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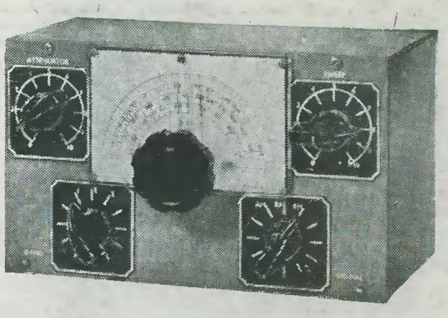

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TRANSISTOR COMPONENTS TEST SET

15p

VOLUME 13
NUMBER 11
JUNE
1960

The RADIO Constructor

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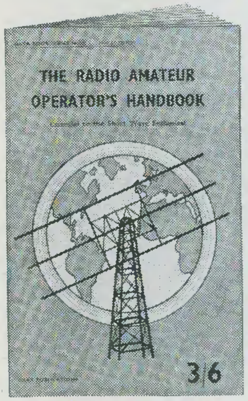

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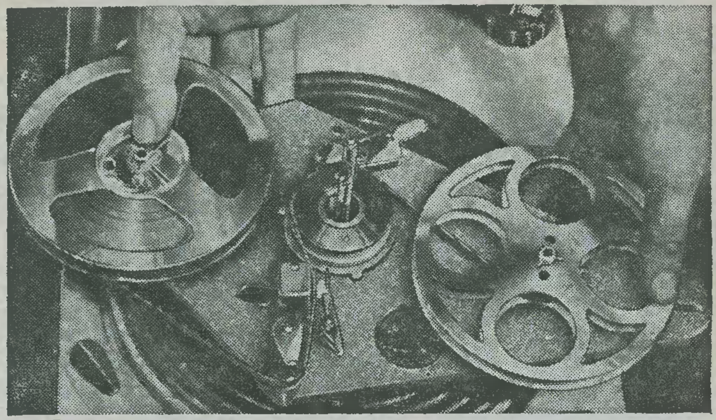

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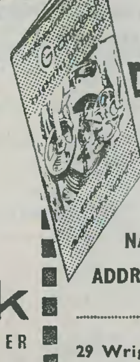

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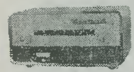

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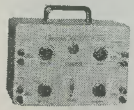

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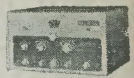

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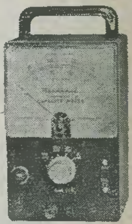

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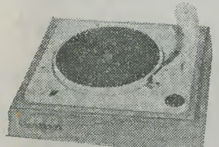

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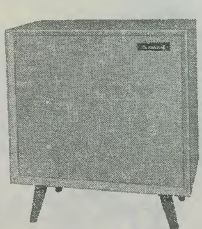

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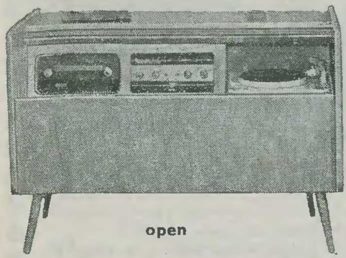

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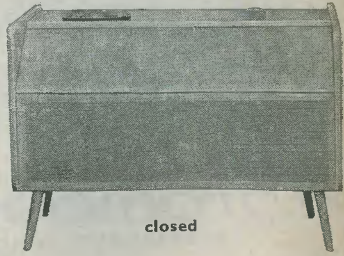

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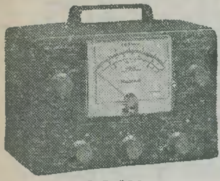
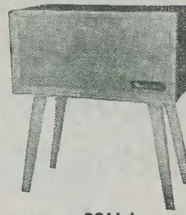
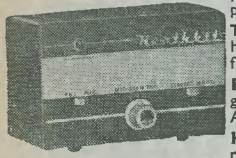


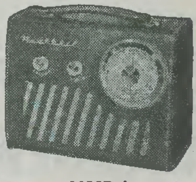
AG-9U



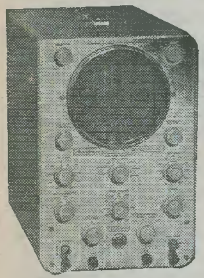
SSU-1



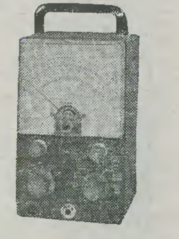
USP-1



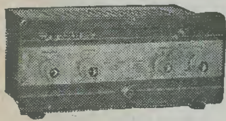
UXR-1



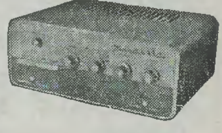
O-12U



V-7A



S-33



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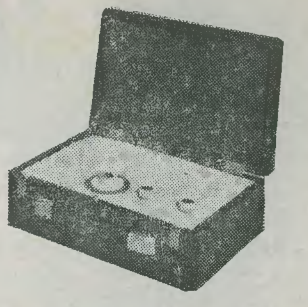

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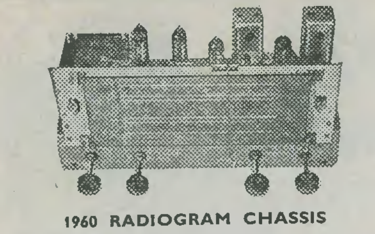

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1T4	6/–	6N7M	6/6	EB91	6/–	HABC80	12/6
2X2	3/6	6Q7G	8/6	EBC33	8/6	HVR2A	6/6
3S4	7/6	6SA7	6/–	EBC41	8/6	MU14	9/–
3V4	7/6	6SJ7M	6/6	EBF80	10/–	P61	3/6
5U4	7/6	6SN7	6/6	ECC84	9/6	PCC84	9/6
5Y3	7/6	6V6G	6/6	ECF80	9/6	PCF80	9/6
5Z4	9/6	6X4	7/6	ECH42	10/6	PCL82	11/6
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6BE6	7/6	12AT7	8/–	EF39	5/6	PL82	10/6
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6BW6	9/6	12AX7	8/–	EF50	5/6	PY81	9/6
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6F6	7/6	12K7	6/6	EF86	12/6	SP61	3/6
6H6	3/6	12Q7	6/6	EF92	5/6	UBC41	9/6
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6J7G	6/6	80	9/6	EL84	8/6	UL41	9/6
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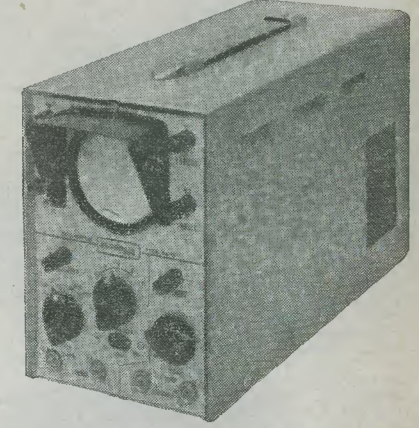

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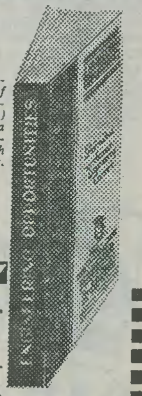

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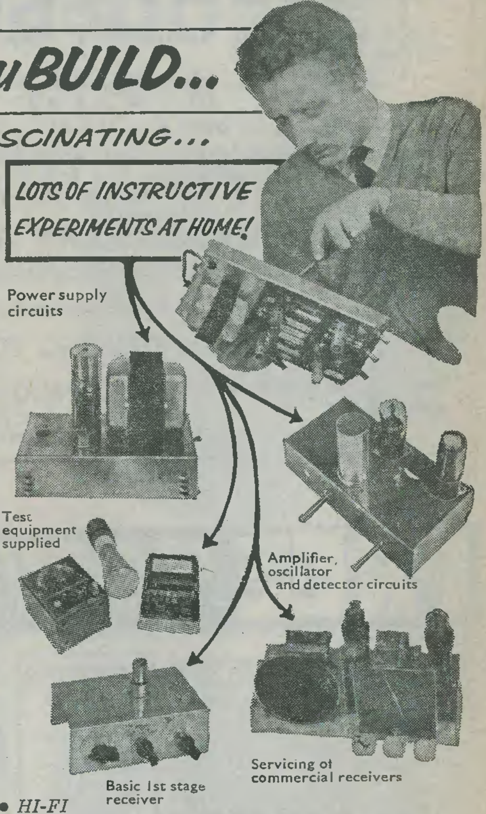

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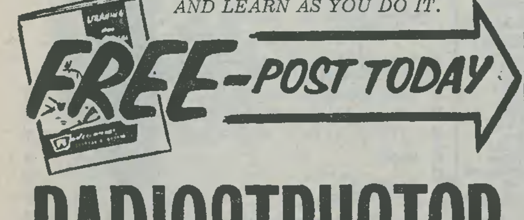

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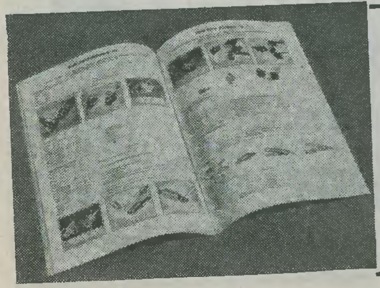

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CONTENTS FOR JUNE

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TRADE NEWS. Manufacturers, publishers, etc., are invited to submit samples or information of new products for review in this section.

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

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suggested circuits

No. 115 A Versatile Neon Test Unit

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

SMALL AND INEXPENSIVE ITEMS OF TEST equipment which may be slipped into the pocket are always of interest to the home-constructor and the service engineer. Such units, despite their simplicity, are frequently capable of diagnosing quite complex faults under field conditions, and they often provide facilities which would otherwise necessitate bench equipment.

A rather novel example of a pocket test unit is described in this month's contribution to the "Suggested Circuits" series. The unit employs a small neon bulb and is capable of carrying out a number of tests on all mains-driven and some battery receivers. To begin with, it can detect the presence of h.t. voltage in a circuit, thereby enabling quick checks of continuity in the h.t. wiring to be made. Secondly, it can indicate the presence of high voltage a.c., a facility which includes the identification of live or neutral mains conductors. It can detect, thirdly, the presence of e.h.t. voltage in a television receiver. Fourthly, it can test condensers for leakage; and, finally, it can provide an a.f. tone at two output levels for checking the a.f. stages of a receiver.

The Circuit

The circuit of the neon test unit appears in the accompanying diagram. As may be seen it consists of a neon bulb, together with various resistors and condensers. Connection into the circuit and selection of test function is carried out by plugging test leads into two, or three, of the five sockets shown.

It will be helpful, in describing the operation of the test unit, to commence with the last facility enumerated above, that of providing an a.f. tone at two output levels. In order to obtain the a.f. tone the "Chassis" socket on the unit should be connected to the chassis of the receiver under test, and the "Test 1" socket to its smoothed h.t. positive rail. The neon bulb should then become illuminated (at a low intensity), this indicating that the tone is being generated.

Under these conditions the h.t. supply of the receiver is applied to the neon bulb via the combined series resistance of R_1, R_2 and R_3 shunted by C_3. The circuit combination is that of a sawtooth generator whose running frequency is controlled by the value of the series resistance, the applied h.t. voltage, the characteristics of the neon, and the capacity of C_3. The values of R_1, R_2, R_3 and C_3 are such that, for all the varying h.t. voltages liable to be encountered, the frequency of the sawtooth generated lies between some 500 and 2,000 c/s. The amplitude of the sawtooth voltage built up across R_1, R_2 and R_3 in series is of the order of 24 volts, and approximately 4 volts appears across R_2 and R_3. Thus, an a.f. output having an amplitude of 4 volts appears at the "Tone-High" socket, this being obtained via the isolating condenser C_1. The voltage across R_3 is approximately 1/40 of that across R_2 and R_3 in series, with the result that a tone having an amplitude of approximately 0.1 volt is applied, via C_2, to the "Tone-Low" socket.

The "Tone-High" output is intended for connection, via a test lead, to the grid of the a.f. output valve of the receiver under test, whereupon the tone should be audible at good strength from the loudspeaker. In similar fashion, the "Tone-Low" output is intended for application to the grid of the preceding voltage amplifier, whereupon an output of approximately the same level should be heard from the loudspeaker. Due to the presence of the isolating condensers C_1 and C_2 it is, of course, possible to apply the a.f. output to points other than valve grids. A test lead from the "Tone-High" socket may, for instance, be applied to the anode preceding the output valve grid, whereupon a check of the efficiency of the coupling circuit is at once carried out.

In practice, the approximate tone amplitude voltages mentioned above at the two output sockets will drop when connection is made to the appropriate grid circuits in the receiver due to the presence of grid leaks, preceding anode loads, and similar components connected effectively between grid and chassis. The effect will be most pronounced when the high voltage output is used. A little experience will soon, however, show the results to be expected in an average receiver.

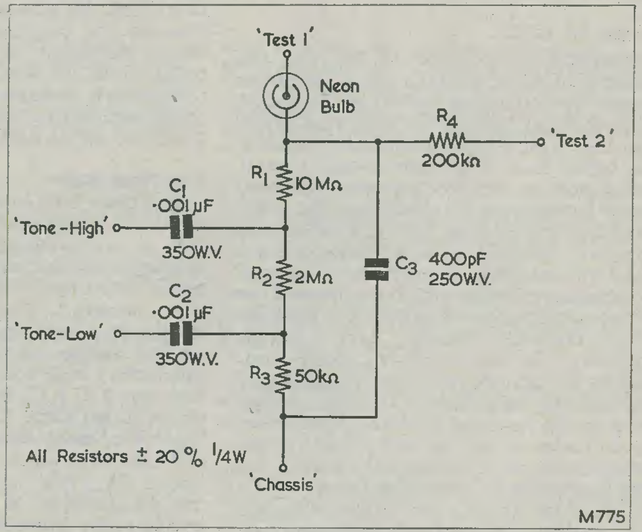


Fig. 1. Circuit of the Versatile Neon Test Unit, the various applications of which are fully discussed in the text

Voltage Tests

The series resistance needed to obtain satisfactory tone generation is considerably higher than that needed for bright illumination of the neon bulb. In consequence, tests for the presence of voltage are made by connecting test leads to the "Test 1" and "Test 2" sockets. With this method of connection the neon bulb is in series with the 200kΩ resistor, R_4, and the tone generation network is out of circuit.

When used to check for the presence of h.t. voltage the "Test 2" socket should be connected to chassis and the test lead from the "Test 1" socket applied to the h.t. points being tested. In many instances screen-grid and anode potentials will be above the striking voltage of the bulb, with the result that these points may be checked also. The unit may further be employed for checking a.c. voltages above chassis—these including mains input voltages in the case of a.c./d.c. receivers, and mains transformer h.t. secondary voltages in the case of receivers employing an isolated power supply. Because of this facility, it becomes possible to carry out such tests as ensuring that both anodes of a full-wave rectifier are receiving an a.c.supply. Other similar tests will readily occur to the reader.

When it is desired to test for the presence of a.c. mains voltage, the two leads from the "Test 1" and "Test 2" sockets should be applied across the supply points, whereupon the neon bulb will glow if voltage is present. Should it be desired to ascertain whether a chassis, or conductor, is at live or neutral potential, one test lead should be connected to earth and the other to the chassis or conductor being tested. A live connection will cause the neon bulb to become illuminated. When carrying out a test of this nature it is always advisable to check *both* mains points, whenever possible. The fact that the neon glows when connected to one of the points not only confirms that that point is live but also tests the neon bulb circuit and earth connection. The possibility of a live conductor being incorrectly assumed to be neutral, due to faulty test conditions, is thereby obviated. In practice, a large mass of metal having a reasonably high capacity to earth will frequently function as an "earth" when identifying live and neutral mains conductors; in this case both mains points *must* be checked to ascertain the reliability of the "earth".

