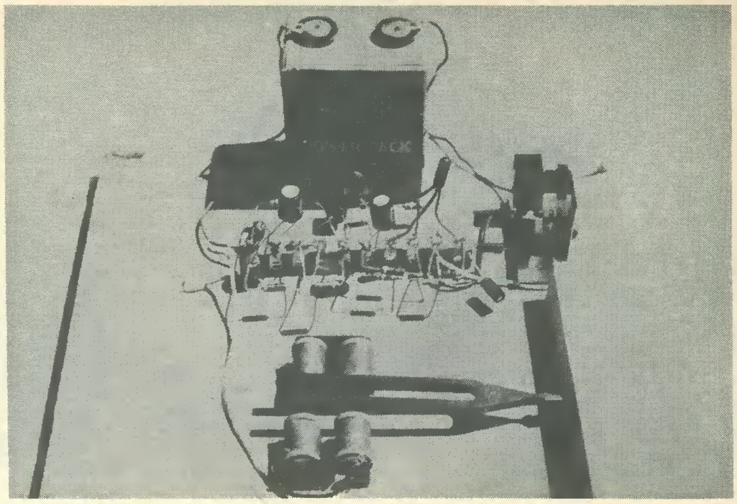
Once oscillations had started with the author's model, they could be maintained if the supply voltage was reduced to as low as 3 volts. Oscillations were slow to start at this voltage, but once started were of very good sine-wave form. If distortion is experienced at 9 volts it might be worthwhile trying a lower supply voltage if the slower build-up time is tolerable. The frequency was checked by means of a digital frequency meter (Racal type SA520) and over a sample period of 15 seconds, 12 counts of 440 and 3 of 439 were obtained, with a cheap A tuning fork in the oscillator.

Some previous constructors of similar oscillators, e.g. Kretzman, (p. 121, "Modern Transistor Circuits", McGraw-Hill, 1959) suggest that a permanent magnet should be fixed with pole pieces $^1/_{64}$in from the ends of the tines of the fork. The writer believes that this is based on a misconception, and is quite unnecessary. However, if the fork persistently oscillates at twice its correct frequency, such a magnet would perhaps correct the operation. Another possible approach to prevention of second harmonic oscillations could be to insert a treble-cut filter at a suitable point in the circuit, to reduce amplification of high frequency signals while allowing low frequencies to pass almost unchanged. However, the writer would be very surprised if these modifications were needed.

For greater frequency stability, temperature control of the fork is needed. The frequency is entirely determined by the fork, and hence it is only as stable as the fork. Thermally insulating the fork by enclosing the coil-fork assembly in a softboard box is a simple improvement which is fairly effective. Improvements in the amplifier can be made to improve the waveform. One way of obtaining such improvement other than reducing supply voltage (which lengthens the build-up time) is to introduce some form of automatic gain control into the amplifier or, simply, more to introduce a manual gain control between TR_1 and TR_2. This would be set at maximum to give a quick build-up, and then reduced to the minimum value which would sustain the oscillations.

Alternative Coils

If it is intended to home-wind the coils, the method of construction illustrated by Figs. 4, 5 and 6 may be employed.



A prototype model of the substandard generator, made up by the author to check circuit operation

Two 1½in square pieces of 18 s.w.g. mild steel sheet form the mountings, these being bent and drilled as in Fig. 4. The two holes in the vertical portion of the mounting are then drilled and tapped to take a 2BA thread. The coil formers are made by bending thin card into a cylinder round a No.11 drill (0.191in), and cementing the ends so that the cylinder can be removed when dry. Four ⅜in lengths of this cardboard tube will be required. The cheeks are eight thin fibre (or card) washers with internal diameter $\frac{3}{16}$in and external diameter ½in cemented to the cardboard tube with Araldite. Enamelled copper wire of 46 s.w.g. is then wound on to the formers to fill the space between the cheeks. Care is needed in winding with this very fine wire, and also a great deal of patience. It might be thought worth while to improvise a simple coil winder, say from Meccano parts, for this process.

Four 1in lengths of 2BA threaded mild steel rod form the cores, and one end of each core is slotted to take a screwdriver. These rods are then screwed into the mountings with the screwdriver slots taking up the position shown in Fig. 6, so that the completed coils can be fitted on them. The coils should be connected in the sense illustrated by Fig. 5. A current of 1mA may be safely passed through them, and each coil head tested with a compass needle. One pole on each of the two coil assemblies should attract the N end of the needle, and the other repel, when the current is passing.

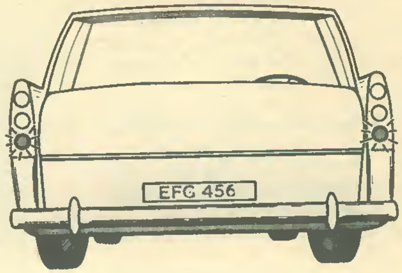
When it has been confirmed that the coils are connected correctly, the cheek of each coil nearest the mounting is cemented to the mounting plate. See Fig. 6. The coils must then be mounted near to the ends of the tines of the tuning fork so that the coils are about 0.1in from the fork, as in Fig. 7. The iron cores may be screwed in and out to control the oscillations.

Each pair of coils should have a resistance of about 2,000Ω, although quite a wide variation is permissable.

Constructors not wishing to undertake the tedious and rather difficult task of winding the coils may be able to employ high resistance windings taken from other components, these being mounted in a similar manner, in terms of a magnetic circuit, to the coils just described. Although not checked by the writer, the windings from old 2,000Ω headphones should, for instance, prove satisfactory, provided these can be removed from the headphone polarising magnet.

The writer has also checked results with a 2,000Ω ex-Govt. P.O. type relay winding. After removing the armature this was tried in place of each of the coils in turn and worked quite well. It would seem reasonable to assume that other coils of similar resistance and with soft iron cores should be equally satisfactory, the constructor devising suitable mountings to take such coils.

Brake Light Warning Device



by

T. R. Balbirnie, B.Sc.

A simple and ingenious circuit which gives a dashboard indication in the event of failure of either of the brake lights

Some motorists delight in an array of panel lights which show when various electrical items are operating. Most of these are distracting and useless—the total of their worth being to impress the passengers.

In the author's opinion a brake light warning device does not fall into this category if it is designed to come on only when one of the brake lights fails. Motorists will readily appreciate the value of such a device. Frequently the driver of the car in front flashes a right turn which turns out to be the result of his dithering on the brake pedal with the nearside brake light "blown". The possibility of dangerous consequences is obvious and unfortunately it is possible to travel for a long time without knowing that you are potentially dangerous.

Failure Indicating Device

The author thought that the designing of a device which would indicate the failure of one brake light would be an easy project but circuits which came quickly to mind had to be dismissed for one reason or another. One method tried consisted of placing a low resistance relay in the brake light circuit. It was hoped that this could be adjusted such that it would normally pull in when the brakes were applied due to the current for two lamps but that it would not do so with the current for one. A pair of "break" contacts on the relay were to be used to operate a panel warning light. This scheme proved to be very unreliable. The change in resistance due to one lamp failing is small and operation of the relay was uncertain.

The final circuit, which has been used with great success, is that given in the accompanying diagram. The relay was a cheap type with a single pair of "make" contacts rescued from the junk box. The original winding was stripped off and replaced by one of 100 turns of 22 s.w.g. enamelled wire removed from an old transformer. A centre tap was provided in the winding as shown. The whole device was mounted in a small metal box with flying leads fitted with car-type snap connectors. It was mounted in the boot near the bunch of snap connectors for the brake lights, whereupon it was an easy matter to make the necessary connections.

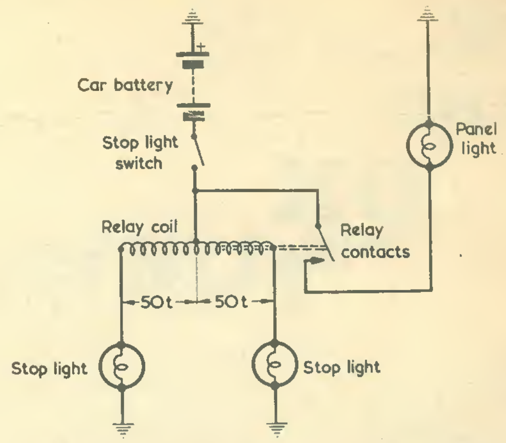
The theory of operation is very simple. When the brake pedal is pressed current flows to each lamp via the appropriate half of the relay winding. As the current is supplied to each lamp in opposing directions the magnetic effect is zero and the relay is not energised. If one lamp fails, however, there will be a flow of current in one direction only, the relay will operate, and the panel light will come on. The panel light will not, of course, work if both brake lights fail but this is a rather remote possibility.

The Relay

Since the relay is a modified component, it will be necessary to experiment a little before fitting it permanently in the car. The relay used by the writer was a 30Ω 6 volt type removed from manufacturer's surplus equipment. This had a coil core which was 1in in length with a diameter of ¼in. The writer's car has a 12 volt system and the stop-light bulbs are 12 volt 21 watt types. Each half of the new relay winding is therefore called upon to carry approximately 2 amps.

Any reasonably robust relay of conventional construction and having a small number of contact sets (including the "make" set required here) should give reliable results in the present circuit. After removing the existing winding, the constructor should initially wind 50 turns of wire on the core and ensure that the relay energises reliably when this coil is connected in series with the car battery and a stop-light of the type employed in the car. If this does not result in reliable operation a few more turns may be needed. The mechanical sensitivity of the relay should be attended to if too many turns are required, and it may be desirable to remove any contact sets which are not needed for the present application. If it is found possible to obtain good operation with less than 50 turns the smaller number of turns should be fitted, as it is desirable for the resistance of the coil to be kept low. When this sensitivity check has proved satisfactory the remaining half of the relay winding may be added. In the author's case, 50 plus 50 turns were sufficient to cause the relay to operate smartly when either of the brake lamps was removed.

A thick wire is essential for the coil winding, because the current flowing is high. Too much resistance in the winding will cause dimming of the lamps as well as overheating in the coil. The small resistance given by a well designed coil should cause only a very slight dimming of the lamps.



How the brake light warning device is installed in the car. The relay coil employed by the author had 100 turns with a centre-tap, as shown here

The panel warning light could be a radio or car type fitted with a 12 volt bulb of low wattage rating.

NEW TUNING MODULE FOR A.M./F.M. RECEIVERS

The latest circuit module now available from Mullard has been designed for use in a.m./f.m. receivers and can operate in conjunction with any of the Mullard i.f. circuit modules type LP1164, LP1165 or LP1171. The new module, type LP1169, is a two-transistor, f.m. tuner containing an r.f. amplifier and a self-oscillating mixer that are tuned by the two outer sections of a four-sectioned, solid-dielectric capacitor. In addition to the two transistors, the tuner contains a diode with an associated circuit so that automatic frequency control can be used if required.

The LP1169, which has a frequency coverage for f.m. reception of nominally 87 to 108 Mc/s, is designed for use with aerials having an impedance of 75 or 300 ohms. The intermediate frequency is approximately 10.7 Mc/s and the bandwidth 350 kc/s. At 100 Mc/s, the power gain is at least 26dB and the noise factor not more than 8dB.

The two inner sections of the tuning capacitor are intended for use with an external circuit (ferrite-rod aerial and coils) when receiving the a.m. short, medium and long wavebands. (The long and medium wavebands can be covered by means of the tuning capacitor in the LP1169 and the oscillator coil in the LP1171.)

Module type LP1169, therefore, has the advantage that no mechanical coupling to another capacitor is needed to ensure that tuning of an a.m./f.m. receiver can be accomplished by means of a single tuning knob.

The tuner operates from a nominal supply of 6.8V, and draws a current of approximately 3.5mA. It is fully screened and is approximately 82 x 37 x 35mm, with the capacitor shaft protruding another 25mm.

★

THE DX THREE

THE RECEIVER TO BE DESCRIBED WILL PROVE AN ideal design for the beginner to construct, not only by reason of its simplicity but also by virtue of the low costs involved when purchasing the components. As shown here, it is a 3-valve receiver—12AX7 detector and first audio stage, 6BW6 power output stage and EZ80 full-wave rectifier—provision being made for the addition of a suitable r.f. stage at a later date. In this respect, a 2-gang variable capacitor has

COMPONENTS

Resistors
(All values ½ watt 10% unless otherwise stated)

R_1	1.5MΩ
R_2	100kΩ
R_3	10kΩ
R_4	47kΩ
R_5	4.7kΩ
R_6	1kΩ
R_7	470kΩ
R_8	500kΩ pot, log track, with $S_{1(a)(b)}$
R_9	240Ω
R_{10}	10Ω
R_{11}	1kΩ 5 watts

Valves

V_1	12AX7
V_2	6BW6
V_3	EZ80

Valveholders
4 off B9A, 1 with skirt and screen for V_1

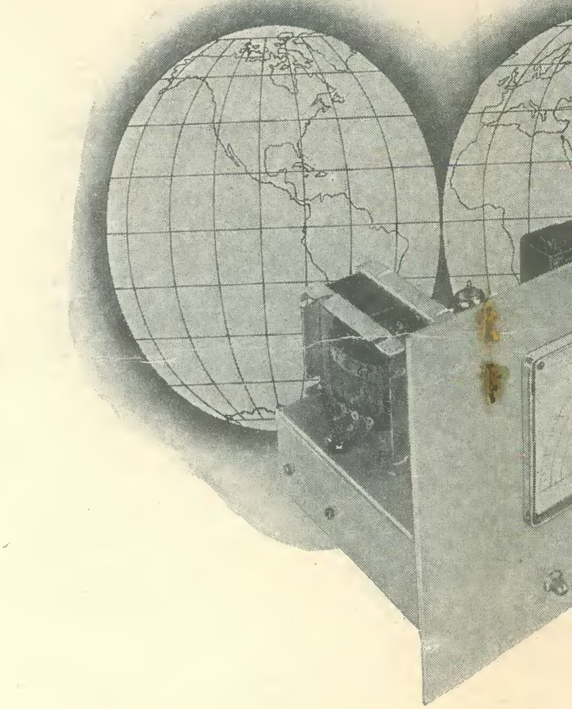
Speaker
3Ω impedance

Phone Jack
JK_1 Phone jack (Igranic)

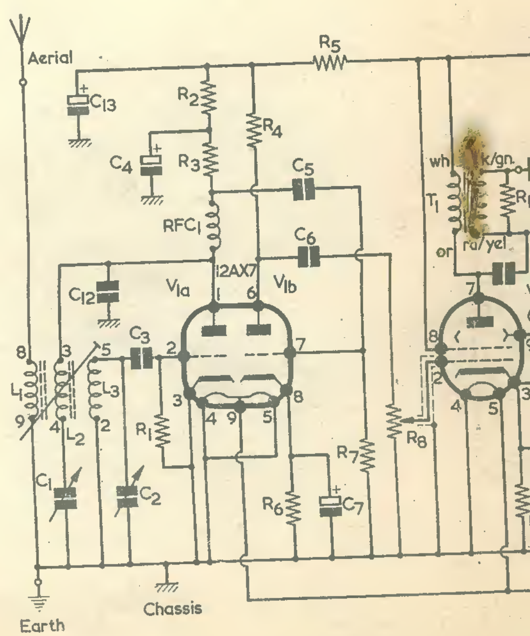
PL_1 Assembly
6.3V, 0.3A (H. L. Smith & Co. Ltd.)

Capacitors

C_1	100pF variable, type C804, (Jackson Bros Ltd)
C_2	310pF, 2-gang variable, type E2 (Jackson Bros Ltd)
C_3	100pF silver-mica
C_4	8μF, electrolytic, 350V wkg.
C_5	0.01μF ,tubular, 400V wkg. Mullard
C_6	0.01μF, tubular, 400V wkg. Mullard
C_7	10μF, electrolytic, 6V wkg.
C_8	25μF, electrolytic, 25V wkg.



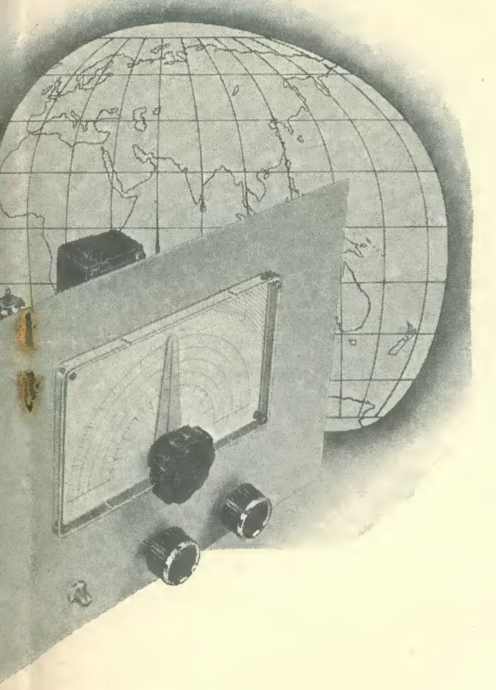
**This simple 3-valve design is eminently suitab
Speaker or headphone operation facilities ar
design includes a double-wound mains transf
from the a.c. mai**



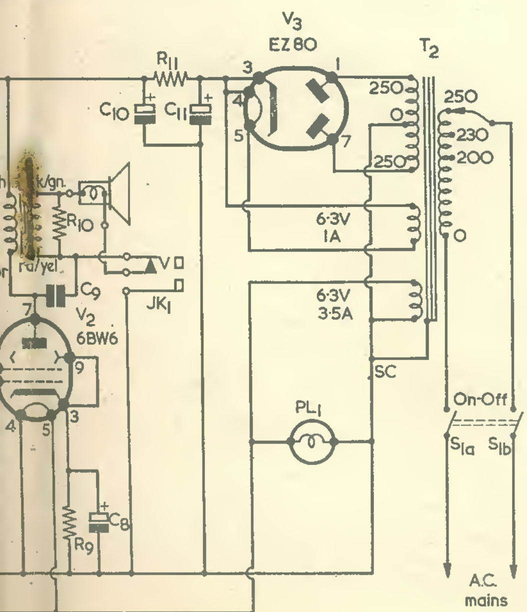
Cover Feature

by

NORMAN R. KING



ly suitable for construction by the beginner. lities are available to the operator and the s transformer providing complete isolation .c. mains supply



been included in the prototype at the outset to cater for this later modification, connection being made at present to one of its sections only. However, the receiver gives a very satisfactory performance in its existing form, and many constructors will prefer to operate it without the later addition of an r.f. stage. In this case, a single-gang tuning capacitor should be employed for C_2 instead of the 2-gang capacitor specified in the Components List.

C_9	0.1μF, tubular, 400V wkg., Mullard type B7N
*C_{10}	32μF, electrolytic, 450V wkg.
*C_{11}	32μF, electrolytic, 450V wkg.
C_{12}	33pF
C_{13}	2μF, electrolytic, 450V wkg.

*Contained in single can with mounting clip

Transformers

T_1	Type 117E (H. L. Smith & Co. Ltd.)
T_2	Type MT1AT Douglas, Pri: 0–200–230–250V; Secs: 250–0–250V, 80mA; 6.3V, 3.5A; 6.3V, 1A tapped at 5V 2A

Tagstrips and Socket Strips

6-way, 2 tags earthed
Speaker output and aerial/earth (H. L. Smith & Co. Ltd.)

R.F. Choke

RFC_1 2.5mH, type CH1 (H. L. Smith & Co., Ltd.)

Panel and Chassis

See Fig. 2 (H. L. Smith & Co. Ltd.)

Miscellaneous

4 and 6BA nuts and bolts, earth tags, screened cable, p.v.c. covered wire, 2-core mains input cable, sleeving, ⅜ and ½in rubber grommets, solder, etc.

Panel-Signs Transfers

Set No: 4 Wording
Set No: 6 Dials
(Data Publications Ltd.)

Inductors

$L_{1,2,3}$ Denco Miniature Dual-Purpose, Green, Ranges 3, 4 and 5

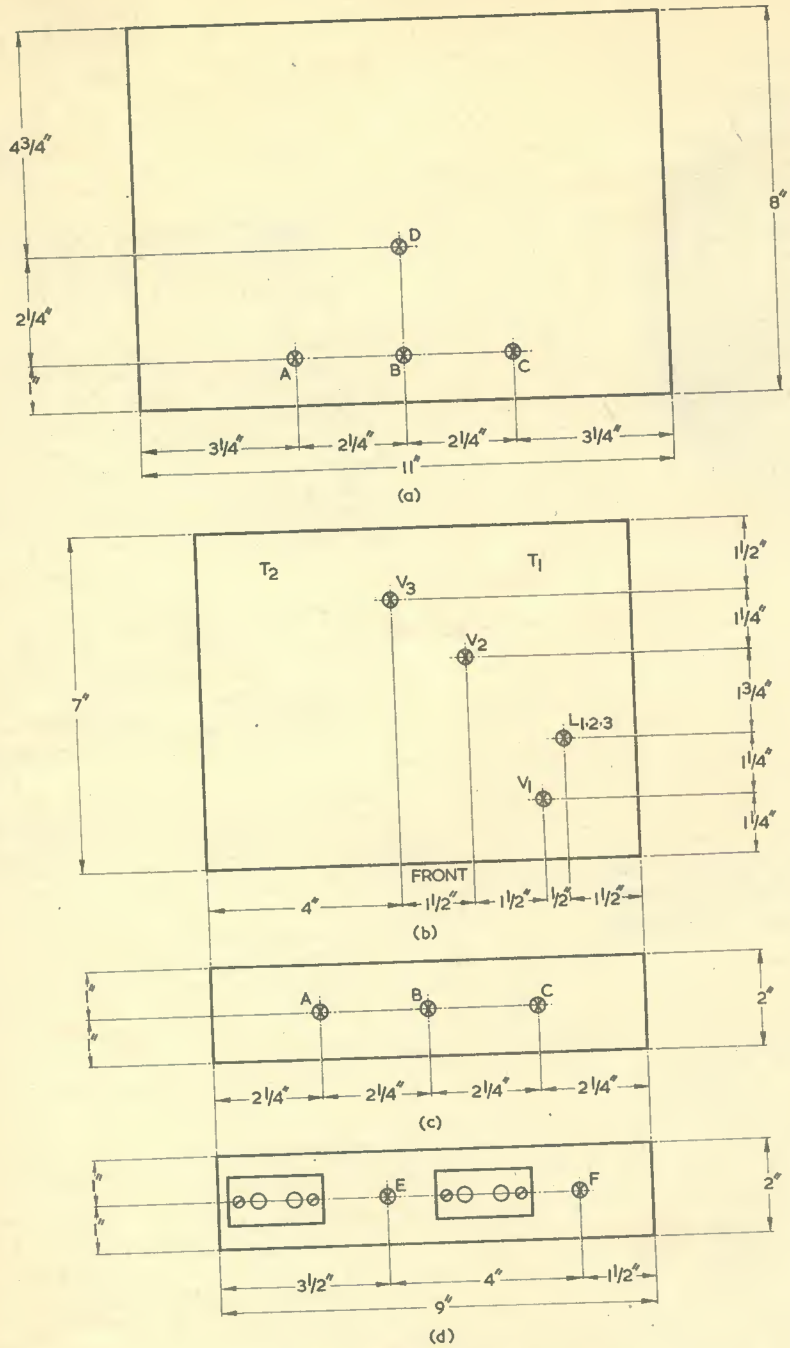


Fig. 2 (a) Drilling details of the front panel
(b) chassis deck
(c) chassis front apron and
(d) chassis rear apron

Provided a good outside aerial and a direct earth connection are used, excellent results will be obtained over all the short wave frequencies covered by the receiver. The total frequency range is 1.67 Mc/s (180 metres) to 31.5 Mc/s (9.5 metres) in three ranges using the plug-in coils specified. A bandspread capacitor has not been included in the circuit as shown here but should the intending constructor consider this addition desirable it would require to be a 25pF panel-mounting variable capacitor, such as the Jackson Bros. Cat.

No. C804. The bandspread capacitor would be connected in parallel with the main tuning capacitor C_2. Without the bandspread capacitor it is necessary to fit C_2 with a slow-motion drive, and a simple epicyclic drive will prove to be reasonably satisfactory, although tuning will still be somewhat critical. A suitable type here is the Jackson Bros. drive under Cat. No. 4511/5. If desired, a more comprehensive slow-motion drive can be employed, and the mounting of such a drive is left to the constructor. In this respect, it should be noted that the accompanying photographs illustrate the writer's receiver at an early stage when a drive was not fitted. There is room on the chassis for the 2-gang capacitor to be moved back through 1in, thereby accommodating most slow-motion drives likely to be encountered.

A considerable amount of experimental work has been carried out on the detector and first a.f. stages, and the component values specified here have been found to produce the best results. The output stage offers a high power for speaker operation. Headphones may be plugged into a jack on the rear apron, whereupon the speaker is automatically muted. It is desirable to initially keep the volume control at a low setting when inserting the headphone jack plug, owing to the high output power available.

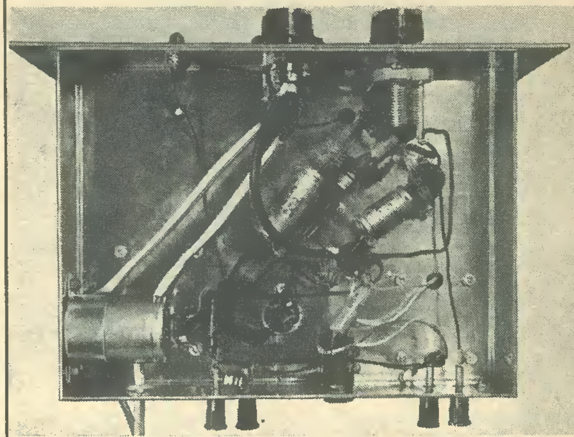
The power supply section of the receiver includes an EZ80 full-wave rectifier and the Douglas MT1AT mains transformer. The EZ80 rectifier is capable of a maximum current output of 90mA and the mains transformer has a secondary rating of 250–0–250V at 80mA. In the circuit shown, the total current consumption is 48mA, under quiescent conditions, with 275 volts at pin 3 of the rectifier and an h.t. line voltage of 227 at the junction of C_{10} and R_{11}. From these facts it will be readily seen that the power section is under-run and is, therefore, cool at all times. Should the 2-valve design be adhered to as shown here, there is available a maximum current surplus of 32mA which could be utilised to run some other item of ancillary equipment having an h.t. current rating within the 32mA limit. If however, as is suggested later, an EF183 r.f. stage is added, this would consume approximately 17mA which, together with the 48mA already accounted for, would leave a smaller surplus of 15mA, thereby resulting in the power section being operated (without ancillary equipment) comfortably within its maximum limit. An octal plug and socket could be included on the rear chassis apron to provide a power supply outlet to ancillary equipment when the 2-valve receiver design is adopted.

Circuit

Signals from the aerial are fed direct to the winding L_1 of Fig. 1 and appear across the winding L_3, this being tuned by variable capacitor C_2. The grid capacitor C_3 and grid leak R_1 have values which ensure that reaction is smooth and free from backlash.

The coils depicted as L_1, L_2 and L_3 are the aerial, reaction and tuned windings respectively of coils in the Denco Miniature Dual-Purpose Green series. Three coils are required, these being for Range 3 (1.67—5.3 Mc/s), Range 4 (5—15 Mc/s) and Range 5 (10.5—31.5 Mc/s). The coils plug into a B9A valveholder, and the numbers in Fig. 1 indicate the pins to which the windings connect.

$V_{1(a)}$ functions as a grid-leak detector, the detected a.f. signal at its anode being passed to $V_{1(b)}$ via C_5. Reaction is obtained direct from $V_{1(a)}$ anode, and is controlled by variable capacitor C_1. Capacitor C_{12} limits the r.f. voltage fed back from the anode and further improves the performance of the reaction circuit.



Below-chassis view of the receiver. The method of mounting the smoothing capacitor assembly, with R_{11} wired across the two positive tags, is clearly shown. The position of the 6-way tagstrip may also be seen from this illustration

The first audio amplifier stage, $V_{1(b)}$, is a simple triode circuit in which the anode resistor R_4 is the load across which the output voltage is produced. Bias is developed across the cathode components R_6, C_7. The bias voltage across these latter two components is caused by virtue of the fact that the current flowing through the valve produces a small voltage across R_6 and C_7, this making the cathode positive with respect to the grid. The output signal voltage taken, via capacitor C_6 to potentiometer R_8, is now a much amplified copy of the input voltage.

The input signal for V_2 is taken from the slider of potentiometer R_8, which functions as a.f. volume control. V_2 provides further amplification and offers an output, at a power level suitable for a speaker, via transformer T_1. Resistor R_{10} is included to ensure that V_2 anode circuit is still adequately loaded if high resistance headphones are plugged in. Insertion of the headphone jack plug automatically mutes the speaker.

The components C_{10}, C_{11} and R_{11} ensure that a ripple-free h.t. potential is available. Note that C_{10} and C_{11} are contained within a single can, the chassis connection being made via a mounting clip secured to both the metal container and chassis.

The mains transformer, T_2, is fitted with primary tappings at 200, 230 and 250V, and the tapping appropriate to the local mains voltage should be used. The a.c. mains supply is applied to the primary winding via the double-pole switch $S_{1(a)(b)}$, this being integral with the volume control R_8.

The rectifier heater is supplied from a separate 6.3V 1A winding on T_2, the remaining heaters being run from a 6.3V 3.5A winding with one side earthed to chassis. The total current consumed by the heaters of V_1 and V_2, and by pilot lamp PL_1, is 1.05A only, whereupon 6.3V at 2.45A is available for ancillary equipment, should this be desired. If the r.f. stage to

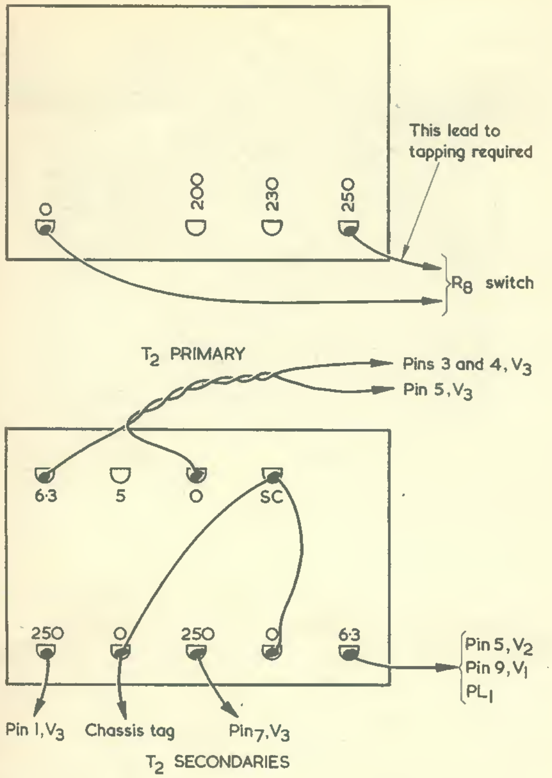


Fig. 3. Wiring-up details of mains transformer T_2

be discussed later is added, the available surplus current at 6.3V is 2.15A. So far as hum is concerned, no trouble was experienced with the prototype despite the fact that one side of the heater supply is at chassis potential.

A further refinement to the circuit as shown here would be that of inserting a panel-mounted 100pF variable capacitor in the aerial input lead to the inductor L_1. This capacitor must *not* make contact with the metal panel and must therefore be secured by means of two insulating washers, one in front and one behind, the panel, together with insulating material around the bush of the capacitor. A simple continuity test will soon ensure that no unwanted contact is being made. Operation of this capacitor will vary the aerial loading and will eliminate any "dead spots" that may be apparent with respect to obtaining reaction over all the frequency range covered. In the prototype no such dead spots were in evidence but this will depend, to some extent, on the aerial used with this receiver.

Construction

Figs. 2 (*a*), (*b*), (*c*) and (*d*) show the drilling details for the front panel, chassis deck, chassis front apron and chassis rear apron respectively.

In the first instance, the panel should be drilled as shown in Fig. 2 (*a*), hole A being for the panel lamp PL_1, hole B for the volume control R_8 and hole C for the reaction capacitor C_1. These holes should be of $\frac{7}{16}$in diameter. Hole D is for the slow-motion drive centre for the variable tuning capacitor C_2, the vertical measurement given being approximately correct for the component specified. However, variations may occur due to slight differences in chassis deck height, and it is preferable that the exact height be found by offering up the capacitor to the panel when it is standing on the chassis deck. The diameter of hole D depends on the type of slow-motion drive employed.

The front panel should now be clamped to the chassis front apron such that the 1in overhang is apparent at either end of the panel, and centre-punch marks made at the centre of holes A, B and C. Remove the clamp and drill these holes in the chassis front apron.

Drilling details of the chassis deck are shown in Fig. 2 (*b*). Holes of $\frac{3}{4}$in diameter are cut for V_1, V_2, V_3 and the coilholder, using a chassis-cutter, if available. The transformers T_1 and T_2 should next be placed on the chassis and used as templates whilst marking with a centre-punch the positions for their mounting holes. These are 4BA clear. The orientation of the transformers may be found from the above-chassis illustration and the information in the following paragraph.

The mains transformer should have its primary tags towards the left-hand apron of the chassis (secondary tags on the inside) and should be finally positioned such that it is set $\frac{3}{4}$in from the left-hand apron to allow the fitting of a $\frac{1}{2}$in grommet between the transformer edge and the left-hand edge of the chassis. Output transformer T_1 should be oriented such that the orange and white wires from the primary are nearest the front of the chassis. After the mounting holes for the transformers have been marked out, mark out further holes for grommets of suitable size to take the wires passing to the respective primary and secondary windings. The mains transformer is fitted (later) with its 250–0–250V tags nearest the chassis. (See Fig. 3).