Testing for E.H.T.

It should be possible to test for the presence of e.h.t. voltage in a television receiver by connecting the "Test 2" socket to chassis and holding an insulated probe from the "Test 1" socket close to the e.h.t. final anode lead. The neon should glow if e.h.t. is present. In some receivers, however, it may be necessary to disconnect the e.h.t. lead from the cathode ray tube before the neon bulb will glow in the presence of e.h.t. Under this condition, the neon bulb indicates the presence of pulses of e.h.t. voltage from the line output stage rather than the presence of a relatively steady e.h.t. voltage "smoothed" by the reservoir capacity provided by the cathode ray tube. The unit may also indicate the presence of high voltage pulses on the anode of the line output valve, and cathode of the booster diode, if the insulated test probe is brought close to the wires connecting to these electrodes.

It must be strongly emphasised that the tests outlined in the last paragraph are intended to indicate the presence of high voltage by means of electrostatic coupling only. *The test probe from the "Test 1" socket must never be connected directly to the cathode ray tube final anode, the line output valve anode, the booster diode cathode, or any similar high-voltage point in a television receiver, or damage will result.* The coupling to the neon tester is provided entirely by holding an insulated section of the test probe close to the insulation of the wires carrying the potentials being checked. **To avoid shock during tests for e.h.t. voltage, the test probe and its lead should be provided with insulation suitable for the potentials being checked.**

Testing Condensers

In order to check condensers for leakage, the "Test 1" socket should primarily be coupled to the smoothed h.t. positive rail of a receiver, after which the condenser to be tested is connected between the "Test 2" socket and chassis. Condensers having a capacity above 500pF or so will cause the neon to flash momentarily when they are connected. If the bulb continues to glow, or if it flashes intermittently after a condenser has been connected, the condenser possesses leakage resistance. A good condenser will cause only an initial momentary flash.[*]

Condensers having values below that which cause the momentary initial flash may also be checked with the tester. In this case, low leakage resistance will be indicated by a steady glow having the same intensity as would be given if the condenser were replaced by a fixed resistor having the same value as the leakage resistance. Since the effect of the condenser discharging through its own leakage resistance does not now occur (because the condenser does not receive a charge during an initial flash of the neon bulb), tests on low value condensers are considerably less sensitive than are tests on condensers having values sufficiently high to cause the initial flash.

The Neon Bulb

The neon bulb employed in the test unit should be a type having a small physical size and a low striking voltage. The writer checked a number of bulbs in the prototype circuit and found, so far as tone generation was concerned, that all gave satisfactory results at applied potentials ranging from striking voltage up to 400 volts. The leas satisfactory bulb for this particular application was a G.E.C. Button Tuneon, because this required some 180 volts striking potential. The most satisfactory bulb was an ex-W.D. type which struck at a voltage as low at 70. (With such a bulb the test unit may be employed to check battery receivers having h.t. potentials higher than this figure.) This last neon bulb consists of a glass tube just over an inch long and approximately ¼ inch in diameter, in which are fitted two straight electrodes. The bulb had two wire lead-outs and is of the type employed for voltage stabilisation in American surplus equipment.

Construction

As may be gathered from a consideration of the circuit, construction of the unit should involve few complications. Due to the high values of resistance used in the tone generation network, care has to be taken to minimise leakage between the various sockets. This requirement may, perhaps, be met more readily if the components are housed in a case made of insulating material rather than metal. A case made of insulating material has the further advantage that it may be placed in any convenient position close to, or on, a chassis under test without the risk of accidental short-circuits. The components needed are small in physical size. It may well be found that the front panel area will be that needed to accommodate the neon bulb and the five sockets, the depth being that dictated by the backward projection of the bulb. Three test leads fitted with suitable probes or clips will be required for use with the tester.

---

[*] Actually this is what would be given by a *perfect* condenser having infinite leakage resistance. Any practical condenser having a leakage resistance greater than that which results in a continual glow will cause a second flash to occur at some finite time after the initial flash. For normal radio applications leakage resistance will be satisfactorily high if no second flash occurs over a period of some 5 to 10 seconds after the initial flash.

Can Anyone help?

27 Mc/s Mains Operated Radio Control Receiver.—S. Adamson, 178 Victoria Avenue, Southend, wishes to buy a circuit for such a receiver using indirectly heated valves. No limitation to receiver size or number of valves but must be sensitive and stable. Only requirement is for the receiver to operate a 5,000Ω relay by means of h.t. current rise or fall.

* * *

Monitor Type 61.—F. Murray, 79 Albert Road, London, E.17, requires a circuit diagram and data to convert this unit into an oscilloscope—hire or purchase.

* * *

R109 Receiver.—R. Prowse, 5 Tresluggan Road, St. Budeaux, Plymouth, would like to contact any reader who has information on converting this receiver to a.c. mains operation.

* * *

Oscilloscope Type 43.—J. Tyblewski, 1 Grange Farm, Riseholm, Lincoln, would like to buy, borrow or hire, any circuit details or manual of this oscilloscope.

* * *

R107 Receiver.—J. A. Lush, 55 Edgcumbe Road, St. Austell, Cornwall, would like to obtain a copy of the service manual for this receiver. Any additional data would also be welcome.

* * *

Ex-Admiralty Receiver P104.—E. A. Humphries, 28 Adderley Road, Birmingham 8, has recently purchased this 14-valve receiver but cannot obtain any data or manual. Can any reader help?

* * *

Wearite 3AH Tape Deck/Mullard Type "C" Tape Amplifier.—J. N. Collis, 6 Garbett Road, Winnall, Winchester, is anxious to obtain information on matching these equipments and is willing to pay for help received.

* * *

Receiver Type CW-46048D.—R. W. Hilton, 8 Hogshill Lane, Cobham, Surrey, requires the circuit details of this receiver—part of the RU19 Aircraft Radio Equipment made by Western Electric Company. Also wanted are the set of 9 plug-in coils—or even single coils that readers may possess.

* * *

Ferguson 17in Model 506T.—D. J. Picton, 79 Hamperwill Lane, Oxhey, Watford, Herts., is in need of any information and the circuit diagram of this current commercial t.v. receiver.

* * *

Trix Audio Amplifier T633B.—C. Jackson, 54 New Street, Mold, Flints., requires any technical and/or performance data available particularly output impedances and rating. Would reimburse any expenses.

W/S No. 11 made by Aeronautical & General Instruments Co. Ltd.—A. C. Mee, 17 Wycliffe Road, Urmston, Manchester, would like to obtain the circuit or manual of this equipment. He is in possession of information on the following if any reader could assist—R1154, R1155, BC221F, together with some U.S. Radio Compass data.

* * *

Indicator Unit BC929A (U.S.A.).—J. K. Whiting, 19 Cromer Avenue, Grange Estate, Grimsby, Lincs., would be extremely grateful if any reader could supply him with modification details converting the above unit into an oscilloscope.

* * *

R206 Receiver and G73 Admiralty Wavemeter.—F. Whitehead, 91 Blackpool Road, Ansdell, Lytham St. Anne's, Lancs., requires the circuits, or handbooks, of these units on loan.

* * *

Eddystone S640 Receiver.—J. McKay, 8 Valley Road, Great Clacton, Essex, would like to buy or borrow the manual for this receiver.

* * *

Barker 888.—C. E. Chapman, 64 Oxford Close, Mitcham, Surrey, requires the circuit diagram of this receiver. Can offer circuit of the Barker 88 to anyone interested.

* * *

E.M.I. Institute's Superhet Kit RK32A.—W. Blackburn, 42 Yeading Court, Hayes, Middlesex, wishes to buy, borrow or hire, the circuit details of this receiver.

* * *

Peto-Scott "Trophy-8" Receiver.—E. Brown, 21 Rainbow Road, Canvey Island, Essex, urgently requires the circuit or handbook of this receiver.

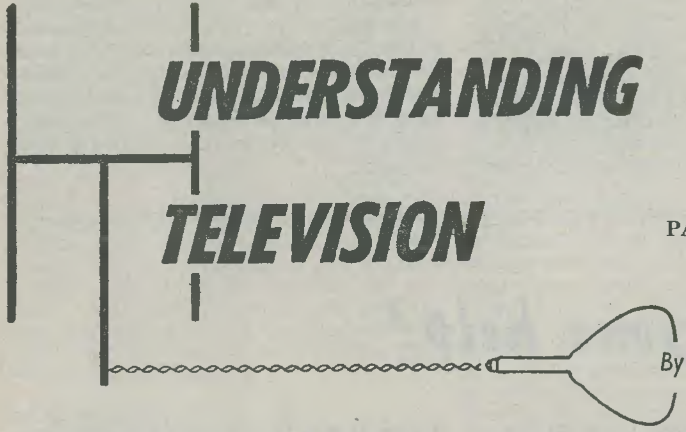
* * *

PCR2 Receiver.—T. E. Lewis, 5 Findern Green, Cardale Road, Nottingham, has obtained one of these receivers in which the coils have been modified to alter the coverage. Would like to receive any details on these coils, formers are numbered 78595 and 78601, in order that the original coverage may be restored. Information on the coil data, or where they may be purchased, would be greatly appreciated.

* * *

Test Set Type 73, Ref. 10SB/105.—F. L. Owen, 18 Cleveleys Road, Southport, Lancs., has obtained one of these units, which contains a VCR138A tube mains unit. The circuit or any other information on this unit would be most welcome.

UNDERSTANDING TELEVISION



PART 29

By **W. G. MORLEY**

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

In the last contribution to this series we dealt with methods of improving e.h.t. regulation, together with the various types of interference liable to be generated in the line output stage. We also covered the subject of width controls. In this article we shall carry on to line linearity controls and deflector coil assemblies.

Line Linearity Controls

Unlike the widely diverse width control arrangements employed in domestic television receivers, line linearity controls tend to fall into a small number of well-defined categories. These categories are as follows: controls which vary the current flowing in the booster diode reservoir condenser circuit at the beginning of the scan period, controls which provide a reactance in series with the line deflector coils which varies as the scan period progresses, and devices which vary the deflection efficiency of the line deflector coils during the scan period.

Fig. 170 illustrates a typical example of a linearity control which varies the current flowing in the booster diode reservoir condenser circuit. In this diagram the boosted h.t. reservoir condenser is effectively formed by two components, C_1 and C_2 these having values which are commensurate with each other. The linearity control is then inserted between the two. The linearity control consists of a coil having an adjustable ferrite core, with the result that it is capable of offering a varying inductance.

At the initial part of the line scan period, energy from the line output transformer is fed, via the booster diode, directly to C_2, and to C_1 through the linearity control. The rate at which energy flows into C_1 may be altered by adjusting the inductance of the linearity control. It becomes possible, therefore, to vary the speed at which current decay in the first part of the scan period takes place by adjusting the ferrite core of the coil, and a control of linearity is effected in consequence. It will be noted that this linearity control is capable of adjusting rate of change of deflection current only during the first part of the scan (that is, before change-over of deflection current direction). In practice, this is normally adequate enough, the linearity control being adjusted such that the rate of scanning on the left-hand side of the picture is approximately equal to that on the right-hand side.

A linearity control which inserts varying reactance in series with the line deflector coils, and which has been used much more frequently than that of Fig. 170, is illustrated in Fig. 171 (*a*). In Fig. 171 (*a*) we see a coil having a ferrite core in combination with a permanent bar magnet. Either the core, or the magnet, is capable of being moved relative to the other. In this particular control a strong magnetising force is deliberately applied to the core during part of the scan cycle in order to reduce the inductance of the coil. To ensure that the magnetising force has a marked effect on coil inductance it is usual to employ a core having relatively small dimensions, a diameter of ⅛in representing a typical practical figure. A damping resistor, to prevent ringing, is frequently connected across the coil.

It will be helpful, in explaining the operation of the assembly of Fig. 171 (*a*), to assume that, without linearity correction, the rate of current change in the line deflector coils during the first part of the scan period (before change-over of deflector coil current direction) is greater than that during the

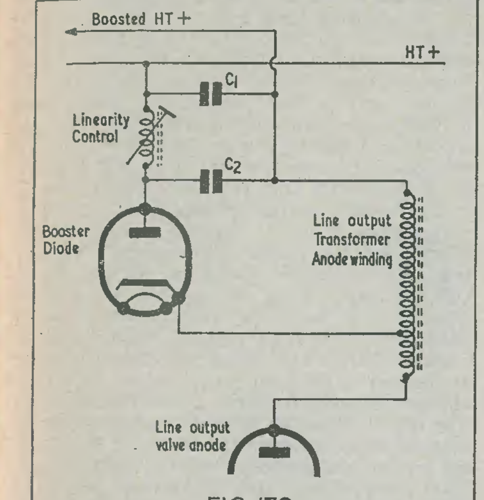


FIG. 170

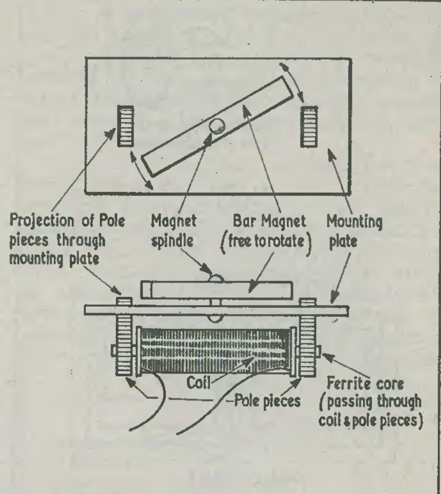


FIG. 171C

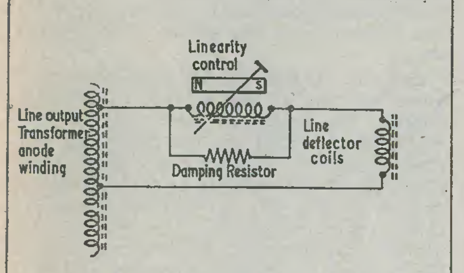


FIG. 171A

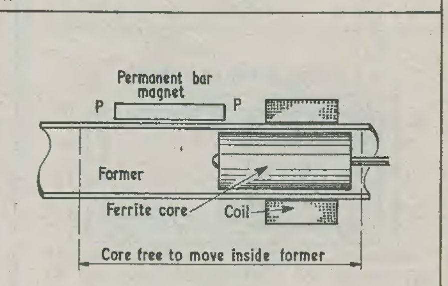


FIG. 171B

G.630

Fig. 170. *A line linearity control which varies the rate of current decay in the line output transformer anode winding during the first part of the scan period. The linearity control has an adjustable ferrite core, and is assembled in a similar manner to the width control of Fig.* 165 (*a*). (*Fig.* 165 (*a*) *appeared in last month's issue.*)

Fig. 171 (*a*) *The linearity control shown here offers a reactance in series with the line deflector coils which varies during the scan period. A low-value damping resistor is frequently connected across the coil to prevent ringing.* (*b*) *A typical method of assembly for the linearity control of* (*a*). *As the core moves out of the coil towards the magnet it becomes more and more subject to its magnetising force. The two magnet poles appear at points "P".* (*c*) *Another version of the linearity control. The pole-pieces are fitted to a mounting plate of non-magnetic material, such as brass. The magnetising force applied to the ferrite core is varied by rotating the magnet*