Dealing next with the rear apron of the chassis, refer to Fig. 2 (*d*) and drill holes E and F, these being for the headphone jack and the a.c. mains input cable grommet respectively. The aerial and earth socket strip is at the left-hand side of the chassis rear apron whilst the remaining socket strip is for the speaker output. These socket strips should be offered to the rear apron upside down such that the respective holes for securing purposes (6BA clear) can be marked with the aid of the centre-punch, this being followed by measuring and marking the holes for the metal sockets proper. It should be noted here that none of the metal sockets should make any contact with the chassis.

Next to be drilled are the 6BA clear mounting holes for the valveholders and coil holder. V_1 valveholder is oriented such that pin 5 is nearest the front panel.

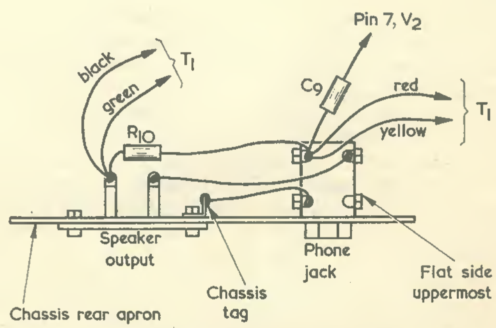


Fig. 4. Wiring-up details of the phone jack and the speaker output tagstrip

V_2 has pin 3 nearest the front panel, whilst the coilholder has pin 5 nearest the front panel. The orientation of V_3 valveholder is unimportant.

The mounting holes for the tuning capacitor must next be dealt with, and this necessitates temporarily assembling the chassis deck and front panel, and fitting the slow-motion drive which is to be used to the latter. The tuning capacitor is then set up in the position it will finally occupy and mounting holes marked out using its mounting lugs as a template. The mounting holes are 4BA clear. Mark out also two holes (assuming a 2-gang component is used) directly alongside the fixed vane solder tags. These holes will later take ⅜in grommets.

The smoothing capacitors C_{10} and C_{11}, contained within a single can, should now have the fixing clip secured to the can. Using this assembly as a template, mark and drill the two fixing holes (4BA clear) in the chassis side apron—see illustration of the below-chassis view. This component should occupy a final position such that the lugs of the fixing clip securing the can are towards the underside of the chassis deck.

A six-way tagstrip, two tags earthed (see Fig. 5), should now be secured to the under side of the chassis by means of two 6BA nuts and bolts in the position shown in the below-chassis illustration. This tagstrip should be at an angle of approximately 45° and approximately 1¼in from the holders for the coil and V_2.

Earth tags should be fitted under one of the fixing nuts for V_1 valveholder, the coilholder, V_2 valveholder, the nut nearest the earth socket on the rear chassis apron and the nut of the speaker output socket strip nearest the phone jack.

When securing the mains transformer, the output transformer, the tuning capacitor and the smoothing capacitor to the chassis, use 4BA nuts and bolts with shake-proof washers. All other nuts and bolts should be 6BA. Having secured all the components to the chassis and the front panel, wiring-up may commence.

Wiring-up the Circuit

The easiest method of assembling this receiver is to commence with the wiring-up of the power supply section around V_3 and T_2.

Feed the a.c. mains input cable through grommet F on the rear apron of the chassis and make the connections to the switch section of R_8. Note here that some potentiometers have their switch tags in slightly differing positions than other types and a simple continuity test, using say a torch battery and bulb, will soon show the correct tag positions. Make the connections to the a.c. input side of the mains transformer using the 0V tag and a primary tap suitable for the local mains voltage. Fig. 3 indicates the 6.3V tags on T_2 which connect to V_3 heater (the 5V tag is unused). Note that the heater wires to V_3 are twisted.

Wire up the valveholder for V_3 and the remaining 6.3V heater line to both V_1 and V_2, at pins 9 and 5 respectively. Earth to the chassis, by means of short lengths of bare wire, tags 3, 4 and 5 of V_1 and tag 4 of V_2, also earthing the central metal spigots of these valveholders. Earth to chassis tags 2 and 9 and the spigot of the coilholder. Note that the correct 6.3V heater tags of the mains transformer for V_1 and V_2 are those tags directly alongside the 250–0–250V tags. The transformer tag marked "SC" should be joined to *both* the tags marked 0 on the lower row of tags, i.e. that row of tags nearest the chassis deck. It will be seen, from the above, that the heater supply for V_1 and V_2 has a return via the metal chassis.

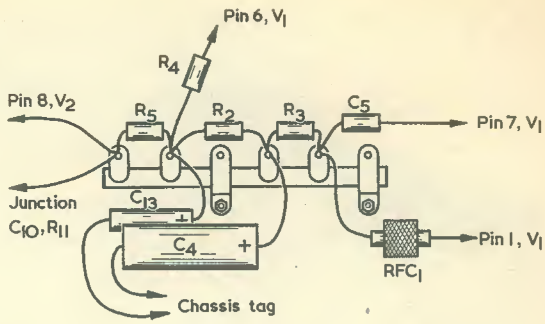


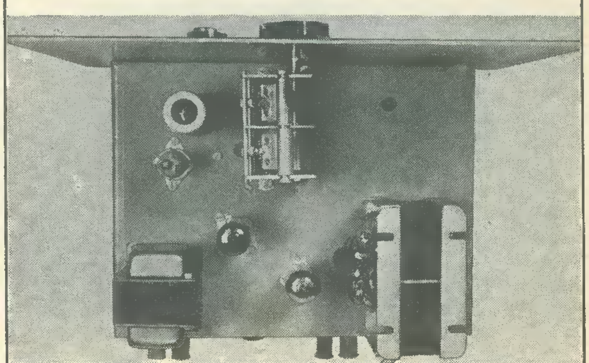
Fig. 5. Wiring-up details of the tagstrip

The smoothing resistor R_{11} should be wired directly across the positive tags of the smoothing capacitors —see illustration.

Output Stage V_2

Having completed the wiring of the power supply, the output stage around V_2 should next be dealt with. First, wire up the output transformer T_1. The leads to this component should be cut to suitable length and connected in the following manner. White lead to pin 8, and orange lead to pin 7 of V_2 valveholder. The red and yellow leads should be joined together and then soldered to one tag of the phone jack, as in Fig. 4. The capacitor C_9 should now be connected between pin 7 of V_2 valveholder and the same tag of the phone jack. The black and green wires of T_1 should next have their wire ends joined together and be soldered to one tag of the speaker output socket strip, after which the remaining wiring in Fig. 4 is carried out.

Complete the remainder of the wiring in the V_2 stage, including the soldering of R_9 from pin 3 (which should also be connected to pin 9 of V_2) to the adjacent



Above-chassis view of the receiver. Note here that the two-gang variable tuning capacitor has been included to allow for the later addition of an r.f. stage

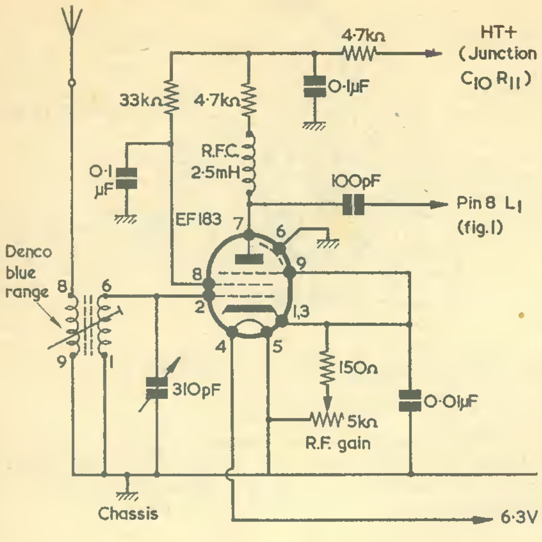


Fig. 6. The circuit of the suggested r.f. stage

chassis tag with C_8 in parallel, observing correct polarity in C_8. The slider of R_8 connects to pin 2 of V_2 by way of screened cable, and the braiding of this cable is earthed at the chassis tag adjacent to V_2 valveholder. Television coaxial cable may be used for this screened lead.

Detector and 1st Audio Stage $V_{1(a)},_{(b)}$

To wire up this stage, it will first be necessary to temporarily remove the reaction capacitor C_1 from the panel and chassis. C_1 is fitted and connected into circuit when the remainder of the wiring in this stage has been completed.

The components wired into circuit around V_1 valveholder should be positioned close to the chassis to provide clearance for C_1 when this is operated. The tagstrip should be wired up as shown in Fig. 5. All wire ends associated with the components mounted around V_1 valveholder and the tagstrip should be as short and direct as possible, suitable lengths of sleeving being used where required.

If the 2-gang tuning capacitor is fitted, the rear section is employed for C_2.

Testing the Receiver

The voltages obtained with the prototype receiver are shown in the accompanying Table and were obtained with an a.c. mains voltage of 235 Test voltages will, of course, depend upon the mains voltage given at the time of checking, the resistance of the testmeter used and component tolerances. Generally speaking, voltage readings should be within about 15% of those shown in the Table.

Adding an R.F. Stage

An r.f. stage will shortly be added to this receiver (at the time of writing) and the suggested design for this circuit is shown in Fig. 6. It should be stressed,

Position	*Voltage*
Pin 3 V_3	275
Junction C_{10}, R_{11}	227
Pin 7 V_2	195
Pins 3, 9 V_2	10.2
Junction R_4, R_5	215
Pin 6 V_1	175
Pin 8 V_1	1.2
Pin 1 V_1	100

All readings obtained with a.c. mains voltage at 235V.

however, that this design has not been tried out in practice, although there is no reason why the circuit should give any undue trouble.

The addition of an r.f. stage will, of course, greatly improve the performance of the receiver and also provide the additional benefits of increased selectivity and sensitivity along with the removal of damping effects upon the detector stage due to direct loading by the aerial.

The r.f. gain control should occupy the position on the panel which is at present taken by panel lamp PL_1, the latter component being refitted to the panel above the chassis deck. To balance the front panel controls, a 25pF bandspread capacitor could be secured to the panel opposite PL_1 and wired in parallel with C_2 of Fig. 1.

The coils required for the r.f. stage are of the Denco Miniature Dual-Purpose type in the Blue series, ranges 3, 4 and 5 being obtained to match the ranges already in use with the detector stage.

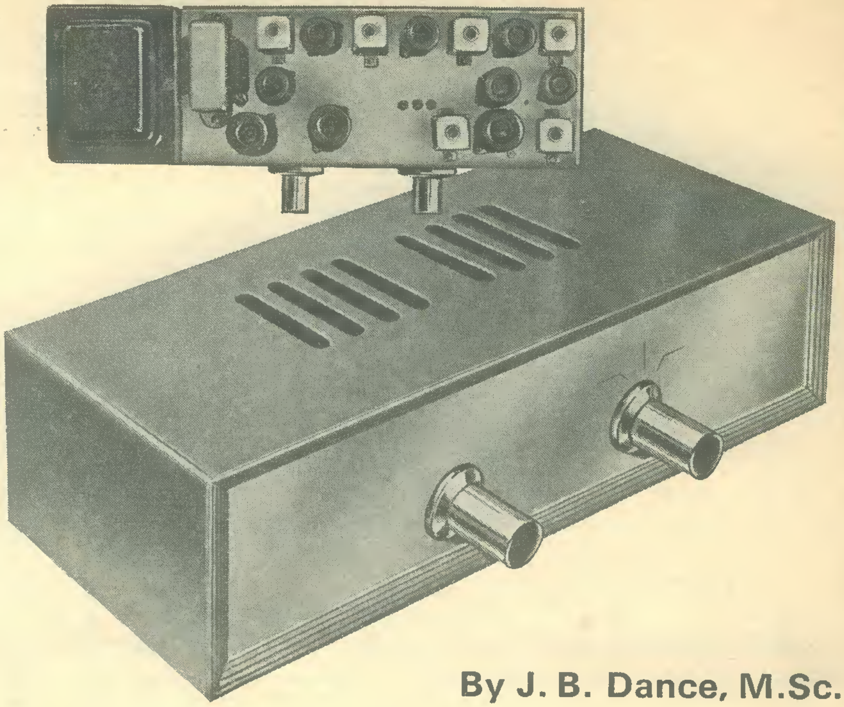
The r.f. valve and coilholder should occupy a position on the chassis deck to the left of the 2-gang tuning capacitor (allowing sufficient space for the operation of the tuning capacitor moving vanes) and between the mains transformer and the front panel.

The r.f. stage should be simply inserted into the circuit of Fig. 1 between the aerial input and tag 8 of L_1. In order that the addition of the r.f. stage should be as simple as possible, the aerial input socket should be connected direct to pin 8 of the r.f. coilholder and the output of the r.f. stage connected, via the 100pF coupling capacitor, to tag 8 of the detector coilholder.

If a slow-motion tuning mechanism has been included with the main tuning capacitor, a 25pF variable capacitor could be included in the r.f. stage as an r.f. trimmer control across pins 1 and 6 of the coil, the bandspread control not being required. Again, if the suggested bandspread capacitor has been fitted then the r.f. trimmer control could well take the position mentioned above for PL_1, this latter component either being omitted altogether or positioned elsewhere on the front panel.

As a final point, and returning to the design in its present form, the dial on the front panel is taken from Panel-Signs Set No. 6. A simple cursor can be readily made from a small piece of Perspex and scribed with a fine line, this being filled with Indian ink. Suitable wording for panel controls is given in Panel-Signs Set No. 4.

CRYSTAL CONTROLLED F.M. RECEIVER



PART 2

By J. B. Dance, M.Sc.

This is the concluding article describing an f.m. receiver incorporating the S.T.C. triple-crystal unit, and it gives details of construction and alignment

Every amateur builder of electronic equipment has his own ideas on the subject of construction. The method of construction used in the prototype will be described, but obviously there are many possible variations.

The writer prefers to employ a chassis which is reasonably strong and therefore 18 s.w.g. tinplate was used. A piece 17.4ins long by 8.4ins wide was cut into the shape shown in Fig. 6. The angles at which the corners are cut away are not critical and readers are left to use their judgement in this matter. Bending of the chassis may be done either before or after drilling, according to preference. It should be noted, before proceeding further, that the dimensions given in Figs. 6 and 7 apply to the mains transformer, speaker transformer and smoothing choke employed by the writer. It is perfectly in order to use larger components here, of course, but it will be necessary to enlarge the overall chassis dimensions accordingly.

The sections marked A and M are bent downwards at an angle of 90° to the remainder of the metal. (One of the pieces of equipment made for folding sheet metal manufactured by Messrs. A. B. Parker, of Wheatcroft Works, Wellington Street, Batley, Yorkshire, is extremely convenient for making chassis of this type.) The sections B, D, J and L are then bent downwards at 90° also. The sections C and K are bent downwards at 90°, followed by sections E and I. Finally, sections F and H are bent downwards.

The sections B and J are soldered to the section F, preferably using a very hot soldering iron which has been heated by a gas flame. (The electric soldering irons usually used by amateurs do not normally carry enough heat for this application.) The chassis should be inclined so that the junction to be soldered is at the lowest point on the chassis and the solder will then run naturally into the junction as the hot iron is passed along. Ordinary multicored solder may be used. The sections D and L are then soldered to the section H.

The chassis is now complete. The sections A, E, I and M are already folded in beneath the chassis and increase its strength substantially without making the construction of the receiver appreciably more difficult. A base plate may be attached to these sections later if desired.

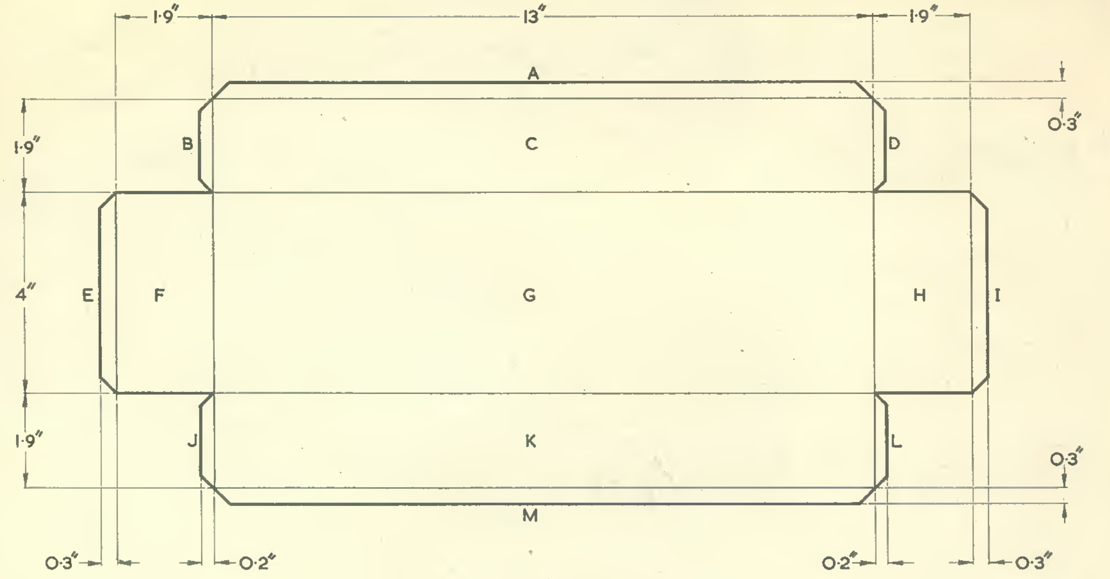


Fig. 6. The chassis before drilling. Work commences with a rectangular sheet of metal measuring 17.4in long by 8.4in wide

Drilling

As was just mentioned, the chassis may be drilled either before or after it is bent and soldered. The holes for the valve bases and for the mains connector are conveniently cut with the appropriate size of "Q Max" cutter. The full drilling diagram is given in Fig. 7. The positions of the centres of valveholders and of coils are shown in this diagram, but the actual holes are not shown in the case of these particular components. For details of the holes required for mounting coils, see the section on coils and Fig. 14.

For V_1, V_2, V_3, V_4, V_5 and X (X is the triple crystal unit) make the main hole in the position indicated; these holes are ⅝in diameter for the B7G valveholders. Make two smaller holes (which will clear 6BA bolts) on a diameter of the main hole and equidistant from the centre of it for the mounting bolts. A line joining the centres of the two valve base mounting holes should, in the case of every valve position, make an angle of about 30° with a line parallel to the length of the chassis. Arrange orientation so that grid and anode pins are closest to the circuit they connect to.

Valves V_6, V_7 and V_8 fit into B9A (Noval) holders. The diameter of the main hole must therefore be ¾in. Otherwise the same remarks apply as in the case of the B7G valve holders.

The hole marked A is for the aerial input socket, that marked B is for the low impedance high fidelity output socket, whilst that marked C is the loudspeaker output socket. All these holes are 0.45in in diameter, the fixing holes on either side being 6BA clearance.

As was pointed out in the Components List last month and earlier here, the use of transformers or a smoothing choke larger than those employed in the prototype may necessitate increasing chassis dimensions accordingly. However, the components used by the author are quite standard and little difficulty on this score should be encountered in practice. Holes D in Fig. 7 are for the speaker transformer, and should have the spacing dictated by the component employed. With the prototype, this spacing was 2.25in. Both holes are 4BA clearance. The speaker transformer is above the chassis. Hole G is the rectangular cut-out for the mains transformer and, in the prototype, was 2.8 x 1.8in, with mounting centres at 2.85in. Again, these dimensions may be modified to suit the component employed. Holes I are for the smoothing choke which, in the prototype, was on 2.8in centres.

Holes E are 0.2in in diameter, and take the three oscillator trimming capacitors type COO4EA/6E. Alternative trimmers may require different mounting arrangements, but they should still be positioned at the same points as the holes E.

Holes F are 6BA clear and take an 8-way tagstrip. The tagstrip is mounted below the chassis and the holes must be countersunk on top to enable the bolt heads to be flush with the surface of the chassis; otherwise the mains transformer could not lie flat on this part of the chassis. Hole spacing may vary from the measurement given in Fig. 7, according to the tagstrip used.

Hole H is for a stand-off insulator. In the prototype this was a Jackson Brothers ceramic stand-off insulator type R-S, which is secured by a 6BA bolt, but a small Paxolin component could also be used. A second insulated tag is also mounted at this hole, as mentioned later under "Oscillator Construction".

For ease of removal of coil and i.f. transformer cans, these were mounted, in the prototype, in a somewhat unconventional manner which requires

(*continued on page 561*)

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RADIO CONSTRUCTORS DATA SHEET 6

CAPACITIVE REACTANCE—RADIO FREQUENCIES

The Table gives reactance in ohms at the capacitances and frequencies indicated. $X_C=\frac{1}{2\pi fC}$.

Capacitance	100 kc/s	300 kc/s	1 Mc/s	3 Mc/s	10 Mc/s	30 Mc/s	100 Mc/s	300 Mc/s
0.5pF	3,180,000	1,060,000	318,000	106,000	31,800	10,600	3,180	1,060
1pF	1,590,000	531,000	159,000	53,100	15,900	5,310	1,590	531
2pF	796,000	265,000	79,600	26,500	7,960	2,650	796	265
5pF	318,000	106,000	31,800	10,600	3,180	1,060	318	106
10pF	159,000	53,100	15,900	5,310	1,590	531	159	53.1
20pF	79,600	26,500	7,960	2,650	796	265	79.6	26.5
50pF	31,800	10,600	3,180	1,060	318	106	31.8	10.6
100pF	15,900	5,310	1,590	531	159	53.1	15.9	5.31
200pF	7,960	2,650	796	265	79.6	26.5	7.96	2.65
500pF	3,180	1,060	318	106	31.8	10.6	3.18	1.06
1,000pF	1,590	531	159	53.1	15.9	5.31	1.59	0.531
2,000pF	796	265	79.6	26.5	7.96	2.65	0.796	0.265
5,000pF	318	106	31.8	10.6	3.18	1.06	0.318	0.106
0.01μF	159	53.1	15.9	5.31	1.59	0.531	0.159	0.0531
0.02μF	79.6	26.5	7.96	2.65	0.796	0.265	0.0796	0.0265
0.05μF	31.8	10.6	3.18	1.06	0.318	0.106	0.0318	0.0106
0.1μF	15.9	5.31	1.59	0.531	0.159	0.0531	0.0159	0.0053
0.2μF	7.96	2.65	0.796	0.265	0.0796	0.0265	0.0080	0.0027
0.5μF	3.18	1.06	0.318	0.106	0.0318	0.0106	0.0032	0.0011

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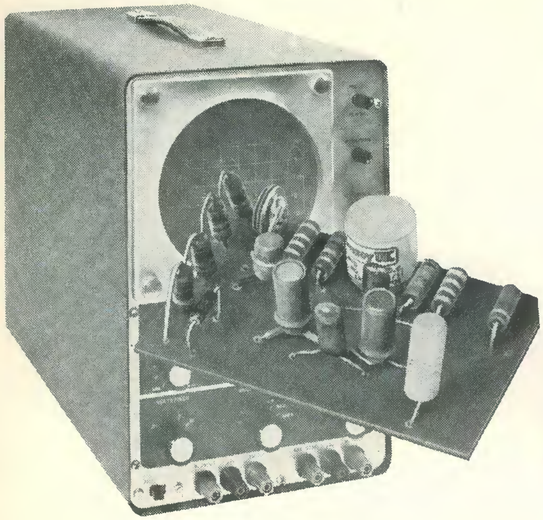

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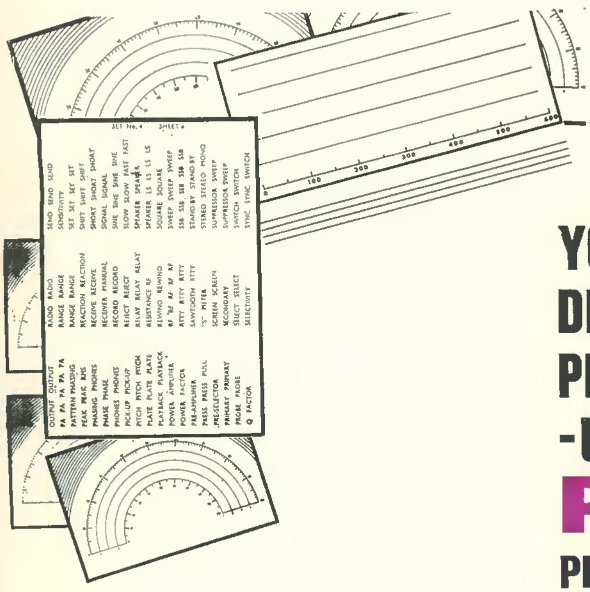

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CRYSTAL CONTROLLED F.M. RECEIVER
Part 2

(continued from page 558)

two extra holes per coil or transformer. Details of this method of mounting are given later, in the section dealing with the coils.

Oscillator Construction

It is quite a good idea to construct the oscillator circuit first, since this section can then be tested. One does not want radio frequency potentials appearing all over the chassis and therefore it is wise to return all of the oscillator circuit earth connections to a common point. Unfortunately the earthy side of the trimmer capacitors cannot be returned to this point unless one goes to the trouble of mounting them on a small insulated sub-chassis. The trimmers are, therefore, connected direct to chassis at their mounting points. All wiring should, of course, be kept as short as possible at these frequencies. C_{28} is not fitted at this stage.

The junction of R_{23}, R_{24} and C_{27} is supported on the stand-off insulator at hole H of Fig. 7. A second insulated tag is required for supporting the end of R_{20} which is not connected to the base of V_6. This tag is held in position by that securing the stand-off insulator. All of the h.t. wiring in the r.f., mixer, i.f. and oscillator sections is held about ¾in away from the chassis underside (but against the side of the chassis) to minimise unwanted coupling.

Testing The Oscillator

When the construction of the oscillator circuit has been completed (including L_{11}—to be described later) a check can be made to ensure that oscillation will take place. A heater supply and a suitable h.t. potential is obtained from a separate piece of equipment, since it is unwise to bolt the relatively heavy mains transformer and smoothing choke (L_{12}) to the chassis at this early stage. A meter with a full scale deflection of between 100 and 500μA is connected between chassis and the junction of R_{23}, R_{24} and C_{27}, the positive meter terminal being taken to chassis.

A meter reading will be obtained if oscillation is occurring. At some settings of the trimmer capacitor which is connected in the circuit at the time, no oscillation will occur. The trimmers should be selected in turn by the switch and each adjusted for maximum reading on the meter. It is possible for some oscillation to occur which is not controlled in frequency by the crystal. The point where the crystal takes over control is indicated by a sharp peak on the meter as the trimmer is adjusted.

If it should be difficult to adjust the trimmer so as to obtain a maximum reading at the lowest frequency (i.e. the Light Programme), the turns of L_{11} may be compressed together very slightly. If, however, the maximum reading is not easily obtained with the highest frequency (the Home Service Programme), the coil may be expanded very slightly. Generally, however, it will not be necessary to do this and the writer found that the circuit worked first time.

It will be necessary to readjust the trimmers when C_{28} is fitted and connected to the mixer stage, since the capacitance in the circuit will then be different. The trimmer adjustment is fairly critical.

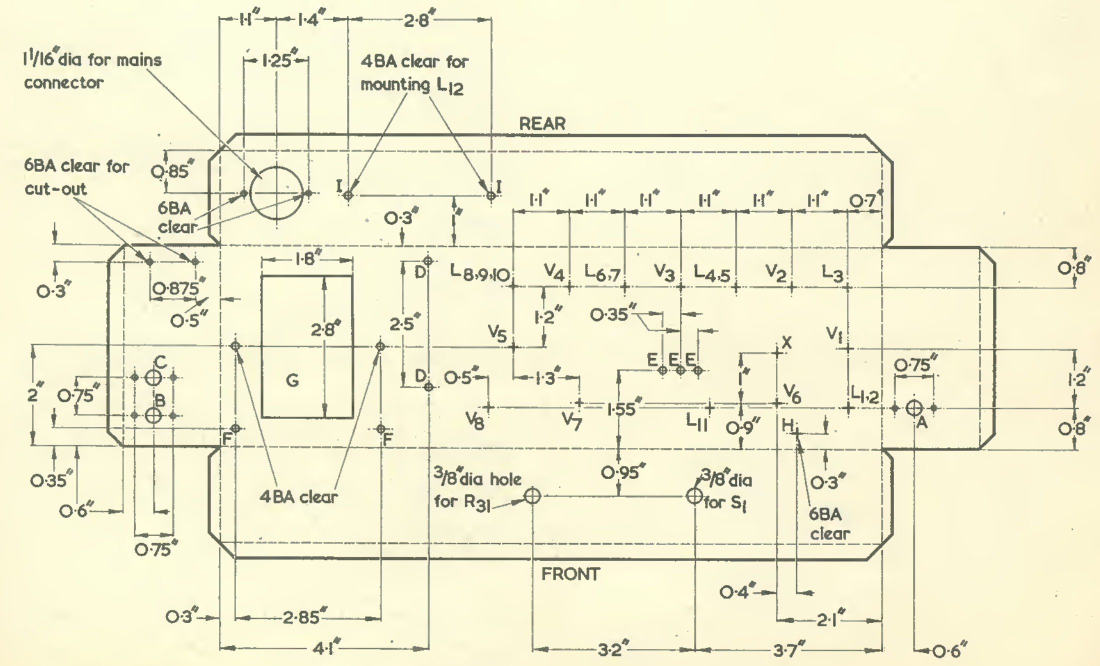


Fig. 7 Top view, showing drilling details

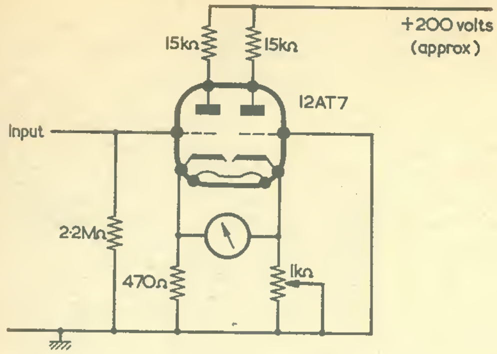


Fig. 8. A simple valve voltmeter for alignment

The RF/IF Section

It is very desirable, although probably not essential to return all earth connections in the r.f. stage to a common point. An insulated tag is used to support R_4, this tag being secured by one of the bolts used for fixing the screening can of the aerial coil. An insulated tag supporting the end of R_1 remote from L_3 is, fastened by one of the bolts holding the screening can of this coil.

All leads in the r.f./i.f. section must, of course, be kept as short as possible if they are carrying radio frequency currents. This applies in particular, to the decoupling capacitor lead-outs.

A 2-way tagstrip is used to support R_{10}, this tagstrip being secured by one of the bolts which holds the can shielding L_6 and L_7.

A further 3-way tagstrip (with one tag earthed) is required to support R_{18}, and R_{19} and C_{25}. This tagstrip is secured by one of the bolts which hold the V_5 valveholder in position. Single insulated tags standing about ¾ to 1in from the chassis are used to support the h.t. wiring to each valve in the section i.f. section. A single insulated tag mounted by L_{10} is used to support the end of R_{15} remote from L_{10}. A few inches of coaxial cable is connected to this tag to take the signal to the audio stages.

The Audio Stages

C_{34} and C_{38} are mounted on the side of the station selection switch which is remote from the oscillator valve, one capacitor being placed above the other. They are afforded some support by a tagstrip which is held in position by one of the bolts securing V_7. C_{35}, R_{28} and R_{27} are connected to this tagstrip. C_{36} had to be mounted fairly near to the mains transformer, since the audio section is somewhat compact in layout. It is mounted on a tagstrip which is held in position by one of the bolts securing the speaker transformer. C_{39} is rather near to R_{34}, which tends to get a little warm. However, the voltage applied to C_{39} is quite low. One end of this capacitor and the speaker transformer output leads are connected to a tagstrip placed near V_8.

Fig. 9. The i.f. trace, as displayed by an oscilloscope

The Power Supply

The mains transformer is a normal half-shrouded component 3.7in in length by 3.1in wide. The smoothing choke, L_{12}, is placed underneath the chassis. The Belling-Lee cut-out is secured to the end of the chassis in one corner and is normally in a vertical plane. The mains input socket is placed between the cut-out and L_{12}.

The power rectifier diodes are wired to the tagstrip which is mounted near the mains transformer. (This tagstrip is secured by the holes marked F in Fig. 7). The heaters supply is also connected to this tagstrip.

Alignment

The alignment of an f.m. receiver (other than the pulse counting type of receiver) always presents some problems.

First of all the oscillator trimmers should be set for maximum reading on a fairly sensitive meter connected between earth and the junction of R_{23}, R_{24} and C_{27} as described previously. The switch S_1 is used to select the trimmer being adjusted.

A valve voltmeter is very desirable for the alignment of the ratio detector transformer, although it is also possible to manage with a very sensitive meter (about 10μA full scale deflection) and a series resistor. A commercially manufactured valve voltmeter is most convenient, but those readers who do not have access to such an instrument may construct the small circuit shown in Fig. 8. This simple valve voltmeter is not intended to be used for the measurement of actual voltages, but is quite suitable for use as an indicator of zero voltage or for the alignment of a circuit for maximum response. The meter in Fig. 8 should have a full scale deflection of between 100μA and 1mA. The 1kΩ resistor is the set-zero control.

If the circuit of Fig. 8 is too sensitive for measuring the voltages in the receiver, a resistor of several megohms should be placed between the input connection and the grid of the left hand triode.

In order to align L_4, L_5, L_6 and L_7, the output from a signal generator set accurately at 10.7 Mc/s is fed to the grid of V_2. An unmodulated continuous wave may be used. The valve voltmeter should be connected across capacitor C_{15} in the a.g.c. line. The cores of the i.f. transformers are set for maximum reading of the voltmeter. As the circuits come into alignment, the output of the signal generator should be reduced so that the final alignment with the signal generator is carried out with a very small input. Incidentally, it is possible to use the oscillator of a short wave receiver instead of a signal generator.