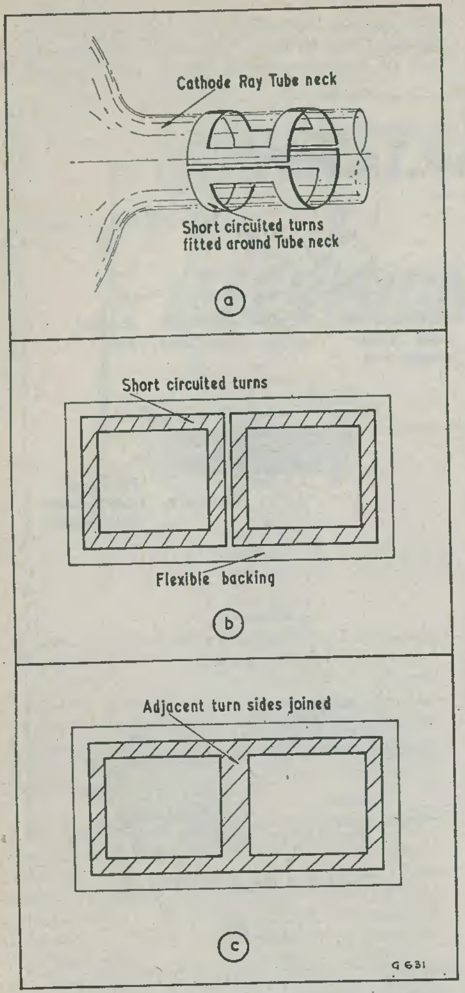


Fig. 172 (*a*) *A control of line linearity may be achieved by fitting two short-circuited turns to the cathode ray tube neck, as shown here. The deflector coil assembly is then fitted over these turns. The short-circuited turns generate a field which opposes that of the line deflector coils, the opposing field increasing as the rate of change of deflecting field increases.* (*b*) *The short-circuited turns consist of thin copper strip fitted to a flexible backing of insulating material.* (*c*) *To simplify manufacture it is usual to join the two adjacent sides of the turns*

second part. The visible effect on the cathode ray tube screen will then be that the left-hand side of the picture will appear to be "opened-out" horizontally, whilst the right-hand side will appear to be compressed. The linearity control coil and the magnet are positioned in relation to each other such that the magnetising force given by the current flowing through the coil, in the first part of the scan period, opposes the magnetising force provided by the magnet. In consequence only a low magnetising force is applied to the core, and the coil offers a high reactance. Approximately half-way along the scan period the current flowing through the line deflector coils reverses. The current in the linearity control reverses also, and the magnetising force it provides assists that offered by the permanent magnet. As a result the reactance offered by the linearity coil decreases. Thus we have the situation where, at the beginning of the scan period (when current changes rapidly), the linearity control offers a high series reactance whilst, at the end of the scan period (when current changes slowly), it offers a low reactance. The result is that the control counteracts the original effect, wherein the left-hand side of the picture was expanded and the right-hand side compressed. By adjustment of the relative positions of the core and magnet it is possible to vary the amount of compensation provided and, thereby, obtain acceptable line linearity over the whole of the picture width.

For the purpose of the explanation just given, we assumed that, without the linearity control, the left-hand side of the picture would be expanded and the right-hand side compressed. In practical line output stages this type of non-linearity is that which the control of Fig. 171 (*a*) is most frequently called upon to correct. The control can, however, compensate for the reverse state of affairs (right-hand side expanded and left-hand side compressed) merely by reversing the polarity of the magnet, or by reversing the connections to the coil.

Figs. 171 (*b*) and (*c*) illustrate two typical practical examples of the control assembly. In Fig. 171 (*b*) the ferrite core is free to move inside the former on which the coil is wound. As the core passes through the coil in the direction of the permanent bar magnet fitted to the former it becomes more and more subject to its magnetising force. Control of linearity, in this instance, is obtained by moving the core along the former. Fig. 171 (*c*) shows an assembly where the core is fixed between pole-pieces of magnetic material. The permanent bar magnet is free to rotate. Control of linearity is, this time, obtained by adjusting the position of the magnet relative to the pole-pieces.

A completely different type of line linearity control is shown in Fig. 172 (*a*). This device functions by varying the efficiency of the line deflector coils during the scan period, and it has been used extensively in recent years. The device consists basically of two "short-circuited turns" of copper strip which are inserted between the deflector coils and the cathode ray tube neck, the horizontal sections of the turns passing through the centre of the line deflection field. Currents are induced in the turns by the line deflector coils, with the result that they generate an opposing magnetic field. The inducted currents increase when the rate of change of magnetic field in which they exist increases; so that a rapidly changing deflection field causes a larger opposing field to be generated than does a slowly changing field. The short-circuited turns provide, therefore, opposing fields which compensate for varying rates of change of deflecting field, and a linearising action is achieved as a result.

In practical applications, the short-circuited turns are manufactured from thin copper strip mounted on a flexible backing of insulating material as in Fig. 172 (*b*). The flexible backing is then wrapped around the cathode ray tube neck and taped in place, causing the turns to take up the position shown in Fig. 172 (*a*). In order to simplify manufacture it is usual to join the two adjacent turn sides, as in Fig. 172 (*c*). Joining the two turns in this manner has no effect on the currents circulating in either.

The linearising action of the short-circuited turn device is capable of adjustment by moving it in and out of the space between the deflector coil assembly and the tube neck. Such an adjustment is, however, difficult to provide on a completely assembled receiver owing to the flimsy nature of the backing. It is usual, in consequence, to fit the short-circuited turns to the cathode ray tube with the aid of a positioning jig before the tube is fitted into the receiver, the positioning jig having been designed for optimum linearity with the particular run of receivers being manufactured.

Deflector Coil Assemblies

We have already discussed, in theoretical terms, the manner in which electromagnetic deflection of the electron beam inside the cathode ray tube takes place.[1] We saw that the vertical and horizontal deflection needed to cause the beam to trace out the complete television picture could be provided by two sets of electromagnets mounted on the neck of the tube. One set of electromagnets caused a vertical field to appear inside the neck of the cathode ray tube, and this provided horizontal deflection of the beam. The other set of electromagnets caused a horizontal field to appear, and this provided vertical deflection. Separate line and frame sawtooth currents from the line and frame output stages were fed through the coils of the electromagnets. The cathode ray tube beam, in consequence, was caused to trace out the scanning pattern applicable to the system in use. In a practical television receiver the two sets of electromagnets are combined together to form a single deflector coil assembly. We shall now deal in detail with this assembly.

Fig. 173 depicts the conditions inside the tube neck at the point where the deflecting magnetic fields are applied. This diagram illustrates the paths taken by a number of electrons as they approach the deflecting field. Electrons entering the field are subject to the forward-acting[2] accelerating force given by the highly positive final anode. On entering the field they suffer a deflecting force, in this case downwards. The directions in which the electrons travel vary gradually as they pass through the field, after which they proceed in a straight line once more. Fig. 173 demonstrates two points. Firstly, the paths of the electrons, although separate, are convergent when they enter the deflecting field. This is because the electron beam is intended to come to a focus at the screen of

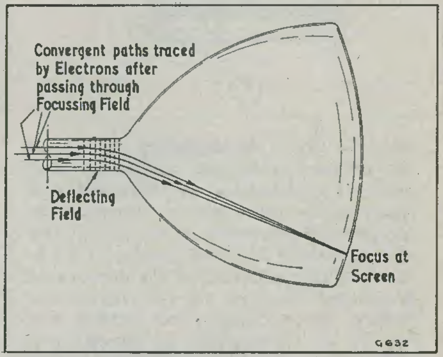


Fig. 173. *The deflecting field in the neck of the cathode ray tube has to provide equal amounts of deflection to the electrons which pass through it despite the fact that their paths are diverse. The electrons, as they enter the deflecting field, are already convergent, and a focus is finally achieved at the screen of the cathode ray tube. The focusing field referred to in the diagram may be either electrostatic or magnetic. The deflecting field is magnetic*

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[1] "Understanding Television", part 7, July 1958 issue.

[2] The term "forward", used here and later in this context, means "towards the cathode ray tube screen".

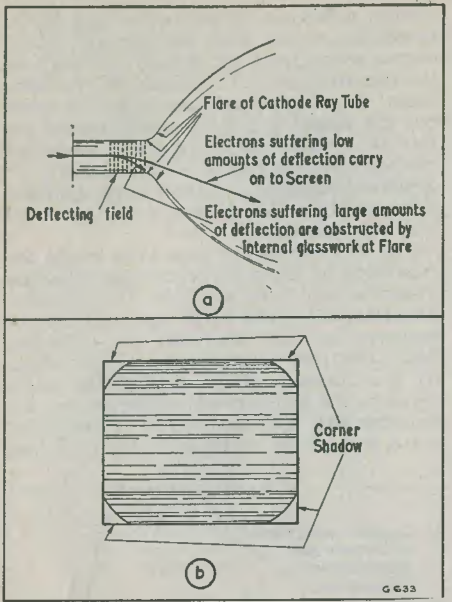


Fig. 174 (a) If the deflecting field is set too far back, electrons undergoing large amounts of deflection are prevented from reaching the screen due to obstruction by the internal glasswork at the flare. This effect is known as corner cutting. (b) The result of corner cutting is the appearance of corner shadow on the reproduced picture. In practice, corner shadow may not be as symmetrical as shown here, different corners showing differing degrees of shadow

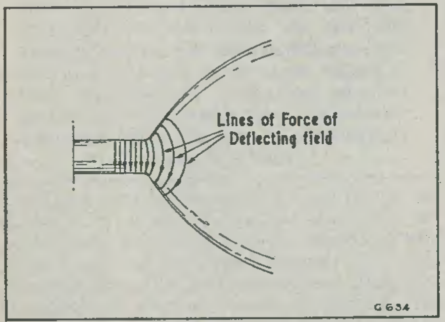


Fig. 175. In order to avoid corner cutting with cathode ray tubes having wide deflection angles, the deflecting fields are made to extend well into the cone

the cathode ray tube. Because of the separate paths it is necessary to ensure that all electrons passing through the deflecting field suffer an equal amount of deflection, or focus at the screen will not be achieved. In order to provide equal deflection, the deflector coils have to be designed such that all the electrons pass through a uniform field of equal strength. The second point illustrated by Fig. 173 is that the deflecting field has to be well forward. If the deflecting field is too far back, electrons which suffer heavy deflection will not reach the screen because of obstruction by the internal glasswork at the flare of the cathode ray tube. This effect is shown graphically in Fig. 174 (*a*).

Briefly returning to the two points we have just discussed, the condition wherein electrons following separate paths do not suffer equal deflection is referred to as *deflection defocusing*. The effect is more liable to occur for large amounts of deflection, with the result that deflection defocusing usually becomes apparent at the edges of the reproduced picture. The state of affairs depicted in Fig. 174 (*a*), wherein the more widely deflected electrons are unable to reach the screen is known as *corner cutting*. Corner cutting becomes evident on a reproduced picture as *corner shadow*, in the manner shown in Fig. 174 (*b*). It is possible to introduce corner cutting, even when this is not normally present in a particular combination of cathode ray tube and deflector coil assembly, by moving the assembly backwards, away from the screen. Since the deflecting field also moves backwards the state of affairs existing in Fig. 174 (*a*) results. This fact enables a measure of one aspect of deflector coil usefulness, known as *pull-back*, to be adduced. The term "pull-back" defines the distance a given deflector coil assembly fitted to a given cathode ray tube may be moved back from its fully forward position before corner cutting becomes evident, and it is expressed in inches or centimetres. (The term may also be applied as an estimate of performance to a cathode ray tube, whereupon it provides a measure of the freedom from internal obstruction at the flare, as checked by a "standard" deflector coil assembly.)

Currently manufactured cathode ray tubes have wide deflection angles and it is necessary for the line and frame fields of the associated deflector coil assemblies to be sited well forward if corner cutting is not to occur. The line deflection field must, especially, be well forward, as this has to provide the greater amount of deflection. In consequence, modern deflector coil assemblies have the line coils constructed in such a manner that the deflecting field extends well into the cone of the cathode ray tube, as shown in Fig. 175. The field inside the cone is inevitably curved and great care has to be taken during coil design to ensure that it is sufficiently uniform to avoid deflection defocusing or distortion of picture shape. Since the corner cutting problem is not so acute for frame deflection, it is usual in modern assemblies for the frame deflector coils to be positioned somewhat further back than the line deflector coils and for their fields to project less, consequently, into the cone.

Picture Shape Distortion

Before proceeding further we must now quickly review the different types of picture shape distortion which may be caused by faulty performance in a deflector coil assembly. The terms applied to the different types of distortion are referred to later.

Fig. 176 (*a*) illustrates *parallelogram distortion*. The fault here is obvious, it is due to the frame and line deflecting fields not being at right-angles to each other. *Trapezium distortion* is illustrated in Fig. 176 (*b*). In this particular example, the bottom of the picture is wider than the top, and the fault is that the line deflecting field is not regular; it offering greater deflection over the path followed by electrons which travel downwards. Trapezium distortion covers any form of picture distortion where two sides (either horizontal or vertical) are parallel and one of the remaining sides is longer than the other. Fig. 176 (*c*) illustrates *pincushion distortion* and Fig. 176 (*d*) *barrel distortion*, both terms defining, in manifest fashion, the departure from straightness of the four edges. The terms "pincushion" and "barrel" are sometimes used to describe the case where one, two, or three, of the picture edges are curved, the remaining edge or edges being straight. Thus, the raster of Fig. 176 (*e*) could be described as having "pincushion distortion on its top edge and barrel distortion on its right-hand side".