The valve voltmeter is now connected across C_{25}

and the core of L_8 is adjusted for a maximum reading of the meter.

Alignment using the Transmitted Signal

The i.f. stages have been approximately aligned by the above procedure, but with a crystal controlled local oscillator, the final alignment *must* be carried out using the transmitted signal. This eliminates the possibility of mis-tuning these stages due to the use of an inaccurately calibrated signal generator or a crystal which does not oscillate at a frequency exactly 10.7 Mc/s below the transmitter frequency.

An aerial is now connected to the receiver input. A programme should be received and should produce a voltage across C_{15}. If no such voltage is obtained turn the volume control to maximum and try to adjust the cores for maximum signal strength. If no signal can be heard, the initial frequency of alignment with a signal generator was incorrect and the alignment should be repeated with the signal generator at a slightly different frequency.

When a response is obtained using the aerial input, connect the valve voltmeter across C_{15} and adjust the cores of L_4, L_5, L_6 and L_7 for maximum response. Then adjust the core of L_2 for maximum response when the centre frequency is being received (that is, the Third Programme). If maximum response can be obtained with the core in two different positions, the correct adjustment occurs at the maximum where the core is not very far in the coil.

The core of L_3 should be adjusted in conjunction with the oscillator trimmers. These adjustments are interdependent and it may take some time before optimum results can be obtained on all three programmes.

The core of L_8 should now be adjusted for maximum voltage across the capacitor C_{25}.

The valve voltmeter should then be connected across C_{33}. As the core of L_9 is adjusted, through resonance, the meter reading should increase to a maximum, then decline steadily to zero and rise to a maximum with the opposite polarity. Finally it will decline again. The core should be adjusted so that the potential across C_{33} is at the centre zero point. Adjustment of the core in one direction will then produce a voltage across C_{33} of a certain polarity, whilst adjustment of the core in the opposite direction will produce a voltage of the opposite polarity.

When the receiver has been working for about an hour and has reached its working temperature, a final check should be made on the alignment of all the cores. Connect the valve voltmeter across C_{15} for the alignment of all cores from L_1 to L_7 inclusive. L_8 is adjusted for maximum voltage across C_{25} and L_9 is adjusted as just described.

Final Alignment

If possible, it is worthwhile checking the final alignment with a wobbulator. A wobbulator consists essentially of a signal generator, the output frequency of which sweeps through the f.m. band, and an oscilloscope. The frequency with which the trace on the cathode ray tube passes across the screen is the same as that at which the signal generator sweeps through the f.m. band; the two frequencies are synchronised, usually at 50 c/s.

When this type of equipment is used and the oscilloscope input is connected across C_{15}, the i.f. response curve will appear on the screen of the cathode ray tube. It will have the appearance of Fig. 9. The curve is inverted, since the potential of the a.g.c. line is negative with respect to the chassis. The cores of the i.f. transformers should be adjusted until the peak of the response curve is fairly broad and flat. This may involve slightly staggering the tuning and hence a loss of gain.

Fig. 10. The overall response curve

When the oscilloscope input is connected across C_{33}, the overall response of the receiver will be displayed. The curve will have the appearance shown in Fig. 10. The central part of this curve must be a straight line if the detector is to provide low distortion. If the curve shows a loop at one or both ends, this indicates that there is some phase difference between the modulating frequency and the output, and it is not important. One should not necessarily expect to get a suitable response curve immediately one switches the equipment on; the deviation and signal levels must be suitably adjusted. The prototype gave what appeared to be a very linear response in this test.

Drift

It is also worthwhile checking the thermal drift of the resonant frequency of the tuned circuit L_9 C_{20}.

This is measured by finding the variation of the voltage across C_{33} with time after switching the receiver on from cold. This variation should be a small fraction of the maximum voltage obtainable when the core of L_9 is adjusted in either direction.

It must be emphasised that the use of a wobbulator and the checking of the amount of drift are by

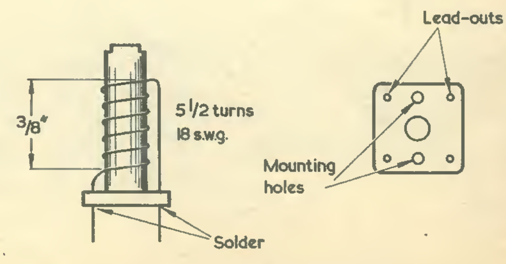


Fig. 11. The oscillator coil, L_{11}

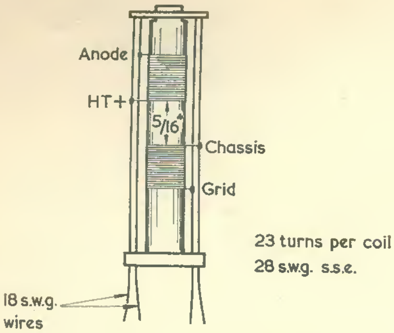


Fig. 12. The i.f. transformer assembly

no means essential operations. Satisfactory performance should be obtained with the simple alignment procedure, but the use of a wobbulator may lead to some improvement and is rather instructive.

The Coils

Suitable commercial coils are available, but the ones used in the prototype were home constructed. They were all wound on standard "Aladdin" coil formers of diameter 0.3in with screening cans measuring $\frac{13}{16}$ x $\frac{13}{16}$in. The cans and formers used for L_1—L_2, L_3 and L_{11} can be quite short with an overall height of 1.3in or more, but those used for the i.f. transformers and for the ratio detector transformer must be tall enough to contain the two tuned circuits and two dust cores required in each. They should have an overall height of 2.4in.*

Details Of Individual Coils

L_{11} is shown in Fig. 11. This coil consists of $5\frac{1}{2}$ turns of 18 s.w.g. tinned copper wire spaced to occupy a winding length of $\frac{3}{8}$in. The wires are soldered to eyelets or tags in the base of the former at the places shown. This is the only coil not fitted with a dust core.

The secondary winding of L_1–L_2 consists of $4\frac{3}{4}$ turns of 18 s.w.g. tinned copper wire spaced to occupy 0.5in. The primary winding consists of $2\frac{1}{4}$ turns of 22 s.w.g. enamelled copper wire interwound with the earthy end of the secondary winding. The windings were spaced and held in position with polystyrene cement so that they did not touch each other. The wires emerging from the coil former are soldered to eyelets or tags in the base of the former.

L_3 consists of $2\frac{3}{4}$ turns of 18 s.w.g. tinned copper wire spaced to occupy a length of 0.3in. Both L_1–L_2 and L_3 require a single dust core, which may be of the v.h.f. type.

The two i.f. transformers, L_4–L_5, L_6–L_7, are identical (see Fig. 12). They consist of two coils, each 23 turns close-wound of 28 s.w.g. single silk enamelled copper wire, spaced accurately $\frac{5}{16}$in from each other. It was felt that this wire was too thin to bring out of the coil base to solder to the appropriate components. Four lengths of 18 s.w.g. tinned copper wire are therefore fixed at the top and bottom of the coil former as shown. They are soldered at the points at which they emerge from the base. The coil windings are soldered to these 18 s.w.g. wires. 50pF silver-mica capacitors (not shown in Fig. 12) are soldered inside the cans across the appropriate 18 s.w.g. wires. The anode and grid connections are taken from their respective windings at the point most remote from the other winding to minimise capacitive coupling. Each i.f. transformer has two dust cores.

The ratio detector transformer is constructed in a similar way to the i.f. transformers, but five 18 s.w.g. wires run the length of the can, since there are five external connections. The secondary winding, L_9, positioned in the lower part of the can, consists of two coils, each 16 turns of 28 s.w.g. single silk enamelled copper wire, close-wound in the bifilar manner and connected in series. The lower end of the primary winding, L_8, was spaced $\frac{3}{16}$in above the upper end of the secondary. The primary winding consists of 35 turns of 36 s.w.g. single silk enamelled copper wire close-wound. The tertiary winding, L_{10}, is wound over the end of the primary remote from the secondary, the two windings being separated by a paper inlay about two thousandths of an inch in thickness. The tertiary winding consists of $9\frac{1}{2}$ turns of 36 s.w.g. single silk enamelled copper wire close-wound. See Fig. 13. The ratio detector transformer is fitted with two dust cores.

All windings of the i.f. transformers and ratio detector transformer were covered in polystyrene cement.

Fig. 14 shows the holes which must be drilled in the chassis for each coil former and i.f. transformer. The central hole, of $\frac{1}{4}$in diameter, permits the adjustment of the dust core from beneath the chassis. The former is fixed to the chassis by bolts passing through the two holes marked "6 BA clear" in Fig. 14. The 18 s.w.g. connecting wires pass through the four corner holes, which can have a diameter similar to the 6BA clearance holes (or to take tags if tags are fitted to the formers). Only two of the four corner holes need to be drilled in the case of L_3 and L_{11} if their formers have eyelets. In the case of the ratio detector transformer a fifth hole is required at the point marked "A" in Fig. 14, since there are five connecting wires.

The cans for shielding the coils have small flaps, which are folded beneath the base of the former. In the prototype, however, the flaps were folded outwards and two holes, additional to those shown in Fig. 14, were drilled in the chassis to secure each can. It is much easier to make any alteration to the coil when one is able to remove the can without

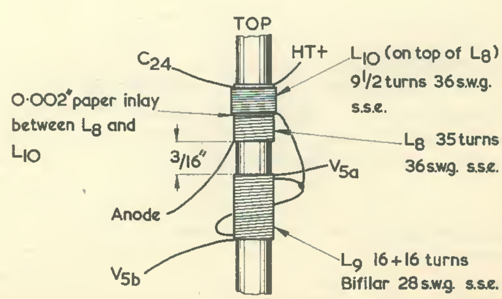


Fig. 13. How the ratio detector transformer is wound

* Coil winding details are based on information given by S. W. Amos and G. C. Johnstone in "Design For an F.M. Tuner", *Wireless World*, April and May, 1955.

removing the coil former; but this can only be done if the small flaps are folded outwards. It should be pointed out that the flaps can break very easily with use.

(Suitable coil formers for L_1–L_2, L_3 and L_{11}, are Denco Ref. 5000A/4PL; and for L_4–L_5, L_6–L_7 and L_8–L_9–L_{10} are Denco Ref. 5000B/6E. The last three formers require Top Plates Ref 5001. The dust cores fitted to L_1–L_2 and L_3 may be Denco Grade 900 (v.h.f. type) and the six remaining dust cores Denco Grade 500. Aluminium screening cans are Denco Ref. 1 for L_1–L_2, L_3 and L_{11}; and Ref. 3 for L_4–L_5, L_6–L_7 and L_8–L_9–L_{10}. These items are available through component retailers or from Denco (Clacton Ltd., 357–9 Old Road, Clacton-on-Sea, Essex. —Editor.)

The Aerial

A simple half-wave dipole is adequate for localities where the signal strength is reasonably good (over 500μV per metre). If car ignition noise is found to be troublesome or if the receiver noise level is appreciable, a reflector and one or more directors may be added to the aerial. The length of the dipole should be about 5% less than half the wavelength of the centre frequency being received (i.e. the Third Programme). A reflector should be a little longer than the dipole whilst a director should be a little shorter. The spacing between the dipole and any of the other elements is not very critical, a distance of one-eighth of a wavelength being suitable.

An outdoor aerial will normally give very much better results than an indoor one.

The author has obtained very good results with a quad aerial, and a full description of such an aerial is given in his article "Cubical Quad Aerial For F.M." which was published in the October 1966 issue of *The Radio Constructor*. This particular aerial, in combination with the present receiver, has enabled excellent v.h.f. f.m. reception to be achieved.

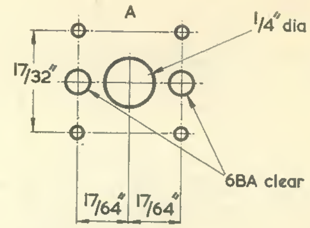
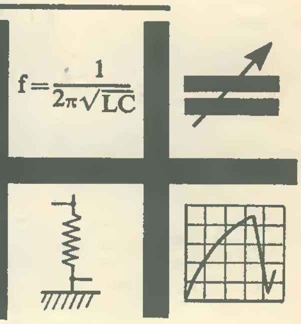


Fig. 14. Chassis drilling diagram for the coil formers

UNDERSTANDING RADIO

The Superhet Receiver



by W. G. Morley

In last month's issue we completed our examination of audio frequency circuits and their operation by dealing with some final points concerned with negative feedback.

We now turn to a different subject—the superhet receiver. With one exception, the stages in a superhet receiver operate in much the same manner as do the receiver stages we have already discussed in this series. The exception in the superhet is a stage which provides an output at a frequency equal to the difference between two input frequencies. Since it is important to understand how this process is carried out, the present article is of an introductory nature, and will deal only with the basic manner in which a difference frequency is formed. We will then be in a position to deal with the superhet receiver in its entirety, as will occur next month.

Heterodyne Formation

In an earlier "Understanding Radio" article (published in the August 1966 issue) we discussed the operation of the grid leak triode detector when provided with a reaction circuit. We concluded at that time by noting that if, whilst receiving a transmitted signal, the reaction control of such a detector is sufficiently advanced to cause the triode to oscillate, an audible *heterodyne* or *beat note* appears in the anode circuit, its frequency being equal to the difference between the frequency of the received signal's carrier and the frequency of oscillation of the detector. As the detector grid tuned circuit is adjusted so that its resonant frequency (and, hence, the frequency of oscillation of the triode) approaches the carrier frequency of the received signal, the frequency of the heterodyne falls until, when the two frequencies are very close together, it is below the lowest audible frequency and cannot be heard. The effect is well-known, and will have been observed by anyone who has operated a receiver which incorporates a detector stage with reaction.

In a superhet receiver it is a function of one of the

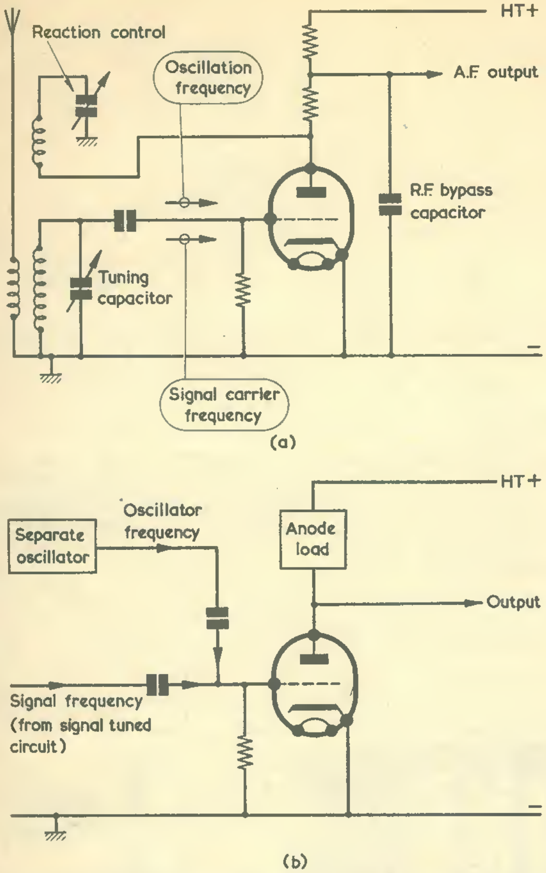


Fig. 1 (a). When the reaction control of a grid leak detector is advanced sufficiently far for the detector to oscillate, two signals are applied to the grid. One is at the frequency of the signal carrier (as picked up on the aerial) and the other is at the frequency of oscillation
(b). A heterodyne will still appear at the anode of the detector if a separate oscillator provides the oscillatory signal. The anode circuit here is shown in simplified form

stages to produce a heterodyne deliberately. To understand more clearly how this is done we may work forward from the grid leak detector with reaction, with which we are already familiar. In such a detector, two input voltages are applied to the grid in the manner shown in Fig. 1 (*a*). One of the input voltages is at the frequency of oscillation of the triode, whilst the other is at the frequency of the signal's carrier. The fact that the input voltage at oscillator frequency is self-generated by the triode is incidental; and we would still obtain the heterodyne at its anode if the triode did not have a reaction circuit and we used a separate oscillator, as in Fig. 1 (*b*). An output from this separate oscillator is applied to the grid leak detector in company with the carrier of the received signal. The frequency of the heterodyne at the triode anode will still be equal to the difference between the oscillator and carrier frequencies.

Let us next see, by drawing the waveforms of the two input signals, just how this difference frequency is formed. We shall use frequencies which are easy to present in diagram form—say 20 kc/s and 21 kc/s—and we shall start by assuming that they are applied to a triode having a linear I_aV_g characteristic. A triode of this nature is shown in Fig. 2; it has conventional cathode bias and offers linear (i.e. undistorted) amplification of the signals applied to its grid. It is *not* a detector. In Fig. 2, our 20 kc/s and 21 kc/s input signals are provided by two a.c. generators in parallel, each having an internal resistance which is shown as an external resistor in series. The voltage appearing at the grid of the triode is the result of the current from the generators flowing through its grid resistor.