Practical Deflector Coil Assemblies

In practical deflector coil assemblies it is desirable for the frame and line coils to provide a high deflection efficiency (i.e. ability to convert deflection current to deflection field), so that power output requirements from the frame and line output stages may be kept to a low value. It is especially desirable to conserve line output stage power, with the result that it is normal

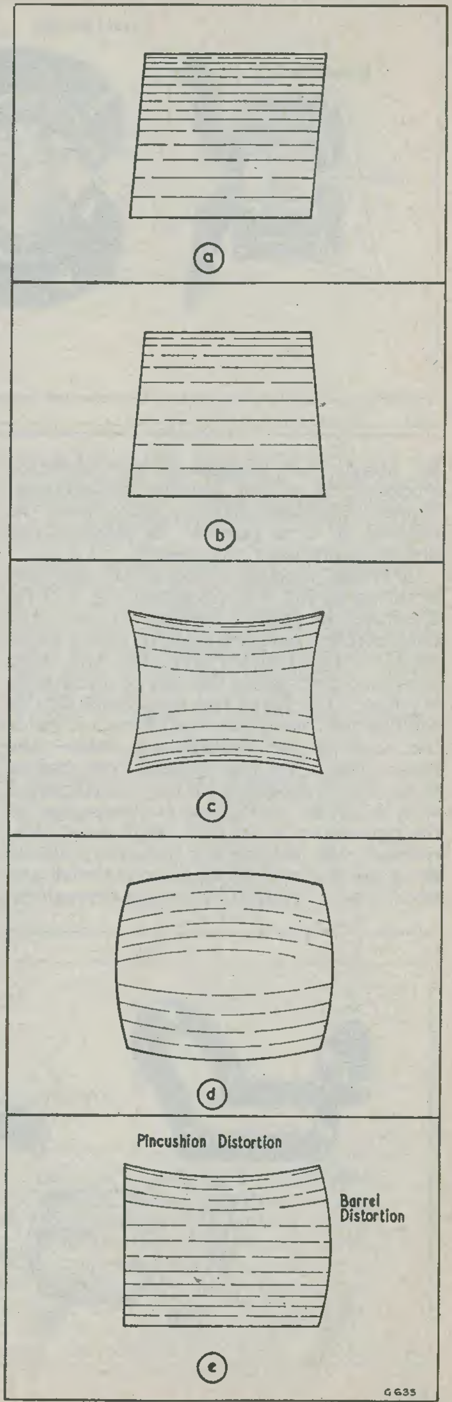


Fig. 176. Various types of picture shape distortion. (a) Parallelogram distortion. (b) Trapezium distortion. (c) Pincushion distortion: (d) Barrel distortion. (e) A combination of pincushion and barrel distortion

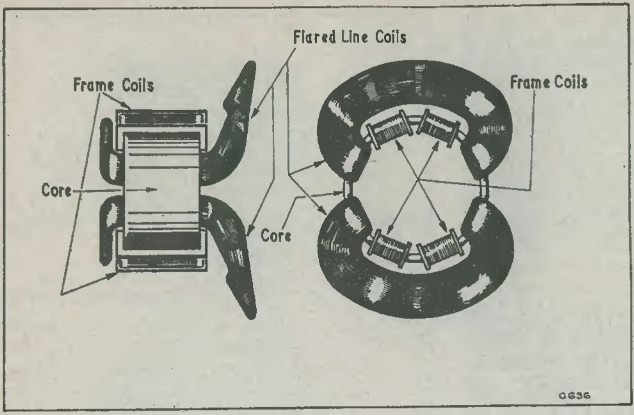


Fig. 177 (a) A modern deflector coil assembly. The parts shown here would be finally secured by a circular outside clamp concentric with the core. Each frame coil in the diagram consists of two windings on adjacent formers.

to design for maximum line deflector efficiency as a first priority requirement. Frame deflection efficiency may, even, be reduced if it is possible to increase line deflection efficiency as a result.

A typical modern deflector coil assembly is shown in Fig. 177 (*a*) whilst Fig. 177 (*b*) illustrates its main component parts. The line deflection coils are made to have a flared shape at their forward ends, the flare being such as to nest against the flare of the cathode ray tube. The flared line coils cause part of the line field to appear, well forward, inside the cone of the cathode ray tube. The functioning of the line deflector coils may be more readily understood if they are compared with the poles of a simple electromagnet, of the type shown in Fig. 178. Both the electromagnet coils and the line deflector coils are fitted inside a ring of magnetic material, and both cause a vertical field to pass through the centre of the assembly. The construction of the line deflector coils causes the ring of magnetic material to closely approach the neck of the tube, thereby increasing the deflection efficiency. The two line deflector coils are connected in a mutually-aiding manner, in just the same way as are the coils of the electromagnet.

The frame deflector coils function in a different manner. These coils are wound direct on the ring of magnetic material (or are wound on formers which are fitted to the ring) and they are connected up such that their fields oppose each other in the magnetic circuit offered by the ring. The effect is shown in Fig. 179 (*a*). The opposing fields in the ring cause a magnetic field to appear in the manner illustrated in the diagram, this field being stronger inside the ring due to the shorter air path.

A different approach to explaining the functioning of the frame deflector coils may be made with the aid of Figs. 179 (*b*) and (*c*). In Fig. 179 (*b*) we have two bar electromagnets which are joined together at their ends by pieces of magnetic material and which are energised such that North-seeking poles appear at their upper ends. The resultant external field is, effectively, similar to that which would be given by a single bar electromagnet. If the two magnets are separated, as in Fig. 179 (*c*) their ends being joined together by two longer pieces of magnetic material, the effect will still be the same except that most of the field will now appear inside the assembly, where the air path is shorter. The arrangement of Fig. 179 (*c*) is equivalent to the frame coil assembly of Fig. 179 (*a*).

After having examined the manner in which line and frame coils operate, we may now see that the complete deflector coil assembly of Fig. 177 (*a*) has its line and frame coils so dispositioned that the field from the line coils inside the assembly is vertical whilst that of the frame coils is horizontal. This is, of course, the combination required.

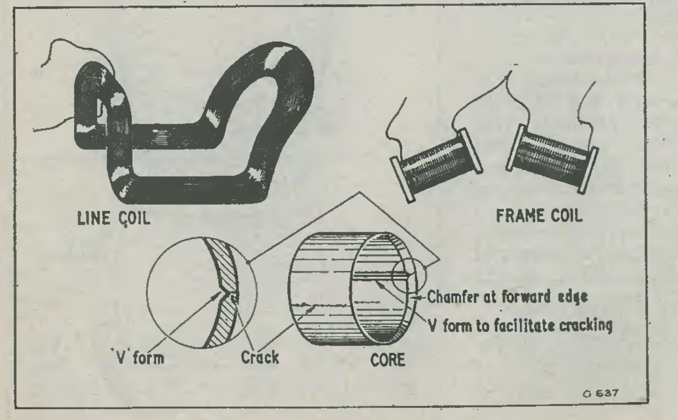
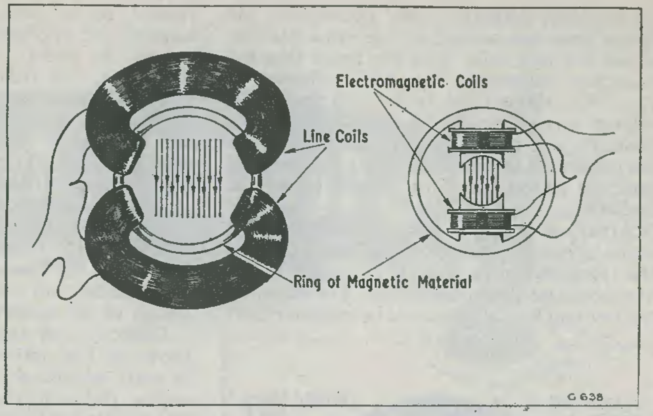


Fig. 177 (b). The individual parts of the assembly of (a). The crack and V-form in the core are explained when core materials are discussed.

Fig. 178. The action of the line deflector coils shown on the left is very similar to that of the simple electromagnet assembly on the right. In both cases a vertical magnetic field is produced



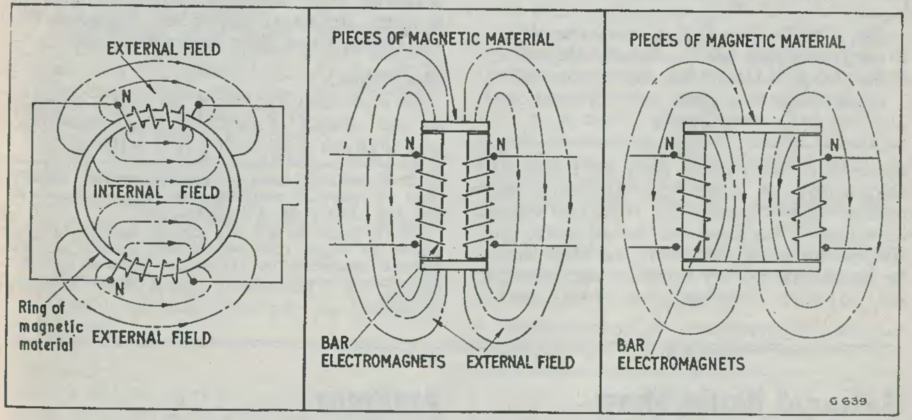


Fig. 179 (a) The frame deflection coils are connected so that their fields oppose each other in the magnetic circuit offered by the ring. In consequence, external and internal fields are formed. Due to the shorter air path the internal field is stronger than the external field. The letter "N" in the diagram indicates a north-seeking pole. (b) and (c) An alternative method of explaining the functioning of the frame coils. If two bar electromagnets, as shown in (b), are energised such that North-seeking poles appear at their upper ends the resultant field is similar to that of a single bar magnet. If the bar magnets are then separated, as in (c), both an external and an internal field appear, the internal field being stronger due to the shorter air path. The assembly of (c) is equivalent to that of (a)

In some deflector coil assemblies, the frame coils are wound in the same manner as are the line coils, with the result that the assembly takes up the form shown in Fig. 180, wherein the frame and line fields appear at right-angles to each other. In a deflector coil of this nature, the frame coils are connected in mutually-aiding manner and function in just the same manner as do the line coils.

Attention has to be paid in the design and manufacture of deflector coil assemblies of the types shown in Figs. 177 (*a*) and 180 to avoid picture shape distortion. For instance, the line and frame coils must be symmetrically opposed to each other both physically and electrically, or trapezium distortion may result. Ideally, both coils of a pair should have exactly the same number of turns, their shapes should be identical, and they should be positioned exactly opposite each other in the assembly. In practice, ideal results cannot be achieved, and close tolerances have to be applied to these three requirements. In order to prevent parallelogram distortion, the frame and line coils must, also, be so positioned, relative to each other, that their fields are at 90 degrees. This point, and the three previous requirements, are usually satisfied by paying close attention during manufacture to accurate winding and assembly, the latter normally being carried out with the aid of positioning jigs. Pincushion and barrel distortion are most frequently the result of incorrect shaping of flared coils, and are taken up in the initial design of the assembly.

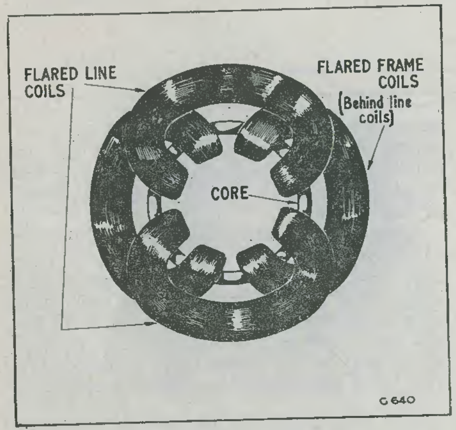


Fig. 180. *In some deflector coil assemblies the frame coils are wound and shaped in the same way as the line coils. This diagram gives a front view of such an assembly*

Deflector coil assemblies of the basic type shown in Fig. 180 were used for many years in early television receivers where deflection angles did not exceed 70 degrees.[3] The introduction of cathode ray tubes having scanning angles of 90 degrees was mainly responsible for the use of the alternative assembly of Fig. 177 (*a*), wherein the fact that flared frame coils are removed from the assembly both ensures that more space is provided for the line coils and that the ring of magnetic material may be moved further forward. There is also the fact that the design of Fig. 177 (*a*) eliminates two flared coils, together with the manufacturing difficulties inevitable with windings of this shape.[4] The size of the flared sections of the deflector coils of Figs. 177 (*a*) and 180 increases roughly in porportion to the scanning angle required. The line coils in modern deflector assemblies intended for 110 degree tubes have very wide flares.

Next Month

In next month's article we shall conclude on the subject of deflector coil assemblies, and shall carry on to the sync separator.

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[3] Such coils did not, however, necessarily employ rings of magnetic material such as that shown in Fig. 180. This point is discussed later.

[4] With some current 110 degree deflection coils, where the frame coils are wound directly on the magnetic material, this advantage is offset by the difficulties of accurate positioning of the coils during winding.

National Radio Show

The annual National Radio and Television Exhibition, sponsored by the British Radio Equipment Manufacturers' Association, is again to be held at Earl's Court, London, from 24th August to 3rd September.

Amateur Television Convention

The British Amateur Television Club is holding its fifth Amateur Television Convention at the Conway Hall, London, W.C.1, on Saturday 10th September.

Amateur Convention

After a lapse of some years, the Radio Society of Great Britain is organising a National Convention to be held in Cambridge from 15th to 17th September. J. A. Ratcliffe, of the Cavendish Laboratory, and Martin Ryle, professor of radio astronomy at Cambridge University, will be among the speakers. Further information may be obtained from the Convention secretary, Howard Waton, G3GGJ, "Arkengarthdale", New Road, Barton, Cambridge.

IN YOUR WORKSHOP

This month Smithy the Serviceman and his able assistant Dick ponder some of the more practical applications of simple trigonometry

"PETER HAS", REMARKED DICK, BREAKING a silence which had lasted for some ten minutes, "been here playing billiards before Paul."

Smithy the Serviceman looked up from his after-lunch crossword puzzle.

"I beg your pardon."

"I was thinking out loud," said Dick. "Incidentally, do you ever get any prizes for solving those crosswords?"

"I endeavour to complete the crossword each day," replied Smithy with dignity, "purely for the satisfaction of successfully pitting my brains against the compiler. What's all this about billiards?"

"But aren't there *any* prizes?"

"They give out book tokens, so far as I know. Why did you come out with that curious statement just now?"

"It's not worthwhile doing a crossword just for book tokens."

"Books are very valuable things," said Smithy pompously. "Indeed, the entire compass of human knowledge is contained in books."

Mnemonic

Dick did not respond to this remark and, in the ensuing silence, Smithy returned to his puzzle. However, after a few minutes in which he obviously found it impossible to concentrate, he put his pencil down on the bench beside him with a bang.

"For pity's sake", he exploded. "What on earth did you mean by that extraordinary sentence you just uttered? I've always accepted the fact that your mental processes are completely divergent from those of normal people, but statements about billiards coming completely out of thin air baffle even me."

"Well," said Dick. "It was a sentence we used at school for memorising trigonometry relations. You know, sines and tangents and things. And I thought about it because I stumbled across some of my old school exercise books last night."

"I see," remarked Smithy slowly. "How does your sentence work?"

"Oh, it's quite easy," said Dick, picking up Smithy's pencil. "The capital letters of the sentence come to PH, BH, PB, BP. And these stand for sine, cosine, tan. and cot."

"That's rather good," remarked Smithy, impressed despite himself. "By PH you mean Perpendicular over Hypotenuse, which is equal to sine, and so on."

"That's right. Rather a good idea, isn't it?"

"I think it is," conceded Smithy, returning

TABLE

A simple method of memorising trigonometry relations

Peter Has	$\frac{\text{Perpendicular}}{\text{Hypotenuse}}$	= Sine
Been Here	$\frac{\text{Base}}{\text{Hypotenuse}}$	= Cosine
Playing Billiards	$\frac{\text{Perpendicular}}{\text{Base}}$	= Tangent
Before Paul	$\frac{\text{Base}}{\text{Perpendicular}}$	= Cotangent

to his normal self now that the problem of Dick's utterance had been solved. "You tend to forget these relations as you get older, and an *aide-memoire* like that can be surpringly useful."