The waveform in Fig. 3 (*a*) shows the current in the grid resistor of Fig. 2 due to the 20 kc/s a.c. generator. If the cycles in the waveform are counted, it will be found that there are 20. The waveform at Fig. 3 (*b*) shows the current due to the 21 kc/s a.c. generator. Both waveforms share the same time axis, whereupon there are 21 cycles in the waveform at (*b*), these occupying the same amount of time as the 20 cycles of the waveform at (*a*). It is assumed that both waveforms have the same amplitude.

The currents depicted by Figs. 3 (*a*) and (*b*) both flow through the single grid resistor. As is to be expected, when the two currents are in phase the resultant current in the resistor is equal to their sum. When they are out of phase, the resultant current in the resistor is equal to the larger current minus the lower current. The envelope of the resultant current in the resistor over the complete period in the diagram is illustrated in Fig. 3 (*c*). At point X, the waveforms of (*a*) and (*b*) are fully in phase and, at this instant, the amplitude of the resultant current at (*c*) is at maximum, being equal to the sum of the two currents at (*a*) and (*b*). At point Y the waveforms of (*a*) and (*b*) are fully out of phase, whereupon the total amplitude at (*c*) becomes zero. At point Z the waveforms of (*a*) and (*b*) are fully in phase again and the total current at (*c*) is at maximum once more.

Let us next examine the situation between points X and Y and between points Y and Z. Proceeding from point X to point Y, the waveforms of (*a*) and (*b*) become more and more out of phase, whereupon the amplitude of the total current at (*c*) continually drops in amplitude, reaching its minimum at point Y. From point Y to point Z the waveforms of (*a*) and (*b*) grow more and more in phase, with the result that the total current at (*c*) continually increases in amplitude, reaching its maximum at point Z.

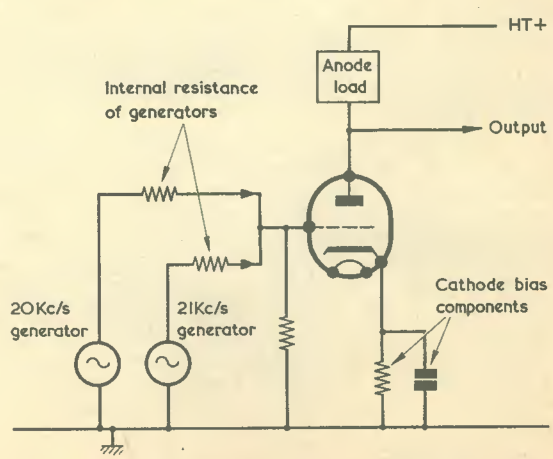


Fig. 2. Applying signals at two different frequencies to the grid of a linear amplifier

It is evident, from inspection, that the amplitude of the waveform at Fig. 3 (*c*) proceeds from a peak to zero and then back to a peak again once for every 20 cycles of the waveform at (*a*), and once for every 21 cycles of the waveform at (*b*). Thus, the variation in amplitude of the waveform at (*c*) passes through one cycle for every 20 cycles of the 20 kc/s waveform, or for every 21 cycles of the 21 kc/s waveform. In consequence, the frequency of amplitude variation of the waveform at (*c*) is 1 kc/s. This is, of course, the difference between the 20 kc/s and 21 kc/s frequencies. It is possible, by drawing any other two frequencies at (*a*) and (*b*), to arrive at a resultant waveform whose frequency of amplitude variation is similarly equal to the difference between the two frequencies.

Since the triode of Fig. 2 amplifies without distortion, a voltage waveform equivalent in shape to Fig. 3 (*c*) will appear at its anode. If, however, we try to extract usable energy at 1 kc/s from the anode, say by connecting a pair of headphones in the anode circuit, we will hear nothing. This is because, at the frequency of 1 kc/s, the *average value* of the waveform of Fig. 3 (*c*) is zero. At this frequency the amplitude of the waveform on one side of the zero line is exactly balanced out by the amplitude on the other side.

Up to now, we have succeeded in producing a waveform which shows a variation at the difference frequency, but this waveform is of no use for any practical purpose. Our next step consists of transferring the set of circumstances we have just examined from the linear triode of Fig. 2 back to the grid leak detector triode of Fig. 1 (*b*). We will say that the input signal frequency in Fig. 1 (*b*) is at 20 kc/s, and that it replaces the 20 kc/s generator of Fig. 2, and that the separate oscillator in Fig. 1 (*b*) runs at 21 kc/s and that it replaces the 21 kc/s generator of Fig. 2. Both the source of input signal and the oscillator output will have internal resistances, these corresponding to the internal resistances, depicted as physical resistors, of the two generators in Fig. 2. After this, there are no further points of similarity. Whereas the triode of Fig. 2 is a linear amplifier the triode of Fig. 1 (*b*) is a grid leak detector.

Since the Fig. 1 (*b*) triode is a detector, rectification occurs at the grid, and the resultant voltage waveform at the anode takes up the form shown, in outline, in Fig. 3 (*d*).* This is a distorted version of the waveform at Fig. 3 (*c*) and it has an average value at 1 kc/s which is indicated by the dashed line. This average value varies in sympathy with the amplitude of the waveform and is not now equal to zero, as it was in Fig. 3 (*c*). If we were to connect a pair of headphones in the anode circuit of the grid leak detector we would, this time, be able to hear a 1 kc/s tone.

Necessity For Detection

Summing up what we have just discussed we can state that if we apply two frequencies to the grid of a linear amplifier valve we can obtain, at the anode, a waveform of the type shown in Fig. 3 (*c*), whose envelope varies in amplitude at a frequency equal to the difference between the two input frequencies. It is impossible, however, to extract any energy at the difference frequency since the average value, at that frequency, is equal to zero. But if, instead, we apply the two input frequencies to a detector, which *distorts* the resultant waveform, we are at once able to extract usable energy at the difference frequency.

* A full description of the operation of a grid leak detector was given in "Understanding Radio" in the October 1965 issue.

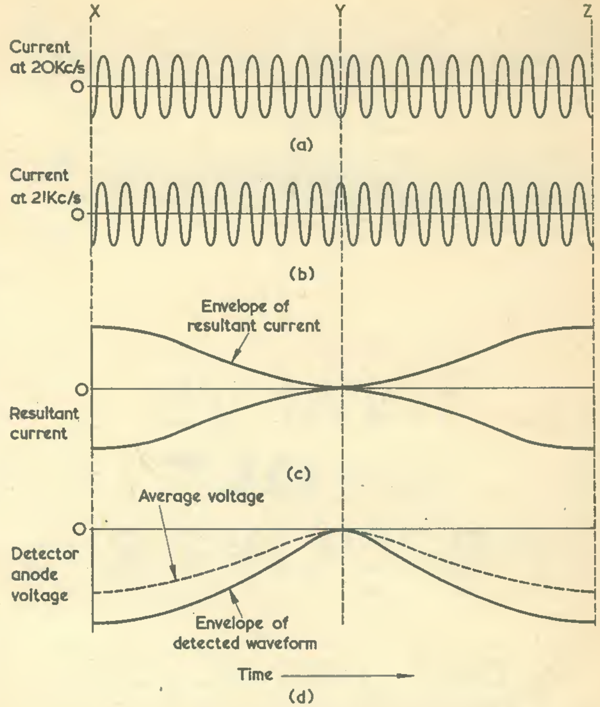


Fig. 3. The waveforms appearing in the circuit of Fig. 2. are shown in (a), (b) and (c). If the waveform envelope at (c) is detected it takes up the shape shown in (d), thereby providing a usable average voltage at difference frequency

The writer has discussed the production of the difference frequency at some length for three reasons. First, he employed the approach illustrated in Figs. 3 (*a*), (*b*) and (*c*) to show, in graphical form, how a difference frequency may be produced by summation of two input frequencies. Second, he next introduced the detector circuit of Fig. 1 (*b*) to demonstrate that, if the difference frequency is to be usable, *it is essential that the two input frequencies be applied to a detector, or to an amplifier which offers sufficient distortion for the average value of the difference frequency to be shifted from zero*. Third, the writer intended to avoid the method of explanation given in many text-books, which relies on mathematics at a higher level than can be appreciated by the beginner. The method adopted here takes a little time to present, but it does demonstrate a somewhat complex process in terms of first principles.

Returning to the opening remarks in this article, the difference frequency given by the detector circuit of Fig. 1 (*b*), and which is shown in Fig. 3 (*d*), is the heterodyne or beat note we then referred to.

In Figs. 3 (*a*) and (*b*) we used two input waveforms of equal amplitude to illustrate the production of a difference frequency. A difference frequency will also be produced when the two original frequencies have widely differing amplitudes, provided that the resultant waveform given by their summation is detected, or undergoes distortion, to allow a usable average value at difference frequency to be given.

Introducing The Superhet

The heterodyne which is given when two different frequencies are applied to a detector (or distorting amplifier) need not be an audio frequency. It may equally well be a radio frequency. In a superhet receiver one of the first functions is to obtain a difference frequency or heterodyne at r.f. by applying the output of an oscillator to a circuit which functions in the basic manner we have just been considering (although in many practical cases it will not employ a grid leak triode detector) together with the signal picked up by the aerial. It is then this heterodyne, instead of the aerial signal, which undergoes the major amount of amplification inside the receiver before application to a detector for reclamation of the modulating signal.

Since the heterodyne in a superhet is at a radio frequency it can be described as "supersonic" (i.e. higher in frequency than a "sonic" or audio frequency). "Superhet" is, indeed, a shortened version of the term "supersonic heterodyne", which was used to describe this type of receiver when it was first developed.

Next Month

In next month's article we shall commence to examine the superhet receiver in detail.

1-VALVE 9-VOLT RECEIVER

By P. NICHOLSON

THE SIMPLE RECEIVER DESCRIBED IN THIS ARTICLE employs a DL94 operating at anode and screen-grid potentials of 9 volts or less, this being followed by an a.f. transistor which feeds into a magnetic earphone. Good local station reception is obtained on medium waves and a large number of stations can be picked up on short waves using an aerial only 24in long. The latter is made of bicycle spokes soldered together to form a whip, although any other similar type of short aerial could be employed instead. No earth connection is required.

The receiver will be of particular interest to the experimenter because of its novel design. Trimmers in the grid and reaction circuits are included, and these enable adjustments to be made for optimum results on all ranges covered.

Circuit Operation

The aerial is directly coupled to the top end of the tuned coil L_2, across which is connected tuning capacitor C_3. V_1 functions as a grid leak detector, the grid capacitor being C_4 and the grid leak R_1. Coverage is on medium waves and on short waves down to around 30 metres.

The DL94 used in the V_1 position is normally employed as an output pentode. Nevertheless, it is capable of providing a useful degree of amplification with an h.t. potential of 9 volts only, as occurs here. Its anode couples to the reaction feedback winding L_1, and thence to chassis via the reaction capacitors C_1 and C_2. The screen-grid potential is varied by R_3, which functions as the panel reaction control.

It will be noted that C_2 and C_3 are ganged, trimmer C_1 is set up such that reaction is given, as R_3 is advanced, at all frequencies in the range covered by L_2 and C_3. With a conventional regenerative detector circuit using capacitive feedback it is normally necessary to increase reaction capacitance as tuning capacitance increases, but with the present circuit the required

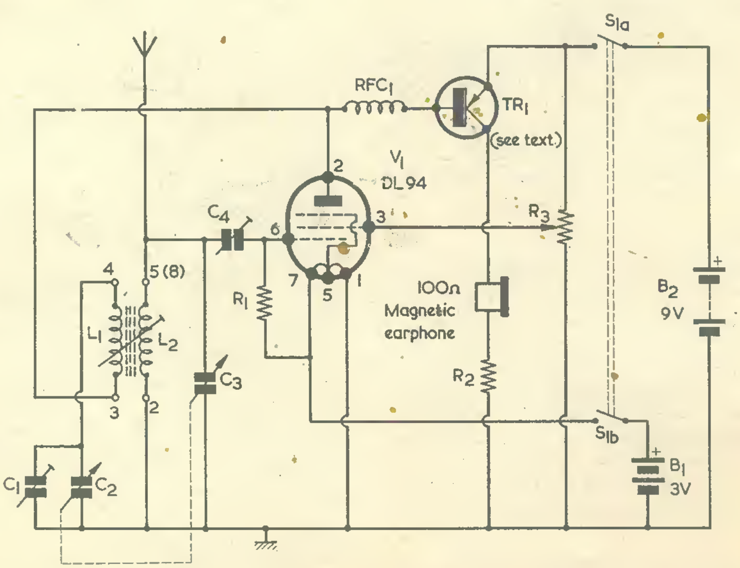


Fig. 1. The circuit of the experimental one valve plus one transistor receiver

increase in reaction capacitance is given automatically by C_2. The result is that less adjustment is required in R_3 over the range being tuned. The improvement in performance given by this technique is particularly noticeable on short waves, and R_3 needs little adjustment over quite wide sections of the short wave bands.

The detected a.f. signal at V_1 anode is passed, via RFC_1, to the base of TR_1. This functions as a common emitter amplifier, feeding an output to the 100Ω magnetic earphone in its collector circuit. R_2 is included to limit collector current. If an earphone of 50Ω resistance is employed, R_2 could be reduced to 180Ω.

The writer found that a "white spot" transistor worked quite well in the TR_1 position, and that better results were given with an Ediswan XB102. The transistor type does not appear to be critical and, if a transistor holder is used, different types may be experimented with. It should be remembered, however, that nearly 30mA can flow in the collector circuit if it should happen that TR_1 bottoms. To prevent possible damage it would, in consequence, be advisable to experiment only with a.f. output transistors having maximum collector current ratings in excess of 30mA.

Coils

The writer used a Denco Miniature Dual Purpose Green coil (Range 2) in the receiver for medium wave reception. Denco Green coils in the Miniature Dual Purpose series are normally employed for coupling an r.f. amplifier to a regenerative detector, and they plug into a B9A valveholder. The tuned winding connects to pins 2 and 5 and the reaction winding to pins 3 and 4, as is indicated in Fig. 1. The coupling winding on the Denco coil connects to pins 8 and 9, and is not used in the present circuit. The writer found that a slight improvement resulted from connecting pin 8 to pin 5, pin 9 being left disconnected, and readers may care to try the effect of making such a connection in receivers built up to the circuit. The connection is, of course, made between the appropriate pins of the B9A valveholder into which the coil is plugged.

Short wave coils may be wound on Denco polystyrene coil formers of the type which plug into a B9A valveholder and have an o.d. of 0.375in. As a guide, and using 28 s.w.g. enamelled wire, 15 turns for reaction and 30 turns for tuning will bring in the 49 metre band with C_3 fairly near the minimum capacitance end of its range, and 15 turns for reaction and 15 turns for tuning will similarly bring in the 31 metre band. All coils are close-wound and the formers should be fitted with dust cores. (These formers, with dust cores, may be obtained from Denco (Clacton) Ltd., 357 Old Rd., Clacton-on-Sea.) The reaction winding, from pin 3 to pin 4, should be wound in the same direction as the tuned winding, from pin 2 to pin 5. Adequate reaction should be given with the windings side by side on the former, as in Fig. 2. It should be mentioned that reaction is rather difficult to achieve at the higher short wave frequencies, and it was found that the relatively high value chosen for C_4 helped to overcome this difficulty.

Layout is not critical provided that all r.f. wiring is kept short. A slow motion drive for the 2-gang capacitor is required to facilitate tuning on the short wave bands. After the receiver has been completed, C_4 and C_1 should be set up to provide best results on both medium and short waves. The filament consumption from the 3 volt supply is 50mA.

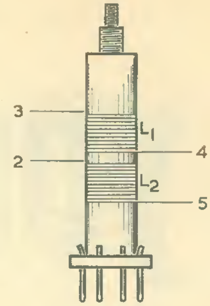


Fig. 2. How the short wave coils are wound

COMPONENTS

Resistors
- R_1 1MΩ ¼ watt 20%
- R_2 220Ω ¼ watt 10%
- R_3 5kΩ potentiometer, linear

Capacitors
- C_1 500pF trimmer
- C_2, C_3 310+310pF two-gang variable
- C_4 500pF trimmer

Inductors
- L_1, L_2 See text
- RFC_1 2.6mH, type RFC (Denco) or similar

Valve
- V_1 DL94

Transistor
- TR_1 P.N.P. transistor (see text)

Switch
- $S_{1(a)(b)}$ d.p.s.t. on-off switch

Batteries
- B_1 3-volt battery
- B_2 9-volt battery

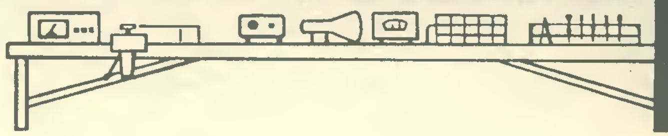
Earphone
- Magnetic earphone, 100Ω d.c. resistance

Miscellaneous
- 1 B7G valveholder (for V_1)
- 1 B9A valveholder (for L_1, L_2)
- 1 transistor holder (if required—see text)
- Slow motion tuning drive
- Knobs
- Short whip aerial

Editor's Note

It may be found that increased output is given if R_2 is shunted by an electrolytic capacitor of around 20μF at 9V wkg., with its negative lead-out connected to the chassis line. Also, reaction on short waves may be improved by bypassing V_1 screen-grid to chassis via a 0.01μF capacitor.

In your workshop



Ceramic capacitors, including in particular those employed in r.f. bypass circuits at v.h.f. and u.h.f., can take up some interesting shapes and styles. In this month's episode Smithy the Serviceman introduces Dick to the types which are most liable to be encountered in television servicing

"WHAT," ASKED DICK, "IS THE difference between a disc ceramic capacitor and a tubular ceramic capacitor?"

Smithy's disgraceful tin mug, charged to the brim with its precious cargo of tea, faltered in mid-air on its way to his mouth. The Serviceman turned an enquiring glance upon his assistant.

"I beg your pardon."

"What," repeated Dick, "is the difference between a disc ceramic capacitor and a tubular ceramic capacitor?"

Smithy's mug completed its ascent to his lips and he drank deeply.

"Well," he replied, returning the mug carefully to the surface of his bench. "I suppose you could say that the disc ceramic is circular in shape and that the tubular ceramic is cylindrical in shape."

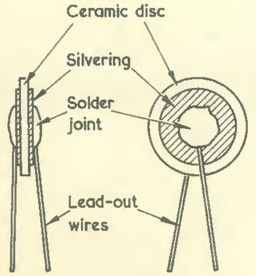


Fig. 1. The construction of a disc ceramic capacitor. A protective coating is added later

Ceramic Capacitors

"I *know* that," snorted Dick impatiently. "What I don't understand is why set manufacturers use disc ceramics in some circuit positions and tubular ceramics in others."

"Probably," replied Smithy mildly, "because the disc ceramic is the better shape for some applications, and the tubular ceramic is the better shape for the other applications."

"Come off it, Smithy," said Dick indignantly. "Set makers choose ceramic capacitors for value and tolerance, and all the other electrical characteristics a capacitor is supposed

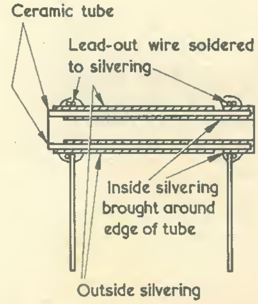


Fig. 2. The basic construction of a tubular ceramic capacitor

to have. They don't choose them for *shape!*"

"They jolly well do, you know," returned Smithy. "Not for *all* applications, I'll admit, but certainly in applications where short lead-outs are required. And now, having answered your question fully and completely, may I return to my tea-break?"

Completely ignoring the gaze of frustrated fury directed upon him by his assistant, Smithy raised his mug once more and thoughtfully sipped its contents. Several further moments passed, then Dick could restrain himself no longer.

"Yes, but *why*?" he wailed. "*Why* should they want to use one or other of the two shapes?"

Smithy sighed and deposited his mug on the bench with a bang.

"Dash it all," he grumbled. "I've been working on radio and TV sets all morning and, no sooner do I settle down for a quite spot of char, then you're on to me with queries about capacitors. I know that I'll get no peace until I've cleared up your questions, so I suppose you'd better come over here so that I can explain it all to you."

Delighted, Dick picked up his stool and carried it over to Smithy's bench. Smithy took a ball-point pen out of his top pocket and proceeded to make some sketches on his note-pad.

"Now, first of all," he said, "let's have a quick butcher's at the basic construction of disc and tubular ceramic capacitors. A disc capacitor consists quite simply of a disc of ceramic with silvering on either side which extends nearly to the edge. (Fig. 1). The two lots of silvering form the two plates of the capacitor and the ceramic acts, obviously, as the dielectric. The two lead-out wires for the capacitor are soldered to the silvering. In most instances the capacitor is then covered with a coating of hard resin or 'cement', which not only protects it but also assists in anchoring the lead-out wires. It is fairly easy to pull away the silvering at the solder joints if excessive tension is applied during wiring-up, and the coating helps to prevent this occurring. Fair enough?"

"Sure," replied Dick, settling himself more comfortably on his stool.

"Right, then," said Smithy. "Let's next tackle the tubular ceramic capacitor. In this case you have a tube of ceramic material. One lot of silvering is applied to the outside, and it covers most of its surface. The other lot of silvering is applied to the inside and is then brought round at one end to the outside as well. (Fig. 2). The lead-out wires are wrapped round the ends one or more times and are then soldered to the silvering. Again, you normally have a protective outside coating of resin or cement. In this case, though, the method of construction causes the lead-out wires to be secured more firmly, and the coating isn't required to give the same degree of lead-out anchoring as is required with the disc ceramic capacitor."

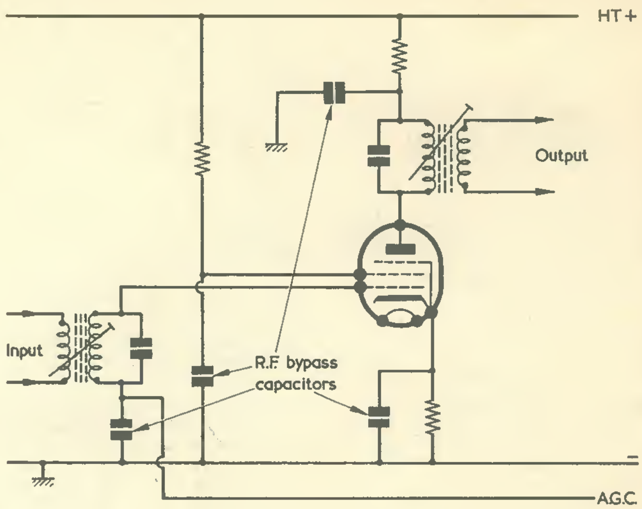


Fig. 3. A typical valve r.f. amplifier, showing the positions of r.f. bypass capacitors

"I can understand all that," replied Dick. "What I can't understand is why discs are used in some circuit positions and tubulars in others."

"To answer that question," replied Smithy, "let's start thinking first about ceramic capacitors used in r.f. bypass positions. We'll ignore capacitors used in other circuit positions for the time being. Now, the capacitors used for bypass purposes have nominal values of around 1,000pF or more and you'll see them at the bottom end of tuned coils fed from an a.g.c. line, as screen-grid and cathode bypass components in valve equipment, and so on. (Fig. 3). It is always necessary to keep inductance out of the bypass circuit, and you have to remember that the capacitor lead-out wires possess a small but still quite significant amount of inductance."

"Inductance?" queried Dick incredulously. "In a straight piece of wire?"

"Definitely," confirmed Smithy. "And your experience with TV tuner units should have brought that fact home to you ages ago. The inductance in the capacitor lead-out wires is

CARTOON CHUCKLE

"There's no need to go solid state like the equipment"

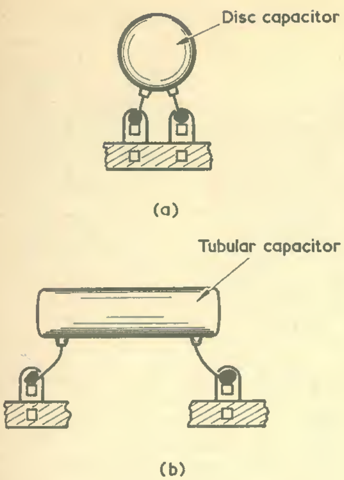


Fig. 4 (a). When two connection points are very close together, shortest lead-out wire length is given with a disc capacitor (b). Lead-out length is shorter with a tubular capacitor when the connection points are more widely spaced

very low but it nevertheless becomes more and more important as the frequency you are trying to bypass increases. The actual capacitor itself, whether it be disc or tubular, has almost negligible inductance, and this is certainly much lower than the inductance given by its lead-out wires. Which now brings me to my original point about choosing a capacitor by shape. If you want to connect a ceramic r.f. bypass capacitor across two circuit points on a chassis which are very close together, it's always better to use a disc ceramic than a tubular ceramic because you can wire it in with shorter lead-out wires. (Fig. 4 (*a*)). If, on the other hand, the circuit points on the chassis are half-an-inch or more apart, the tubular capacitor is the better choice because there is less length of lead-out wire than would be given if you used the disc capacitor. (Fig. 4 (*b*)). In this second example, you're trying to take up as much of the length between the circuit points as you possibly can with the body of the capacitor itself."

High-K Capacitors

"Stap me," remarked Dick elegantly. "I've never looked at the choice between disc or tubular capacitors in that light before."

"It represents normal manufacturing practice," commented Smithy. "You'll find exceptions to the simple rule I've just discussed, these occurring where other requirements are more important than short lead-out wires. Also, the choice of capacitor is influenced by the frequency it is intended to bypass. At frequencies below about 20 Mc/s, the odd half-inch of lead-out wire isn't all that important and it wouldn't matter greatly which type of bypass capacitor you used. As you go up from 20 to 200 Mc/s or so, the choice of capacitor becomes increasingly more important and, at the higher frequencies above 100 Mc/s, it is always very desirable to use the capacitor which offers the shortest lead-out connections in practice. If you look inside a TV tuner unit covering Bands I and III you'll see that most, if not all, of the disc or tubular bypass ceramics are chosen on the basis of obtaining short lead-out wires."

Smithy picked up his mug and, swallowing prodigiously, drained it completely. With a flourish he handed it to Dick, who carried it over to the Workshop sink for replenishment.

"I've never seen anyone drink tea like you," commented Dick dispassionately, as he busied himself with the teapot. "This will be your third mug this morning. You must get through gallons of tea in a week."

"There's nothing to beat it," returned Smithy heartily. "Drinking plenty of tea keeps the system thoroughly flushed out, my boy. There's no chance of the old 'flu bugs and streptococci lodging inside *my* gut, what with the great waves of fluid that I send washing down to them each day!"

Repressing a shudder, Dick put Smithy's filled mug back on the Serviceman's bench and hastily returned to the subject of ceramic capacitors.

"What about ceramics which are used for other jobs?" he asked. "For coupling and things like that."

Smithy took a preliminary drink from his mug.

"You'll still find," he said, smacking his lips, "that, at the higher frequencies, manufacturers tend to use the type which offers the shorter lead lengths. However, the situation is a little more complicated here because it is frequently necessary for the designer to employ capacitors having specific temperature coefficients and in some cases it may be preferable to use a disc where a tubular ceramic might fit into the layout better, and vice versa. Also, in some cases there isn't the same necessity for having short lead-out wiring as is given in bypass circuits. So, you won't always find that the choice between disc or tubular to suit the layout is quite as marked as in r.f. bypass applications. Anyway, let's keep on with the bypass capacitors, because there's another thing I want to tell you about these. In order to get a high capacitance in a small volume, r.f. bypass ceramic capacitors normally employ a ceramic having an extremely high dielectric constant, and which is described as 'high-K'. For some grades of high-K ceramic, this dielectric constant can be as much as 400 times greater than that of mica, which explains why it is possible for high value bypass ceramic capacitors to be made very small in physical size. It has to be remembered, though, that capacitors employing high-K ceramic exhibit fantastically large changes in capacitance for changes in temperature. A typical example would consist of a capacitor offering maximum capacitance at room temperature, this capacitance dropping to three-quarters of its value, or even less, at temperatures of +85°C or −40°C."

"Blimey," said Dick, impressed. "I've never heard of that before."

"Neither, so far as I can tell, have quite a few other people," replied Smithy. "Practically all high-value ceramic capacitors—say, 1,000pF or more—which are small in size are of the high-K type. They're O.K. for quite a few applications other than their intended one of bypassing r.f. circuits, but they should never be used where a constant capacitance, despite temperature change, is important. You shouldn't, for instance, use them as tuning capacitors for a.f. oscillators or things like that. On the other hand, low value ceramic capacitors employ a low-K ceramic material which has much more stable temperature characteristics, and which can be made to offer temperature coefficients from P100 to N750."

"I know all about temperature coefficients," said Dick proudly. "To start off with, the number tells you how much the capacitance changes in parts per million for one degree rise in Centigrade. Also, if the letter's an N the capacitance drops, and if it's a P the capacitance increases."

"That's right," confirmed Smithy. "The capacitance of a P100 capacitor, for instance, increases by one hundred millionths of its value for every degree Centigrade rise in temperature. The P indicates a positive temperature coefficient, whilst N indicates a negative temperature coefficient. There are also, incidentally, ceramic capacitors which have a dielectric constant in a medium range, these offering temperature coefficients which are much higher than N750, but which don't suffer from the very big changes in value given with the high-K types."

"Let's get back," said Dick, "to those high-K capacitors, If they give such large changes in value due to temperature changes, won't this upset their performance as r.f. bypass components?"

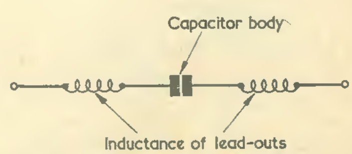


Fig. 5. Exceptionally long lead-out wires on an r.f. bypass capacitor can result in a tuned circuit resonant at a very high frequency

"Not really," said Smithy. "You must remember that all you ask of an r.f. bypass capacitor is that it should offer a minimum value of capacitance which corresponds to a very low reactance at the frequency you're trying to bypass. It doesn't then matter if the capacitance happens to be greater in practice, because all that then results is that the reactance, which is already negligibly low, becomes lower again. In consequence, when you're using a high-K ceramic capacitor you choose a value which will always ensure that you get a satisfactory minimum capacitance regardless of shifts with temperature. Incidentally, this point is reflected in the tolerances to which these capacitors are manufactured, a typical tolerance figure being −20 and +80% on nominal value. The nominal value will be the value the capacitor has at room temperature. In practice, a nominal value of 1,000pF is usually satisfactory for frequencies above 30 Mc/s. Below 30 Mc/s you would require somewhat higher values for r.f. bypass circuits, and you would employ the capacitances we are familiar with in ordinary short wave receivers."

Low Inductance Connections

Smithy quaffed mightily at his tea, then glanced at his assistant.

"O.K. so far?"

"Oh, definitely," said Dick. "Let's next have a go at this business of the lead-out inductance. It still takes a bit of mental effort on my part to think of straight pieces of wire possessing inductance!"

"They do, nevertheless," affirmed Smithy, "and this inductance gets increasingly more important as the frequency goes up. If you are careless enough to use leads which are shockingly long, you can even get into trouble because the capacitor forms a series tuned circuit! (Fig. 5). Such a circuit would have a very low Q because of the high value of capacitance and it would probably resonate in the region of 100 Mc/s or more, but it can still be present and it can still give you unexpected trouble. However, the more usual effect of long lead-outs is that, whilst the capacitor itself is giving a nice low capacitive reactance at the bypass frequency, the lead-out wires are offering a dirty great inductive reactance. So, the golden rule is to keep lead-out wires as short as possible, paying more and more attention to this point as the bypass frequency increases."

"What," asked Dick, "about ceramic capacitors fitted to printed circuit boards?"

"Here again," said Smithy, "the set designer normally chooses a disc or a tubular component according to the hole spacing on the board. Tubular ceramics are usually preferred because hole spacing favours them more than it does disc ceramics. And, of course, tubular ceramics have been available for many years which employ metal legs capable of being inserted direct into printed circuit board holes instead of lead-out wires."

"Is it possible," asked Dick, "to get rid of the inductance given by the capacitor lead-out wires?"

"Oh yes," said Smithy. "To obtain a really low series inductance, you use feed-through capacitors. These are ideal for r.f. bypass work because they can be soldered directly to a metal chassis, with the result that one lead-out wire is completely eliminated. You'll see plenty of feed-through capacitors in TV tuners, both in v.h.f. tuners covering Bands I and III and in u.h.f. tuners covering Bands IV and V. The type of feed-through capacitor used in the older tuners has a skirt which can be soldered to a chassis by means of a soldering iron. (Fig. 6 (*a*)). But, for a long time now, feed-through capacitors in TV tuners have been automatically soldered to the tuner chassis at an early stage of production. Feed-through capacitors of this type consist merely of a ceramic body with silvering on the outside and inside to form the plates. (Fig. 6 (*b*)). The whole chassis, with the feed-throughs in position with solder-rings, goes through an oven which raises it to soldering temperature. (Fig. 6 (*c*)). The solder-rings melt and the feed-throughs then settle down and become soldered direct to the chassis (Fig. 6 (*d*)). The centre pins may be soldered in at this stage as well, or they can be added later."

"What do you mean by solder-rings?"

"They're little rings of resin-cored solder," replied Smithy. "Just the same sort of solder as you use for normal servicing work."