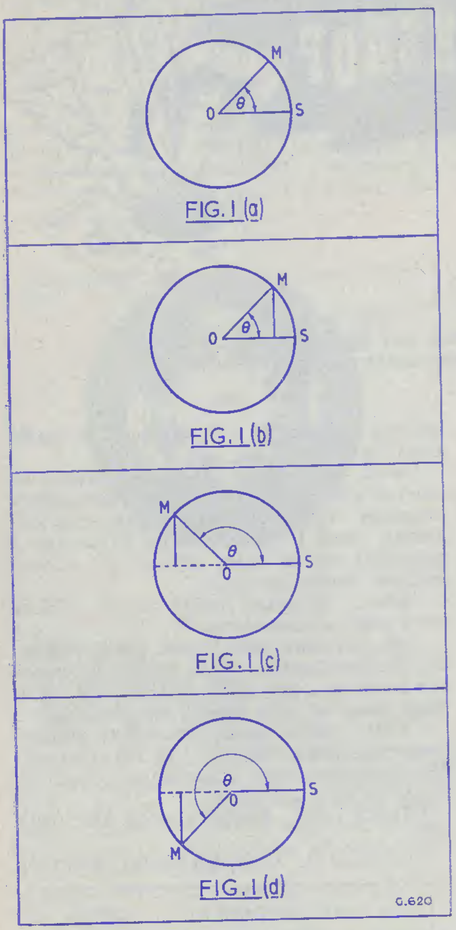


FIG. 1 (a)

FIG. 1 (b)

FIG. 1 (c)

FIG. 1 (d)

Fig. 1 (*a*) *A circle in which radius OS is stationary and in which another, OM, is free to rotate.* (*b*) *The height of M above OS may be indicated by a perpendicular from OS.* (*c*) *The same applies when θ is greater than* 90 *degrees.* (*d*) *The result of having θ lie between* 180 *and* 270 *degrees.*

"*Aide-memoire*?"

"Well, a mnemonic, then."

"Come again?"

"Mnemonic. M.N.E.M.O.N.I.C."

"Oh," said Dick, doubtfully. "Well, anyway, we used that sentence at school to remind us of trig relations."

"And very good, too," replied Smithy, abandoning all hopes of enriching his assistant's vocabulary. "I might add that I'm glad you're interested in trig because it can be of considerable help to you in your electronic work."

"What, trig? We're service engineers, Smithy, not atomic physicists!"

"A service engineer encounters things all the time which introduce trig relationships," replied Smithy. "For instance, what does your signal genny give you?"

"When it's been thumped a couple of times", replied Dick, "it gives me sine wave r.f."

"Trust *you* to let your signal genny get into that state," commented Smithy. "Now, what do the mains sockets at the back of your bench give you?"

"If *you've* paid the electric light bill," retorted Dick, "240 volts a.c."

"And the waveform?"

"Reputedly sine wave."

"Exactly," said Smithy. "So here you have, immediately, two sources of supply, one r.f. and one 50 c/s, and both are sine waves. Why?"

"I suppose", said Dick, "it's because it's the purest sort of waveform you can get. I mean to say, a sine wave contains the fundamental frequency only."

"I don't think much of that for an explanation," commented Smithy uncharitably. "*Why* is it such a pure waveform? Come to that, why is it *called* a sine wave?"

Dick fell silent for a moment and contemplated.

"Quite honestly", he replied eventually, "I'm not too certain why it *is* so pure. Also, I've never really queried in my own mind why it's called a sine wave, either. Wait a minute, though—I'm beginning to get an idea! Now, it's usual to divide a cycle into 360 degrees. Could it be that the amplitude of a sine wave varies as the sine of the angle as you go through the cycle?"

"You're spot-on," said Smithy approvingly. He recovered his pencil from his assistant. "Look, I've give you a little bit of basic insight into the whole sine wave business. Let's first of all draw a circle. (Fig. 1 (*a*).) In that circle we'll put a stationary radius and another which is free to rotate around the centre. We'll call the stationary radius OS, and the moving radius OM. Fair enough?"

"O.K."

Smithy glanced suspiciously at his assistant.

"The angle", he carried on, "between OS and OM we'll call theta."

Smithy inserted the symbol θ on his sketch.

"The height of point M", continued Smithy, "above the line OS is obviously going to vary as the radius moves round. *You* tell *me* a way of expressing that height."

"When you say height above OS", said Dick, "I presume you mean the height perpendicular to OS." Smithy nodded approvingly. "Well, if we draw in a line representing that height (Fig. 1 (*b*)) we get a right-angled triangle. Whereupon the height line becomes the perpendicular and the radius the hypotenuse. So, it's easy, height over radius is equal to the sine of θ."

"Fine," said Smithy. "What happens if we make the angle greater than 90°? Like this. (Fig. 1 (*c*).)"

"The same applies," said Dick. "Because you can still talk about the height of point M above line OS. What you do is draw OS out a bit over to the left and add your height line again. And you still get height over radius being equal to sine θ."

Fig. 1 (*e*) *If the height of M above OS is plotted on a linear scale, the result is a sine wave*

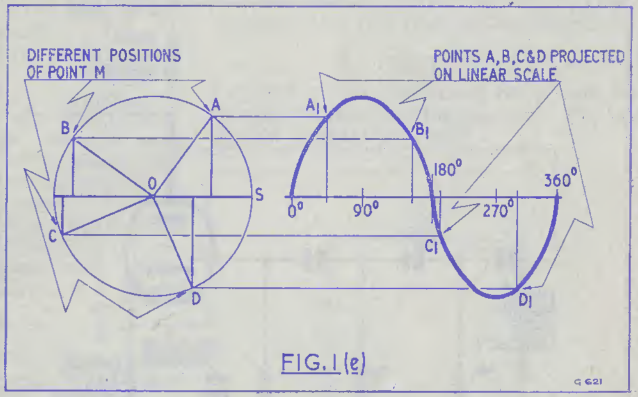


FIG. 1 (e)

"Good boy," said Smithy, drawing in yet another line. (Fig. 1 (*d*).) "Now what about this one?"

"Ah, you've gone over the top here," said Dick, "but the sine relationship still holds true. What happens here is that the sine goes negative because the sines of all angles between 180 and 360 degrees are always negative."

"You're in very good form today," remarked Smithy.

"There are occasional moments," remarked Dick, modestly, "when my transcendental genius shines through."

"Then, let's apply your genius to the last little step," said Smithy. "Because, what I'm going to do now (Fig. 1 (*e*)) is to draw a straight line alongside the circle and divide it into divisions ranging from 0 to 360. And I'm then going to draw in points indicating the heights of M above OS at the divisions which correspond to the angles of θ."

"I'm with you."

"Now", continued Smithy, "if I draw in enough points I'm going to end up with a continuous line which, I think you'll agree, has a very familiar shape."

"A sine wave, no less," remarked Dick. "Now this *is* interesting. The point you're making is that what a sine wave really consists of is a point tracing out a circle at regular speed."

"You're dead right," confirmed Smithy. "If you had a pen tied to the rim of a rotating wheel and it was allowed to mark a moving piece of paper passing beneath it, it would trace out a sine wave in exactly the manner we've got used to seeing it depicted in."

"I'm beginning to understand a few other points now," remarked Dick. "For one thing, you could hardly have a motion any simpler or more fundamental than a spot tracing out a circle. So that explains why a sine wave is considered to be such a pure and fundamental waveshape. It also explains why, when you do calculations with sine waves, you always have to divide the cycle into 360 degrees. This being because the sine wave is, in actual fact, the result of rotation in a circle."

"You've got it," agreed Smithy. "If you can remember the circular rotation concept when you go into a.c. theory, it helps you a terriffic lot in understanding the various equations and things you have to work with. I think there's one further little point we should clear up so far as my little sketches are concerned. You may remember that we said that the height of M above S divided by the radius was equal to sine θ. Now, whatever the size of θ, the radius will always be the same length, so we can say that the height of M over S varies as the sine of θ."

"That fact," remarked Dick, "also covers the second part of the cycle, where the waveform goes below the line because, between 180 and 360 degrees, the sine goes negative. Reversal of sine of the angle causes a reversal of polarity of the a.c. Dear me, we *are* stumbling on some basic theory here!"

Phase Shift

"Take it easy," chuckled Smithy. "All we're doing is discussing some of the really fundamental stuff which so often gets glossed over. Anyway," he added, glancing at the clock, "it's about time we got our noses down to the grindstone."

"Aw, shucks," grumbled Dick. "Just as things were beginning to get interesting! It isn't often", he added plaintively, "that we have a gen sesh on basic stuff like this, you know."

"I suppose not," conceded Smithy. "So perhaps you can apply a bit of your knowledge of basic stuff to practical use. Such an exercise would also bring home the fact that you have to use trig every now and again, even in our job. I've been wanting a simple 1,000 c/s a.f. oscillator in the workshop for some time, so perhaps you could spend the first part of this afternoon knocking one up."

Dick looked a little glum.

"There's *nothing* extra special in making an a.f. oscillator," he protested. "You just find any old a.f. tranny, couple it up to a valve with some sort of feedback circuit, and slap capacity across it till it ackles at 1,000 c/s."

"We're going to aim a little higher this afternoon," pronounced Smithy. "I want you to make the oscillator a phase shift type."

Dick looked a little disconcerted.

"I'm not quite certain," he confessed, after a moment's thought, "how to set about that."

"Oh!" said Smithy. "Well, O.K. then; it's pretty simple in practice. All a phase shift a.f. oscillator consists of is a valve with three phase shifting filters coupling the anode back to the grid. (Fig. 2.) The phase shift filters all have the same value of capacity and resistance, and each shifts the phase of the frequency you select by 60 degrees. The last resistor is, also, the grid leak of the valve."

"What about the anode load resistor?"

"It doesn't enter into the phase shift operation to any significant amount."

"Well, it certainly *seems* to be a simple enough circuit. In fact I would say it's simpler to build up than the sort of thing I was thinking of just now. Does the valve *have* to be a pentode, as you've sketched?"

"Not necessarily," remarked Smithy. "It's just that I've always used pentodes myself on the few occasions when I've knocked up phase shift oscillators. You should get away O.K. with a triode."

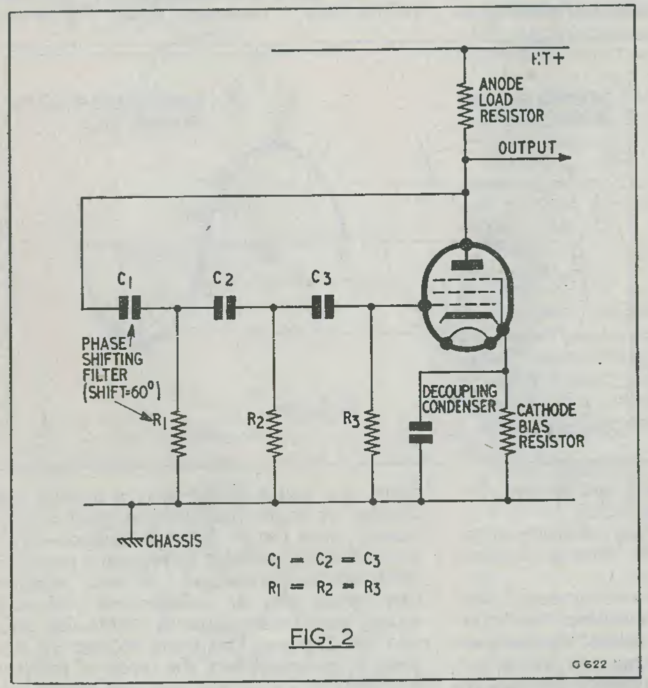


FIG. 2

Fig. 2. The basic phase shift a.f. oscillator

"How about using one section of a 12AU7?"

"No harm in trying," replied Smithy, reaching for the valve manual. "Let's see what the manufacturers recommend for a 12AU7 triode.* Here we are: operation of the 12AU7 as a resistance coupled amplifier. What the manual says is that, for an anode supply voltage of 250, the anode load resistor should be 100kΩ and the cathode bias resistor 3kΩ. That's two of the resistors in your oscillator worked out for you already! All you've got to do is to calculate the capacity and resistance needed in the phase shift bit."

"I would appreciate", said Dick meekly, "ever such a teeny-weeny bit of help there."

"How much do you want?"

"Well, I'd like you to work it all out for me!"

Smithy chuckled.

"O.K.", he said, "I'll get you started, anyway. Now, since the capacity and resistance in each section of the phase shift network are identical, all we have to do is to work out the values for one."

"And that," chimed in Dick, "has to offer 60 degrees phase shift at 1,000 c/s."

"Correct. Now the phase shift angle, which we'll call θ once more, for a simple RC filter like this (Fig. 3) is $\tan^{-1}\frac{Xc}{R}$."

"Which", commented Dick, "has got me poleaxed right from the start! What's this —1 business after the tan?"

"It's a convention," explained Smithy. "If the tan of θ happened to be x, we could express this, using the convention, by saying that $\theta=\tan^{-1}x$. That's all there is to it."

"Fair enough," said Dick. "So we can now say:

$$\tan\theta=\frac{Xc}{R}.$$

We know that θ is 60 degrees because that's the phase shift we want, so we can next say:

$$\tan 60°=\frac{Xc}{R}."$$

"Right, now have a look in your diary and tell me what tan 60° is."

"All my diary tells me", replied Dick promptly, "is the Close Season for Hunting, Shooting and Fishing (Rod and Line), together with a map of London Underground."

Smithy sighed and threw a reference book at his assistant.

"Ah," said Dick, "here it is! Tan 60 degrees is 1.7321. So we now have

$$1.7321=\frac{Xc}{R}."$$

"Right. Now what is Xc?"

"Xc", replied Dick, "is the reactance of a condenser and is equal to $\frac{1}{2\pi fC}$. This makes the equation

$$1.7321=\frac{1}{2\pi fCR}.$$

See Aug. 60, p24.

Do you think we ought to get the C and R out, Smithy? They're getting a bit cluttered up!"

"It wouldn't hurt," replied Smithy. "We'll bring them over to the left and put the 1.7321 on the right. That gives us:

$$CR=\frac{\cancel{1}}{\cancel{1.7321} \times 2\pi f}. \quad \frac{1}{2\sqrt{6}\pi f}$$

We know that f=1,000, so we now get:

$$CR=\frac{\cancel{1}}{\cancel{1.7321 \times 2{,}000\pi}} = 6.4 . 10^{-5}$$

I think our next step should be to work out the right-hand side of the equation. You can do that little bit yourself."

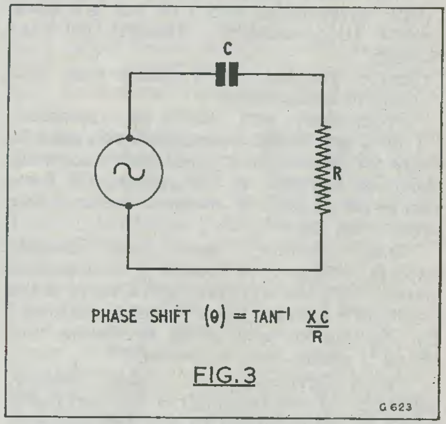


FIG. 3

Fig. 3. One of the phase shift filters of Fig. 2

Smithy watched as Dick grappled with his calculations.

"I make the right-hand side," said Dick triumphantly, after some ten minutes' feverish work, "0.00009~~18854~~, correct to ten places of decimals!"

"Well," said Smithy, maintaining a straight face, "I think, for the accuracy we require here, we will bring that down to 0.0000~~92~~ 64 straightaway."

Smithy affected to ignore the look of anguish in his assistant's face as he crossed off the superfluous figures.

---

* The figures which are given here and later in this article are taken from the *Brimar Valve and Teletube Manual No. 8*, published by Standard Telephones and Cables Ltd.

"Right," continued Smithy, "we can now state that, for each section of the filter:

$$CR = 0.0000\cancel{92}64$$

C being in farads and R in ohms. Or, if you like, microfarads and megohms. It'll make it easier, perhaps, if we multiply up by a million, whereupon the product of CR, measured in picafarads and megohms becomes ~~92~~." 64

"It looks", said Dick, "as though the next thing we have to do is to plump for a figure in capacity or resistance and work the other one out against it. Would 100pF and ~~92~~640kΩ cope for one section of our filter?"

"Perfectly," said Smithy. "The product of 100, in pF, and 0.~~92~~640, in MΩ, is ~~92~~64, which is what we want. Unfortunately, I haven't anything very close to ~~92~~640kΩ in stock."

"200pF and 460kΩ?"

Smithy got up and looked at the spares cupboard.

"We're out of luck there, too, I'm afraid. 470kΩ would be a close enough preferred value to 460kΩ, but I just don't have any. And I've only got two 200pFs anyway."

"500pF and 184kΩ?"

"Ah, that's better. I've got plenty of 500pF silver-micas, and I've *just* got three 180kΩ 10% resistors. Those'll be near enough."

0·02 μF
3·2kΩ
or
200pF
320kΩ,
etc.

Smithy handed the resistors and condensers to his assistant.

"Well, there you are," he remarked. "You've got all the components you need to make up the oscillator, and there's some ali sheet for a chassis in the corner. I'll leave you to get on with it whilst I tackle a few jobs of my own."

"O.K., Smithy," said Dick, already happily engaged in planning component layout. "By the way, how will I know if the oscillator's working when I've got it finished? By shorting the grid down to chassis and seeing if anode current goes up?"

"Good gracious, no," said Smithy, shocked. "There shouldn't be any leaky-grid action in the oscillator to give you an effect like that. The valve just acts as a straightforward a.f. amplifier having cathode bias, and it should take more or less the same anode current when it's oscillating as when it's not. When you've finished the oscillator, I would suggest that you couple its anode via something like 0.001μF to a receiver volume control, whereupon you'll hear the tone from the speaker. I should keep the volume control turned down when you start, as you'll be pumping quite a few a.f. volts into it."

Dick touched his forehead and then his chest with the tips of his right hand to signify submission to his master's requirements, and went enthusiastically to work. The grinning Serviceman turned and retired to his own bench, there to ponder the mysteries of a television receiver with an intermittent fault in its gated a.g.c. line.

Construction and Final Test

The entire progress of the construction of Dick's little oscillator could be followed aurally by anyone who knew his habits. There was first of all the heavy breathing which signified intense concentration as he cut out with tin shears the piece of metal which was to form the chassis. Then the "Ouch" as he cut his finger on the rough edge thereby formed. (All chassis manufactured by Dick had bloodstains on them somewhere.) Next came the piercing and nerve-rending rasp of a file drawn over the edges to smooth them off. Relative quietness, punctuated by more heavy breathing, denoted the scribing of lines along which the chassis would be bent; to be followed by the exultant hammering, with the aid of a piece of wood, of the chassis as he completed the bending process between two pieces of angle iron in the vice. This last action was carried out to the rhythm of a loud and strangely dissonant whistled rendering of the *Anvil Chorus* from *Il Trovatore*. Next came the centre-popping of holes and the energetic operation of the hand electric drill. There was a final triumphant application of the Q-Max chassis-cutter for the valveholder hole, after which the first part of the performance came to an end.

Act II was less exuberant in execution, and it depicted the diligent worker closely crouched over his labours. It opened with the busy chatter of screwdriver and box spanner as Dick bolted his components to the chassis, interrupted occasionally by the shaking-up of a tin of nuts and bolts whenever the size he wanted was not available on the top layer. Heavy engineering then took place for a short while as Dick drilled out two holes he had forgotten previously. This was followed by the busy snip-snip of his cutters as wiring proceeded, a process which sometimes included the sizzle of the soldering iron as it was applied to various joints (and once to the skin of Dick's left hand). Lastly, to signify the completion of wiring up, there was the forceful clatter of tools being thumped on the bench together with a sigh of intense satisfaction.

After quickly examining his wounds, washing his hands and replacing the grubby handkerchief on his cut finger with a piece of Elastoplast (the consumption of Elastoplast in the Workshop was always at its highest during Dick's more creative periods), Dick coupled his oscillator up to a source of power and connected its output to the volume control of an adjacent receiver on his bench. Finally, he inserted a 12AU7, after which he switched on and watched its heaters warm up.

Nothing further happened.

Dismayed, Dick switched off again and checked his connections. Everything seemed to be correct, and he switched on again.

Still nothing happened.

Dick turned his chassis over and, with power on, checked the applied h.t. This voltage was perfectly satisfactory and there was, also, a voltage on the anode of the oscillator triode, together with a bias voltage on the cathode. Disconsolately, Dick turned the chassis right way up again and sat glaring at the valve. Despairingly, he tapped its envelope.

There came a slight microphonic ringing from the nearby receiver loudspeaker. But nothing else.

Although Smithy had, by now, become almost entirely engrossed in his intermittent fault, the complete silence which suddenly enveloped the Workshop warned him that something was amiss.

"How's it going?" he called out.

"It won't work," replied Dick, dismally. "I've checked the wiring and power supply and everything seems perfect."

"Hmm," said Smithy, "try another bottle."

Dick located another 12AU7 and plugged it into his chassis.

"Still no good."

"Blast it," said Smithy. "Perhaps there isn't enough gain in a triode after all."

It wasn't often that the Serviceman expressed annoyance on matters of this nature, and his assistant didn't help things.

"Don't say," he complained, "that I've got to change my wiring over to a pentode after all that work!"

"I don't know what to say yet," grunted Smithy shortly. "Try a 12AT7 in your chassis. It's got the same pin connections as a 12AU7 and it'll plug into the same base. It should give a little more stage gain than the 12AU7."

"We haven't got any 12AT7's," said Dick disgruntledly as he looked in the valve cupboard.

"An ECC81, then," growled Smithy. "It's the same valve."

"Ah, we've got a few of them," said Dick, snatching up a valve and plugging it in.

Smithy had now completely forgotten his faulty television receiver. Both he and Dick waited impatiently for the ECC81 to warm up.

"Still no joy," said Dick.

"As you say," remarked Smithy, in a tone almost as gloomy as that of his assistant, "no joy. All I've got left to suggest is a 12AX7. This will, again, plug into the same valveholder."

"What's its E number?" asked Dick at the valve cupboard.

"ECC83."

Dick located a valve and fitted it into the oscillator chassis. He and Smithy sat, with expressions of the deepest gloom, waiting for the valve to warm up.

All of a sudden an ear-splitting 1,000 c/s tone became audible from the receiver loudspeaker. At once, the expressions of the two changed into ecstatic smiles and, for several moments, they made no attempt to talk as the deafening noise filled the room. Eventually, Dick turned down the receiver volume control so that the sound became a subdued murmur.

"Well," said Dick, with intense gratification. "It worked O.K. in the end, didn't it?"

But Smithy had returned to his valve manual.

"Ah, yes," he remarked musingly after a moment. "I should have recommended using a 12AX7 in the first place. For 250 volts h.t. it gives a stage gain of 60 as against one of 12 only with the 12AU7. And you need a fairly high stage gain to overcome the loss in the phase-shift network. Dear me, I should have thought of that in the first place!"

"Not to worry," said Dick. "We don't hold self-criticism sessions in this country. Not yet, anyway! Should I change the anode load and cathode resistor for the 12AX7?"

"Only the anode load resistor," said Smithy, consulting his manual. "For the stage gain of 60 I've just mentioned the anode load should be 250kΩ. The cathode bias resistor stays the same, at 3kΩ. Incidentally, I noted that the frequency of the tone varied very slightly as you turned the volume down just now, so it may be that variations in an external circuit connected direct to the anode may alter operation. So put in a new anode load consisting of a 200kΩ and a 50kΩ in series, or something of that order. Put the 50kΩ at the h.t. end and tap the output from the junction of the two resistors. That should isolate the external circuit reasonably well."

Before Smithy had finished speaking, Dick had already snipped out the 100kΩ anode load resistor which was already fitted. He soon soldered in the two new resistors, after which he tried the now-finalised oscillator. (Fig. 4.) It worked perfectly.

However, a new query had arisen in Dick's mind.

"Smithy", he remarked. "How is it that you remembered those double-triode equivalents so easily?"

"Well," replied the Serviceman, "so far as the three types we were playing with just now are concerned, it's very easy. An ECC81 is the same as a 12AT7, an ECC82 the same as a 12AU7, and an ECC83 the same as a 12AX7. The numbers go up in numerical

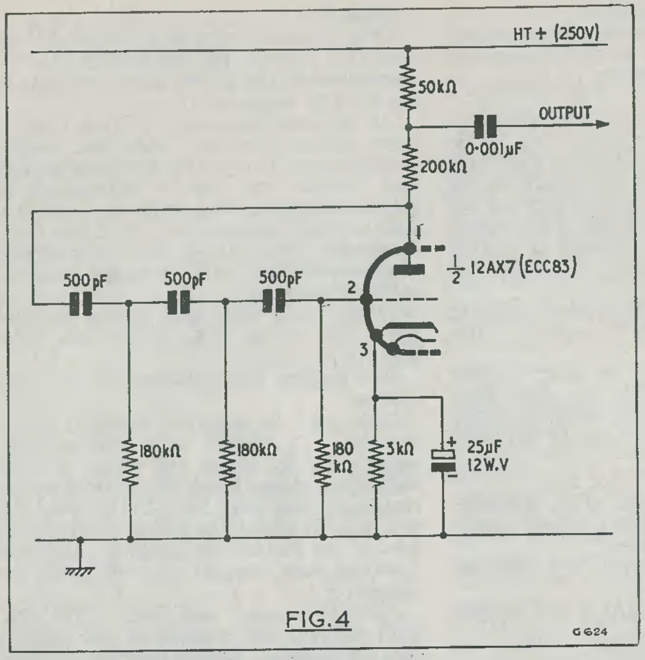


FIG.4

Fig. 4. The 1,000 c/s (nominal) phase shift oscillator finally evolved by Dick and Smithy. The output connection is taken from part of the anode load instead of direct from the anode in order to reduce the effects of external circuitry on oscillator operation. The cathode decoupling condenser is shown here as 25µF, but any value above 10µF should be adequate

order, and the letters T, U and X follow each other in alphabetical order."

"I see," said Dick. "Like my 'Peter has' thing, it's a reminder."

"It is", said Smithy firmly, "a mnemonic."

Find the Area

Dick returned to the subject of the oscillator.

"Well, there's one thing I've learnt this afternoon," he remarked. "And that is that trig can be jolly useful, even to a geyser like myself."

"I'm glad you've realised that," remarked Smithy. "In fact, I'll pass on a little problem to you that involves a bit of trig, and which you might like to have a stab at in your spare time. You start off by drawing a square having a side of 1 inch. With a centre at each corner and a radius of 1 inch you then draw four arcs within the square. (Fig. 5.) These four arcs enclose a four-sided figure —with curved sides—in the centre of the square, which I'm now shading in."

"Things look simple enough so far," commented Dick.

"And so they are," chuckled Smithy. "Now what I want you to do is to find the area of the shaded bit."

"Do you need much maths for this?" asked Dick.

"Only the ability to read and understand trig tables. Plus", replied Smithy, "a little elementary geometry. But don't start to work on it now because this is definitely a spare time exercise. I'll give you the answer next time we meet."

Fig. 5. Smithy's problem. Draw a square of side 1 inch and, with corners as centres, draw four arcs, with radius 1 inch, inside the square. Find the area of the shaded section enclosed by the arcs

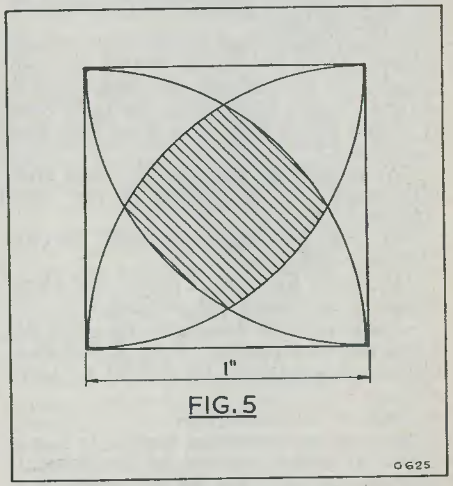


FIG.5

The SUPER LITON

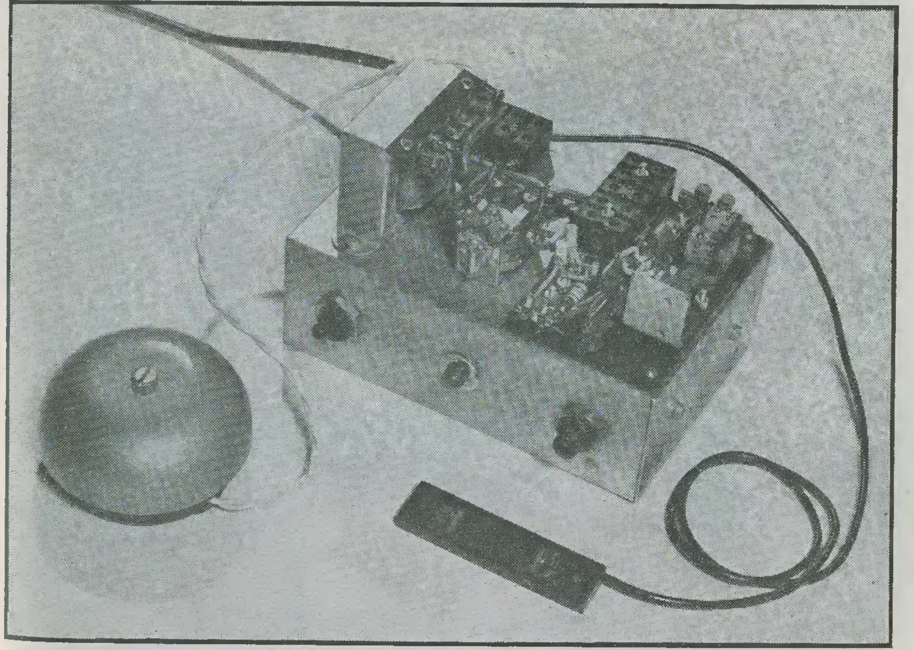
PHOTO-ELECTRIC MAINS OPERATED SWITCH

Described by J. M. Ankers

THE FUNCTIONING OF A PHOTOELECTRIC switch depends entirely on the correct adjustment of the relay.

Failure to operate properly is nearly always traced to a faulty or an incorrectly set relay which should be adjusted to suit the circuit. The collector current in our case varies between 1mA, when the photocell is in darkness, and 6mA, when it is brightly illuminated. It is obvious that the relay must be adjusted to work within this current range, making an allowance for possible variations in transistor characteristics. It has been found from experience that the most reliable operation is obtained if the relay pulls and releases at 4mA and 2mA respectively. A small variation of ±0.5mA does not seem to upset the operation.

Before any adjustment is attempted, one must make sure that the armature rests squarely on the pole-pieces and is completely free to move between the fixed contacts. If the gap in the magnetic circuit is too large it will not be possible for the armature to



Above chassis view of the mains operated switch together with the photo-electric cell and alarm bell

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remain attracted at lower current values.

To obtain an indication of the current flowing through the relay, a milliameter set to a suitable range, is inserted between the collector and the energising coils. An instrument in this position is well protected against burning out through an accidental short circuit during adjustment. The adjustment should be carried out in the following manner.