"I've just remembered something," said Dick. "Isn't the original function

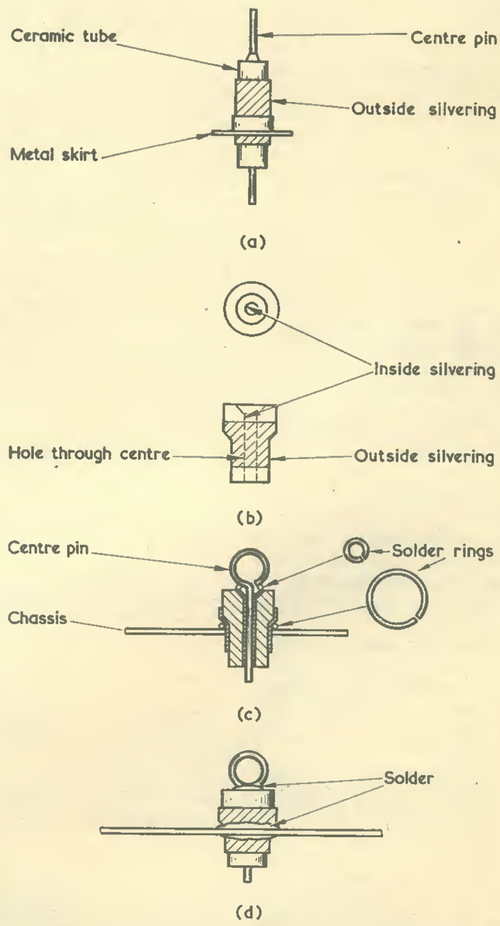


Fig. 6 (a). A conventional feed-through capacitor
(b). A feed-through capacitor suitable for automatic soldering to a chassis. (Capacitors of the particular shape shown here are manufactured by Erie Resistor, Ltd.)
(c). The capacitor and its centre pin fitted in place on a chassis prior to soldering
(d). After soldering, both capacitor body and pin are soldered firmly in position

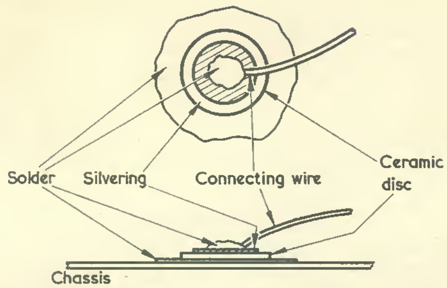


Fig. 7. R.F. bypass capacitors in u.h.f. television tuners sometimes consist of a disc capacitor, the silvering on one side being soldered direct to chassis

of a feed-through capacitor to allow connections to be made from one side of a chassis to the other?"

"Oh, definitely," said Smithy. "And it also, of course, offers the low series inductance I've been talking about. With Band I and Band III TV tuner units you'll often find that some of the feed-throughs have low values, around 10 to 20pF or so. These will be used for the aerial input and i.f. output circuits, and their capacitance will form part of a pi-tuned circuit. These feed-throughs give a convenient means of providing input and output connections as well as offering capacitance to chassis. The remainder of the feed-throughs on a Band I —Band III tuner will be normal bypass components having values of the order of 1,000pF or so, and they will allow power supplies to be fed into the tuner as well. Sometimes, feed-throughs have connections made to one side of the centre pin only. This is because the designer merely wants to take advantage of the very low inductance they offer to chassis. More tea, please!"

Other Ceramic Capacitors

"What, *again*?"

"Of course," said Smithy firmly, holding out his mug. "I'm just about dehydrated, nattering away like this!"

Dick took Smithy's mug over to the sink once more.

"I suppose," he remarked, over his shoulder, "that the 1,000pF feed-throughs we've just been talking about will have high-K ceramic like the ordinary disc and tubular ones we spoke about earlier."

"They'll use ceramic having a high dielectric constant," agreed Smithy, "and they'll similarly exhibit pretty hefty changes in value with temperature."

"I find it rather fascinating," remarked Dick as he placed yet a further full mug of tea at Smithy's side, "to think that you can fit these ceramic capacitors to a tuner unit chassis before the other components. It's almost as though the capacitors were part of the hardware!"

"That's true enough," agreed Smithy. "Ceramic capacitors differ from other types because they can be taken up to soldering temperature. Also, they can be made in very simple basic shapes, which just require two lots of silvering to provide the capacitor plates, and it's possible to get a very wide range of capacitance values merely by choosing the grade of ceramic employed. I should mention next that there's another technique for fitting ceramic r.f. bypass capacitors, and you'll find this in u.h.f. tuners intended for Bands IV and V. In this case the capacitor is merely a flat disc with silvering on either surface, and one side is simply soldered direct to chassis. Connection is then made by soldering to the silvering on the other side. (Fig. 7). So far as keeping series inductance out of the bypass circuit is concerned, you couldn't get more basic than that!"

"I'll say," agreed Dick. "Incidentally, it's funny how these more unusual types of ceramic capacitors seem to be found mainly in TV tuners."

Smithy took an immense draught from his mug.

"That," he replied, lowering the mug to his bench, "is because TV tuners handle signals having much higher frequencies than any other item of domestic electronic equipment. TV tuner design is a specialised business, and it takes advantage of all the special shapes in which ceramic capacitors can be made. Talking about unusual applications, there's another type of ceramic capacitor which I should also tell you about."

"Is there?" replied Dick. What sort of capacitor is that?"

"It's a disc capacitor," said Smithy, "which can be soldered into a printed circuit board without any leads at all. The disc fits into a rectangular slot in the board, which has copper foil connectors coming right up to the slot on either side. (Fig. 8 (*a*)). When the whole assembly, with the capacitor in place, is passed through the solder bath at the factory, the solder bridges over, from the two pieces of copper foil, to the silvering on either side of the capacitor, whereupon the capacitor is well and truly soldered into circuit! (Fig. 8 (*b*)). The solder doesn't stick to the ceramic, of course, and so there's no risk of short-circuits. You'll find capacitors of this type in small printed circuit assemblies, a typical example being the isolating networks behind the coaxial aerial input sockets of TV receivers, in which case the capacitors provide the actual isolation. This is a method of assembly whose main advantage is the reduction of production costs."

Quick Visit

Yet again, Smithy tipped up his mug. Emptying it in one monstrous

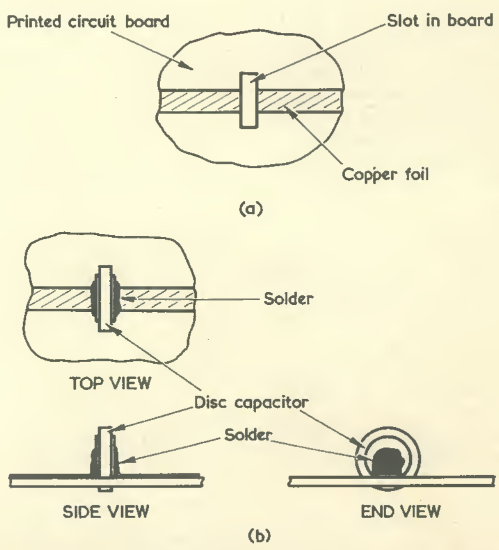


Fig. 8 (a). A portion of printed circuit board having a slot intended for a disc capacitor

(b). After soldering, the disc capacitor is reliably connected to the copper foil on either side of the slot

swallow he placed it, with a gesture of finality, on his bench.

"D'you want any more?"

"No, thanks," said Smithy, wiping his lips. "I think I've had enough tea now to carry me over for the next few hours."

"I should jolly well think so, too," commented Dick. "You've got through no less than four full mugs of it in the last quarter of an hour. Still I mustn't grumble, because it has at least fortified you for the little gen-session we've just had."

"Good show," said Smithy, "So far as the gen-session itself is concerned, what I mainly wanted to do was to demonstrate how the *shape* of a ceramic capacitor can be equally as important in practical circuit design as its capacitance, working voltage, and all the other factors which the designer has to keep in mind. The fact that the ceramic dielectric can stand up to soldering temperatures also enables this type of component to be used in some really interesting applications."

"I've just," said Dick, "got one question left."

"Fire away!"

"In the last few examples you mentioned," Dick pointed out, "the ceramic body is left bare and unprotected after soldering. Is that O.K.?"

"Oh, quite," replied Smithy. "For normal use, the ceramic and the silvering can be left uncovered so long as there is no risk of mechanical damage to it. Sometimes, however, the manufacturers put an extremely thin coating of protective material on ceramic bodies which are intended for automatic soldering processes. This coating doesn't upset the soldering but it remains in place after the soldering operation is finished, and it prevents possible tracking across the ceramic. This can occur in some circumstances. Whether or not a protective coating of this type is provided doesn't affect us so far as servicing is concerned, and all that we need to do is to be able to recognise the various types of ceramic capacitor and to know their performance and limitations."

Smithy stood up.

"And now," he remarked, "we must get back to work. But before doing that, I find I must pop out of the Workshop for a moment."

"What for?"

"For a transistor battery," grinned Smithy.

"What sort of battery?"

"A PP9," returned Smithy, as he firmly closed the Workshop door behind him.

Radio Topics

By Recorder

OLDER READERS MAY RECALL THE pickle that we got into with valves before the last war. There was, to start off with, a fairly wide range of valve bases in use at that time, these including the British 4-pin, 5-pin and 7-pin, the Philips side-contact, the International Octal and the Mazda Octal. The consequence of having all these pin and contact configurations was that many basic valve functions, such as that of the r.f. pentode, were duplicated in the different bases. There was also a great variety of different types, with individual manufacturers developing and producing their own particular and distinctive lines.

Our complaints at that time about the lack of standardisation in valve types were bitter and protracted. But what we would have said had we foreseen the conditions which exist at present in the transistor jungle just beggars description!

Transistor Quantities

Did you know that the number of transistor types available at present is well in excess of twelve thousand? *Twelve thousand!* And don't forget that this number is increasing all the time, as new types are designed, manufactured and introduced to the market.

With transistors we do not, of

course, have the old valveholder problem and, provided there is physical space for it, virtually any wire-ended transistor can be wired into any circuit. On the other hand, most circuits employing transistors are designed around specific types, and it is unwise to employ alternatives without first checking on *all* the relevant information concerning them. There are a lot of pitfalls for the unwary here, incidentally, including such frequently forgotten ratings as maximum reverse base-emitter voltage and the like, and these can often cause the would-be user of transistor alternatives to come seriously unstuck. So, in general, if one transistor type is specified for a particular design, then only that type should be used in circuits employing the design.

So far as I can see, the quantity of transistor types is going to increase over the next five years or so at about the same rate as has occurred up to now. This is because the transistor is still in the process of development and will appear in many improved forms before it arrives at its final ultimate stage. The valve, it should be noted, has virtually reached its ultimate development. The number of different low-power valve types employed in new equipment has, indeed, been *falling* for many years because valve-users are themselves tending to apply a form of standardisation by designing their circuits around a relatively small quantity of standard types. At the same time, very few new valves have been introduced. In the British entertainment field, for instance, virtually the only new valves appearing on the market recently are those intended specifically for colour television receivers, these being new vertical and field output valves, e.h.t. rectifiers and e.h.t. stabilising valves.

It is possible that the valve has had its condition of ultimate development forced upon it, since there is little point in improving it further when it is already being superseded by the obviously superior transistor. It could well be that the transistor will similarly have a condition of ultimate development imposed on it when it becomes superseded, in its turn, by the integrated circuit.

I would predict that, in about ten years time, the transistor will begin to settle down in an approximately final form and that the introduction of new types will have markedly decreased. Most of the small-signal transistors in this final version will have much smaller housings than those in use today and many will be simply plastic-encapsulated without any metal at all. The basic semiconductor material will be silicon. Also, at about this time, the vast array of different types in use will start to dwindle and transistor-users will, themselves, begin to concentrate on the more attractive transistors in the lists. The rest, being ignored, will fall into disuse and will eventually be looked upon as curiosities in the same way as we now look upon the old Pen 45 output valve on its Mazda Octal base.

There is one snag here. Who is going to supply replacements for all the transistors which have previously been made and fitted into equipment? Transistors become faulty much less frequently than do valves and do not inevitably "wear out". The valve replacement market is sufficiently large to make the manufacture of replacements a viable enterprise, but the same may not be true with transistors where the quantity of replacements could be too small for their manufacture to be profitable. It is possible that the industry, in introducing too many different transistor types, has unwittingly produced a stick for its own back as well.

However, apart from this one dismal point concerning replacement difficulties, the future position with transistor types may not be as chaotic as the present scene would lead one to imagine, and it seems very probable that there will eventually be an automatic stabilising and reduction of numbers in the ranks.

By that time, of course, we will just be starting to get worried over the proliferation of integrated circuits!

Wreckers On CB

In the United States, a topic which raises constant controversy is the Citizens Band facility which is available in that country. Citizens Band, incidentally, comprises 23 channels around 27 Mc/s and may be used by any licensed person having approved transmitting equipment with a maximum input to the final of 5 watts. No technical knowledge is required to obtain a licence and the service can be used for business, community work or, it appears, just gossip. It seems, unfortunately, that many users of the band exhibit a high degree of irresponsibility. And as is, sadly, so often the case in modern times, a few devote themselves entirely to wrecking the service at the expense of others who rely upon it.

A particularly fantastic story on this theme appears in the January issue of our American contemporary *Electronics Illustrated*. The article in question—"CB Nightmare In Indiana" by Robert M. Brown—describes conditions in Lake County, Indiana. It states that a bunch of hoodlums who call themselves "Master Control" go out of their way to jam the transmissions of anyone who upsets any of their number by using 250 watt carriers broadcasting obscene talk or endless music. Should they feel justified, they even break up the CB aerials of those they dislike.

The case which leaves the nastiest taste in the mouth concerns a serious automobile accident in which the two occupants, unable to leave their car, tried to summon help on their CB transmitter. But their signals were purposely jammed by the "Master Control" mob and they had to wait for a passerby who could call for an ambulance. The pair were on the critical list for 30 days after they eventually reached the hospital.

It would be nice to think that this sort of thing couldn't happen here. However, one has only to consider the moronic hooligans of our football fields to accept, with something of a sinking heart, that such behaviour could indeed take place if, instead of their toilet rolls and bottles, our own louts had access to equipment which could cause real distress to the community.

Binary Arithmetick

If you've been under the impression that binary arithmetic is an off-shoot of our present sophisticated Age of the Computer, be prepared for a shock. The mathematicians were playing around with binary 200 years ago.

This interesting little fact is one of many which appear in the Encyclopaedia Britannica First Edition Replica (published by Encyclopaedia Britannica International, Ltd., at £30). The Replica is an exact reproduction of the original first edition of this famous reference work. The first edition appeared in 1768, and the Replica has now been produced to mark the anniversary. Apart from devoting half a column to "Binary Arithmetick" that 200-year-old edition also included fourteen pages on the subject of "Electricity".

Ferrite Rod Null

We all know that, as we rotate a medium and long wave radio fitted with a ferrite rod aerial, we obtain two sharp nulls (i.e. states of minimum signal strength) on a received signal for receiver positions 180° apart. These nulls are, of course, due to the directional properties of the ferrite rod aerial.

Ask anyone who works with radio or electronics whether the null occurs when the rod is pointing at the transmitter or when it is broadside on and, in nine cases out of ten, he'll reply that it is the latter. But he'll be wrong. The ferrite rod aerial gives a null when the rod is *pointing towards* the transmitter.

The reason for this apparently inexplicable behaviour is that a ferrite rod aerial is really a loop aerial having a very small coil wound on a high permeability rod which concentrates the flux from a wide area. As with any loop, a null is then given when the loop (in this instance the ferrite rod coil) is broadside on to the transmitted signal. And the coil is broadside on to the signal when the rod points towards it.

It is sometimes difficult, incidentally, to prove this point by such expedients as coupling the r.f. output of a signal generator to a short vertical aerial and rotating a receiver with a ferrite rod aerial near this. Many medium and long wave receivers have relatively long internal wiring to the ferrite rod coils and the capacitive pick-up that results with a very close transmitting aerial causes the null points to be shifted. But the relationship should show up very definitely if the receiver is rotated whilst picking up a signal from a distant transmitter whose bearing is known.

Excess Electricity

And, finally, a little servicing story about the dear old lady who thought that the spot which remained on the centre of her TV screen after switching off was "due to the tube trying to use up all the electricity left in it".

She was dead right, you know!

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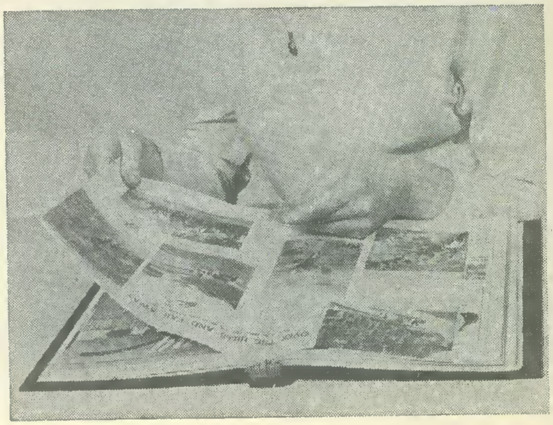

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