Place the photocell near a strong light source, such as an electric light bulb. Illumination can be conveniently varied by covering the photocell, gradually, with an opaque object. If the photocell is uncovered, the armature will be attracted towards the electromagnet. Unscrew the fixed contact screw about 3in until the armature touches the pole-pieces.

Adjust the other fixed contact screw 1in to obtain a gap of about .004in between the fixed and moving contacts. If no slip gauge is available a £1 note, which is approximately .004in thick, can be used as a rough guide.

Reduce the collector current to about 1–1.5mA by partially covering the photocell, this will cause the relay to release. Uncover the cell gradually until the current rises to 4mA

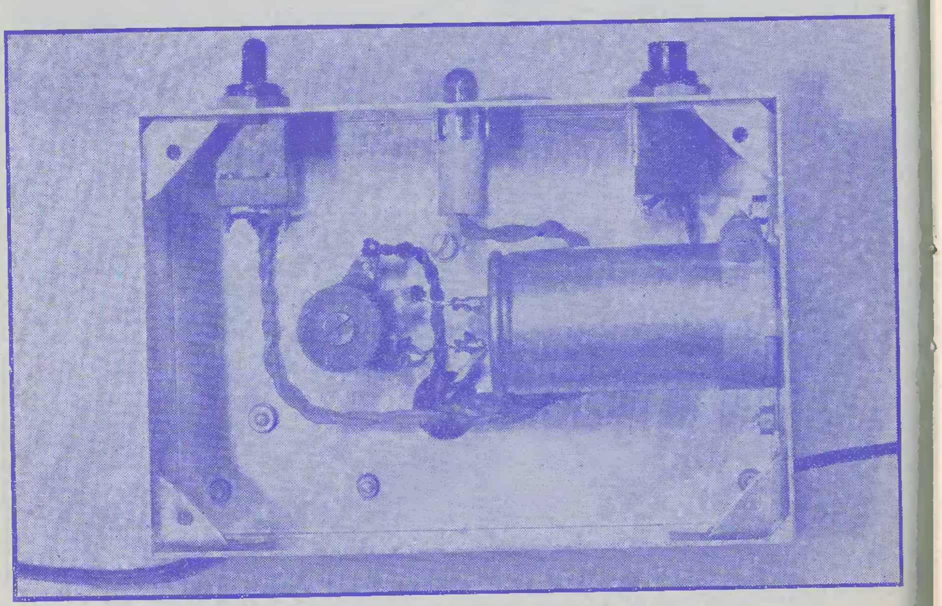
The relay should pull at about 4mA. If it does not, the armature spring tension must be reduced by turning the screw "K" in an anti-clockwise direction. If it pulls at less than 4mA, tension should be increased. Reduce the current now to 2mA and turn the screw (3) clockwise until the armature is released. Repeat this procedure several times to make sure that the relay closes and opens at 4mA and 2mA respectively. Tighten the locking screws and re-solder the connections between the relay and the transistor.

The versatility of the "Liton" switch can be extended by fitting a secondary relay, described in the May 1960 issue. If the change-over switch is fitted to the main "Liton" unit, the secondary relay can be removed from the interior of the car and placed in a more convenient place.

Increasing Sensitivity

The "Liton" switch was built originally to be controlled by daylight and for this purpose a simple one-transistor amplifier is entirely satisfactory. If only weak artificial light is available, a much more sensitive arrangement is necessary. For such a purpose a super-sensitive two-transistor amplifier has been developed which is also suitable for a number of other applications. Its performance makes it ideally suited for all those uses which demand extreme sensitivity.

An input signal of only 2 microamps, at 30 millivolts, is sufficient to control a current of 0.5A in a 12-volt circuit. This is equal to an overall power amplification of 100,000,000 times.



Under-chassis view of the photo-electric mains operated switch

It is doubtful if a more sensitive d.c. amplifier could be built that would be free from drift and thermal instability. With a standard photocell in circuit, the light of a match will trip the relay at a distance of some 2 feet.

The circuit described here has been tried in a number of other projects with great success. It has been used in a valveless radio control receiver, sound-operated alarm, auto-pilot for a model glider, burglar alarm and a guided missile homing on light. Only two additional components are needed, a l.f. transistor and a 68kΩ resistor. This modification should be carried out as detailed herewith. See Fig. 4, page 689, April issue, for tag connections.

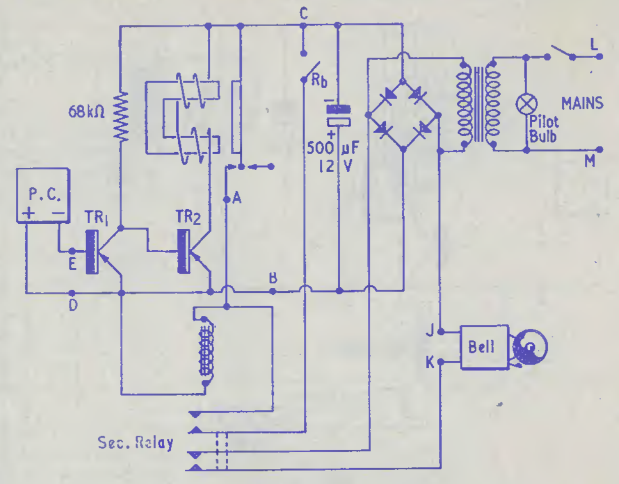


FIG. 9

CIRCUIT OF THE SUPER SENSITIVE MAINS OPERATED PHOTO-ELECTRIC SWITCH

Disconnect the lead going from the relay to tag No. 8, at tag No. 8, and join it to tag No. 13. Connect a 68kΩ resistor between tags No. 8 and tag No. 11. Cut transistor leads to about ¾in, insulate them with systoflex and connect them as follows:

(1) Collector to tag No. 13.
(2) Base to tag No. 8.
(3) Emitter to tag No. 10.

The lead from (A) must now be connected to the contact screw and made (3) in length instead of (1) (Fig. 4), because the operation of the relay is reversed, i.e. it pulls when the photocell is covered. This change is due to a phase reversal produced by the additional transistor.

Assembling the Alarm

Having completed the construction of the "Super Liton", 2-transistor unit, on the paxolin panel, secure the latter to the metal chassis by means of three 6BA screws provided. Screw down the rest of components in the following order: (1) rectifier, (2) transformer, (3) condenser, (4) secondary relay, (5) on-off switch, (6) re-setting button, (7) neon lamp, and (8) 6-way connecting block.

If the can of the smoothing condenser is not insulated, which is very often the case, the condenser must be insulated from its clip with a paper strip, insulation tape, etc.

Insert a grommet in the ½in hole and wire up the unit with reference to the circuit diagram (Fig. 9). As there are only a few connections to make and the wiring is not at all critical, no special point-to-point wiring diagram was considered necessary.

All connections can be easily seen in the illustration of the completed unit. It may be easier for a less experienced constructor to wire up the unit in stages, as suggested below:

(1) Mains circuit, including the panel light.
(2) Rectifier circuit.
(3) Connections between the sub-assembly, power pack and secondary relay.
(4) The bell circuit.

The alarm is now ready and can be tested. Check all connections before connecting the unit to the mains as mistakes are easily made. If the alarm is working properly, the voltage across the terminals of the condenser should be about 15 volts. (When the secondary relay is energised it drops to 12 volts.)

The alarm circuit, including the photocell and the bell, is completely isolated from the mains and there is thus no danger of an electric shock. A "floating chassis" construction has been found entirely satisfactory but, should it be desired to earth the chassis, the terminal "D" can be used for this purpose. Secure a 2BA solder tag under the transformer screw, nearest to the 6-way connecting block, making a connection between this solder tag and terminal D to which an external earthing wire can now be joined.

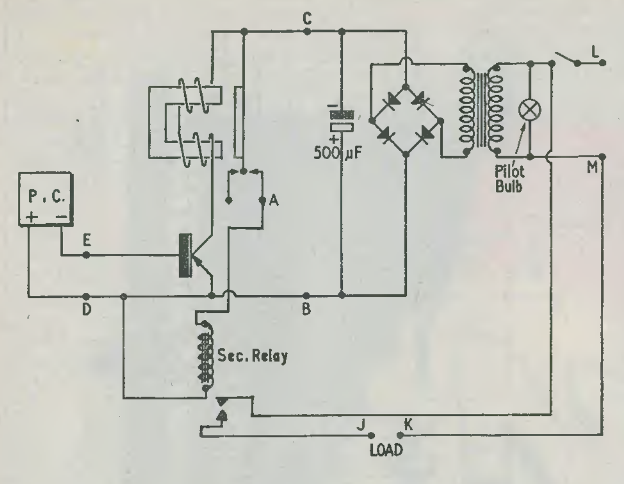


FIG. 10

CIRCUIT OF PHOTO-ELECTRIC SWITCH CONTROLLING A NEON SIGN

Mains Operation

The current drain of the super-sensitive relay is just over 1mA when the photocell is illuminated. A small dry battery could supply this current for several months before a replacement would be necessary. When absolute reliability and fully automatic operation is required, a mains power pack may prove more convenient. The general purpose power pack, described here, will supply enough current for any type of "Liton" switch together with the usual auxiliary equipment that may be used with it.

The circuit diagram of a typical mains operated super-sensitive photoelectric switch used as a burglar alarm, is shown in Fig. 9. The power pack is of conventional design and uses a bridge type metal rectifier. Sufficient smoothing is obtained with only one 500µF electrolytic condenser. The alarm bell is energised from the same transformer as the rectifier.

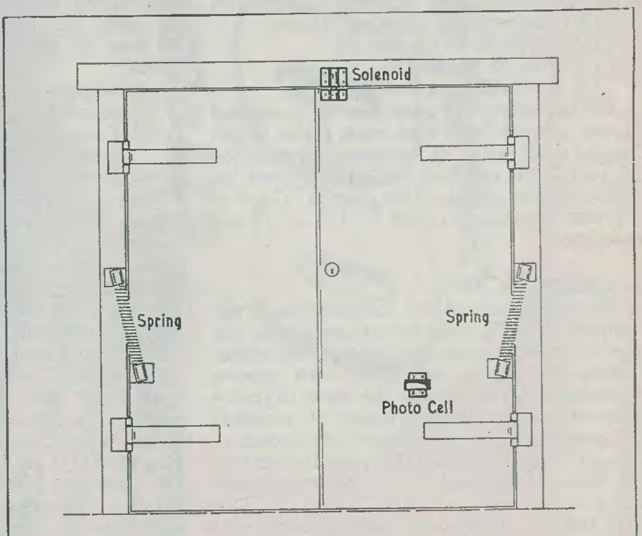


FIG. 11

GARAGE DOORS VIEWED FROM THE OUTSIDE

A good burglar alarm, once tripped, should continue to ring until manually reset. This is easily achieved by means of a secondary latching relay with two sets of contacts.

One set closes the bell circuit when the coil is energised while the other is connected across the contacts of the primary relay. It is clearly seen that the secondary relay, once closed, will not open even if the primary relay contacts separate. The current through the energising coil will continue to flow until the latching circuit is also broken by depressing the re-setting button (Rb). This alarm is so sensitive that no special source of light, visible or invisible, is required. It will work providing the room is not in darkness, i.e. at least one lamp is left switched on.

In one case, the light of an 80-watt fluorescent tube in a shop window was found sufficient to energise the photocell at 15 feet.

A complete alarm, including the power pack, can be built on a chassis 6in x 4in x 2in. A small neon warning bulb, glowing when the alarm is switched on, being very useful especially when the device is operated by non-technical staff.

Screened cable must be used to connect the photocell to the amplifier if trouble due to mains hum is to be avoided. A switch is placed in the primary circuit of the transformer to disconnect the unit from the mains.

Light Saver

The circuit diagram of a photoelectric switch, designed to control a neon sign, is shown in Fig. 10.

A simple one-transistor "Liton" unit is used in conjunction with a heavy duty secondary relay. This light saver can be assembled on the same chassis as the burglar alarm.

When choosing a secondary relay for mains operation one must make sure that the current carrying capacity of the contacts is adequate, the insulation being sufficient to withstand the full mains voltage. It may be advisable to earth the unit for greater safety.

Garage Door Opener

One of the most spectacular applications of the "Liton" switch is the automatic garage door opener. Like all photoelectric control devices, it is actuated by a light beam, in our case the car headlights. The principle of operation is very simple although the mechanical side may sometimes prove rather complicated and expensive. The mechanism that opens the door may be more or less elaborate, depending on the motorist's ingenuity—and his bank balance. Often, electric motors with time switches are employed to open and close the garage doors when a control signal is received. All systems, however complicated, must have these three essential elements: (1) light source, (2) photocell, (3) relay switching the actuating mechanism.

As an example, a very simple and inexpensive photoelectric garage door opener is described here which was built for about £1, plus the cost of the "Liton" unit. It has been in constant use for over a year and has proved absolutely reliable, despite its simplicity. A single transistor unit is used, wired up to close the circuit when the photocell is illuminated.

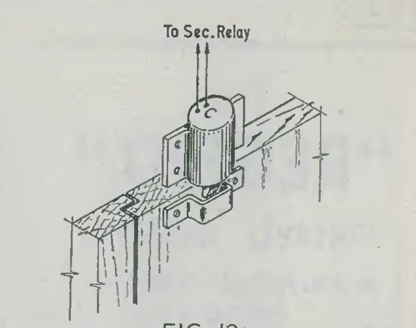


FIG. 12A

DETAILS OF ELECTROMAGNETIC BOLT

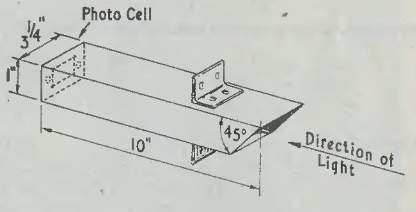


FIG. 12B

PHOTO-CELL HOOD

Fig. 11 shows the garage doors as seen from outside. Two strong springs, of the type normally used to keep the doors closed, are twisted in such a way that the garage door always has a tendency to open. An electromagnetic bolt Fig. 12 (a) prevents the door from opening. A photocell is fitted to the door at a suitable height Fig. 12 (*b*), and connected to the "Liton" unit inside the garage. The solenoid is connected to the transformer secondary through the heavy duty relay.

In order to open the garage door, the driver stops the car 6–8 feet from the photocell and turns the headlights on, thus tripping the relay. The electromagnetic bolt is attracted inside the coil allowing the door to open. The car can now be driven inside the garage. The door is then shut by hand. In order to stop daylight from shining on the photocell and affecting the performance of this device, it was found necessary to place the photocell at the end of a long narrow tube, painted black inside.

TRACKING SATELLITE PIONEER V.

Professor A. C. B. Lovell, director of the Jodrell Bank Radio Astronomy Station recently stated that, on the basis of the present signal strength of the radio signals from Pioneer V, the station could certainly track the satellite until the end of the year when the distance from the Earth would be some 90 million miles. The 150 watt transmitter of the satellite was switched on by Jodrell Bank on Sunday 8th May, signals being obtained "loud and clear" over some 8,200,000 miles. Professor Lovell also stated that this latest achievement in radio communication revealed that inter-planetary communication was a "practical possibility" and communication with satellites in the vicinity of Mars and Venus "quite feasible".

RADIO

THE "REGENT" PORTABLE RECEIVER

A PRINTED CIRCUIT DESIGN

Described by R. J Caborn

This article describes the construction of a sensitive broadcast-band superhet employing four low-consumption battery valves. An attractive cabinet is available for the completed receiver

THE "REGENT" IS A FOUR-VALVE BATTERY receiver which has been especially designed with the home-constructor in mind. It employs a superhet circuit and provides reception on medium and long waves with the aid of a sensitive ferrite frame aerial extending the full width of the chassis. A particularly important feature is the use of a printed circuit board to which all the principal components are secured and connected. This printed board offers the advantages that a considerable saving in assembly time is effected through its use and that all models constructed have wiring layouts which are identical to that intended by the designer.

An attractive cabinet is available for the completed receiver, and its final appearance is illustrated by the photographs which accompany this article.

The Circuit of the "Regent"

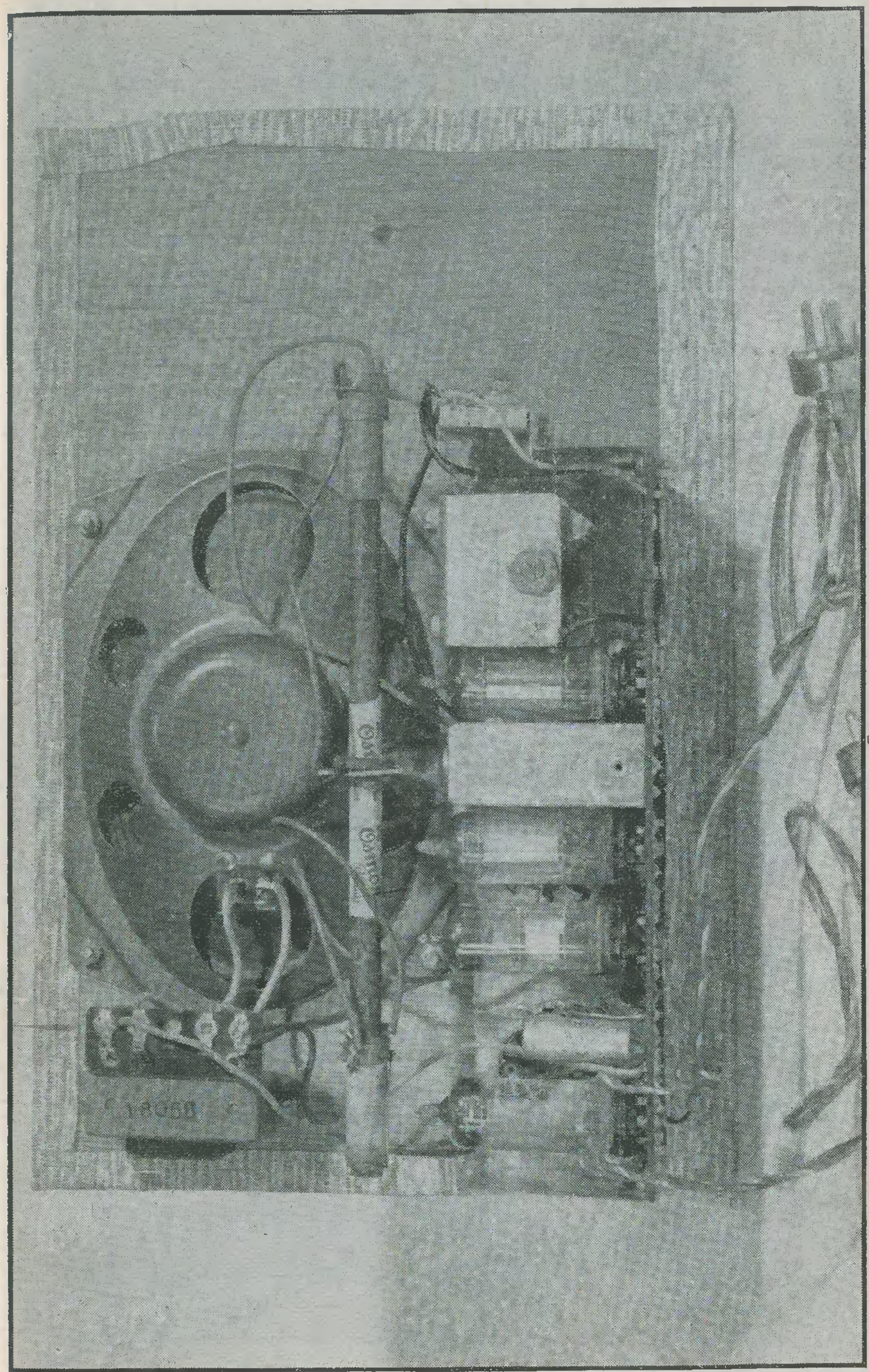
The circuit of the "Regent" receiver appears in Fig. 1. At the left-hand side of this diagram we see the ferrite frame aerial, L_1, L_2. Of these two coils, L_1 is intended for medium wave reception, whilst L_2 is intended for long wave reception. When the arm of wave-change switch $S_{1(a)}$ is in the upper (medium wave) position, L_2 is short-circuited and the receiver is switched for medium wave reception. When the arm of $S_{1(a)}$ is in the lower (long wave) position, L_1 is short-circuited and the receiver is switched for long wave reception.

Whichever coil of the ferrite frame is selected by $S_{1(a)}$ it is tuned by C_1, this being one section of the two-gang condenser. With $S_{1(a)}$ in the medium wave position, trimming of the medium wave tuned circuit is provided by VC_2. When $S_{1(a)}$ is in the long wave position, a further trimmer, VC_1, is connected across the tuned circuit.

The signal voltage built up across the ferrite frame coils, and the associated tuning capacities, is fed via C_3, to the signal grid of the heptode frequency-changer V_1. The first two grids of V_1 provide the grid and effective anode of the oscillator section. The oscillator tuned circuit consists of the coil $L_{3(a)}$ tuned by the remaining section of the two-gang condenser, C_2, and trimmed by VC_3. A fixed padding condenser, C_7, is inserted between the earthy end of the tuned coil and chassis. When the arm of wave-change switch $S_{1(b)}$ is in the lower (long wave) position, the additional capacity offered by C_{15} is connected across $L_{3(a)}$, thereby causing it to resonate at the lower frequency needed for long wave reception. Feedback to the oscillator tuned circuit is provided by C_4 and the coil $L_{3(b)}$, the h.t. supply to the oscillator being via the resistor R_4.

The screen-grid of V_1 (G_4), is connected direct to the screen-grid of V_2, the common decoupling condenser, C_9, being mounted close to the valveholder of the latter valve. Both screen-grids share the common dropping resistor, R_5. This method of connecting the two screen-grids results in a saving of components and space, with no attendant losses in performance.

The intermediate frequency appearing at the anode of the frequency-changer is fed, via i.f.t.$_1$, to the i.f. pentode V_2 in the normal manner. V_2 amplifies the signal applied to its grid and feeds it, via i.f.t.$_2$, to the diode of the diode-pentode, V_3. The detected i.f. signal appears across the volume control R_7, C_{10} functioning as an i.f. by-pass



General view of the prototype receiver showing main components mounted on a printed circuit board condenser, and the signal level tapped off by the slider of the volume control is passed, via C_{11}, to the signal grid of V_3. C_{11} prevents the d.c. component of the detected signal from being applied to the grid. Also, in combination with R_8, it helps to provide leaky-grid biassing for that grid.

The amplified a.f. signal on the anode of V_3 is fed to the signal grid of the output pentode, V_4, via C_{13}. C_8, connected between V_3 anode and chassis, provides tone correction and by-passes any remanent i.f. signal which may be present. The auto-bias resistor R_1, connected in series with the negative h.t. supply, and shunted by decoupling condenser C_{14}, provides bias for the output valve. The anode of the output valve connects to the primary of the speaker transformer in conventional manner.

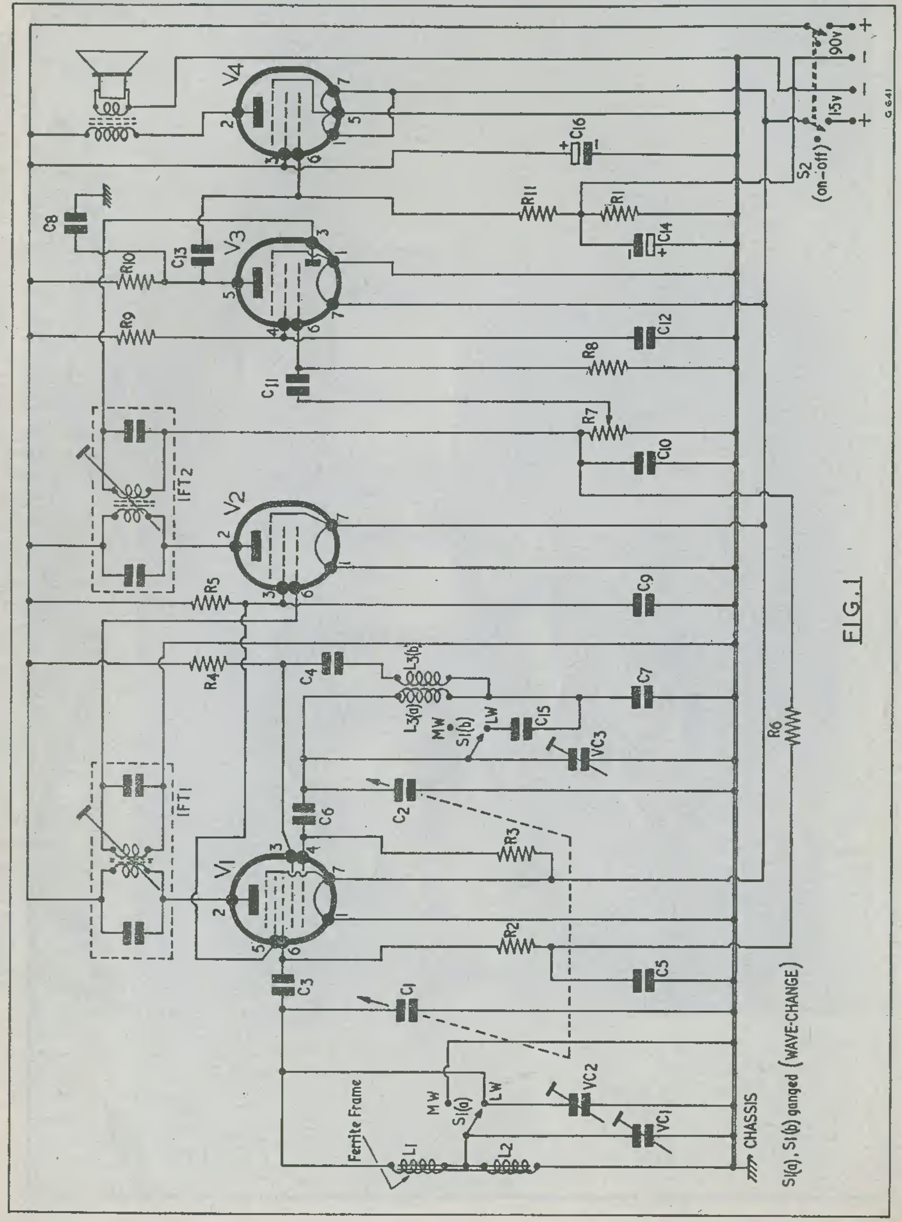


FIG. 1

Fig. 1. The circuit of the "Regent" receiver

All that now remains to be discussed is the a.g.c. circuit. The a.g.c. voltage is provided by the d.c. component of the detected i.f. signal built up across R_7. This d.c. component is fed, via the filter R_6 and C_5, to the signal grid leak, R_2, of V_1. No a.g.c. voltage is applied to V_2.

Soldering to the Board

Before commencing details of construction, it would be advisable to briefly review the techniques involved in soldering to the printed circuit board supplied for this receiver.

The process of soldering to the copper foil employed in printed boards differs somewhat from that of soldering to a wire which has been wrapped around a conventional solder tag. This difference is due to the fact that, with the latter, it is possible to apply a slight abrasive action to the wire with the soldering iron, thereby removing oxides, initially "wetting" the wire, and causing good heat transference from the bit of the iron. With printed circuit connections the abrasive action cannot be carried out, and it becomes necessary, in consequence, to ensure that all component leads are clean before they are passed through the board prior to soldering.

Provided that this essential difference is appreciated, no difficulties should be expected in soldering to the printed circuit board of the "Regent" receiver. The following points should, nevertheless, be observed. A small soldering iron is desirable, and its tip should

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Components List

(Set out for easy reference to Fig. 1)

Resistors

(Apart from R_7, all resistors are $\frac{1}{2}$ watt).

R_1	470Ω
R_2	1MΩ
R_3	27kΩ
R_4	33kΩ
R_5	18kΩ
R_6	2.2MΩ
R_7	1MΩ, log. Volume control with double-pole on-off switch, miniature
R_8	10MΩ
R_9	4.7MΩ
R_{10}	1MΩ
R_{11}	2.2MΩ

Condensers

$VC_{1,\,2,\,3}$	Trimmers 70pF max.
$C_{1,\,2}$	Two-gang 500pF max.
C_3	100pF
C_4	100pF
C_5	0.05μF
C_6	100pF
C_7	470pF
C_8	100pF
C_9	0.05μF
C_{10}	100pF
C_{11}	0.002μF
C_{12}	0.05μF
C_{13}	0.003μF
C_{14}	25μF 12 w.v. electrolytic
C_{15}	470pF
C_{16}	8μF 150 w.v. electrolytic

(*Note*$_1$ $VC_{1,\,2}$ and $_3$ and $C_{1,\,2}$ are available for the "Regent" from Radio Component Specialists.)

Valves

V_1	DK96 (Mullard)
V_2	DF96 (Mullard)
V_3	DAF96 (Mullard)
V_4	DL96 (Mullard)

Inductors

1 Ferrite frame M & LW. (Radio Component Specialists)
1 Oscillator coil type QO8M (Osmor)
1 set i.f. transformers 470 kc/s. (For "Regent" circuit) (Radio Component Specialists)
1 Speaker transformer. (Radio Component Specialists)

Miscellaneous

1 Speaker, elliptical, for "Regent" cabinet. (Radio Component Specialists)
1 Front panel assembly, complete with mounting brackets and ferrite frame bracket. (Radio Component Specialists)
1 Printed circuit board (for "Regent" circuit). (Radio Component Specialists)
1 Wave-change switch, miniature, two-pole, two-way. (Radio Component Specialists)
1 Set knobs, including tuning scale.
1 h.t. battery type 5512 (Vidor) or B126 (Ever-Ready)
1 l.t. battery type 5040 (Vidor) or AD35 (Ever-Ready)
(*Note:* The h.t. and l.t. batteries may be replaced by a mains unit, available from Radio Component Specialists.)
1 Cabinet complete. (Radio Component Specialists)
Nuts, bolts washers, connecting wire, etc.

always be kept clean and well-tinned. Resin-cored solder is necessary, and this should be brought up to the joint at the same time as the soldering iron is applied, so that the fluxing action of the resin takes place at the point where it is most required. **On no** account should a paste or liquid flux be used when soldering to a printed circuit board. In the case of the "Regent" receiver, there should be no necessity to clean the copper of the board before solder joints are attempted, as the board will be supplied with the copper side protected by a suitable oxide-inhibiting lacquer. The lacquer will not interfere with soldering in any way, and does not have to be removed before soldering commences.

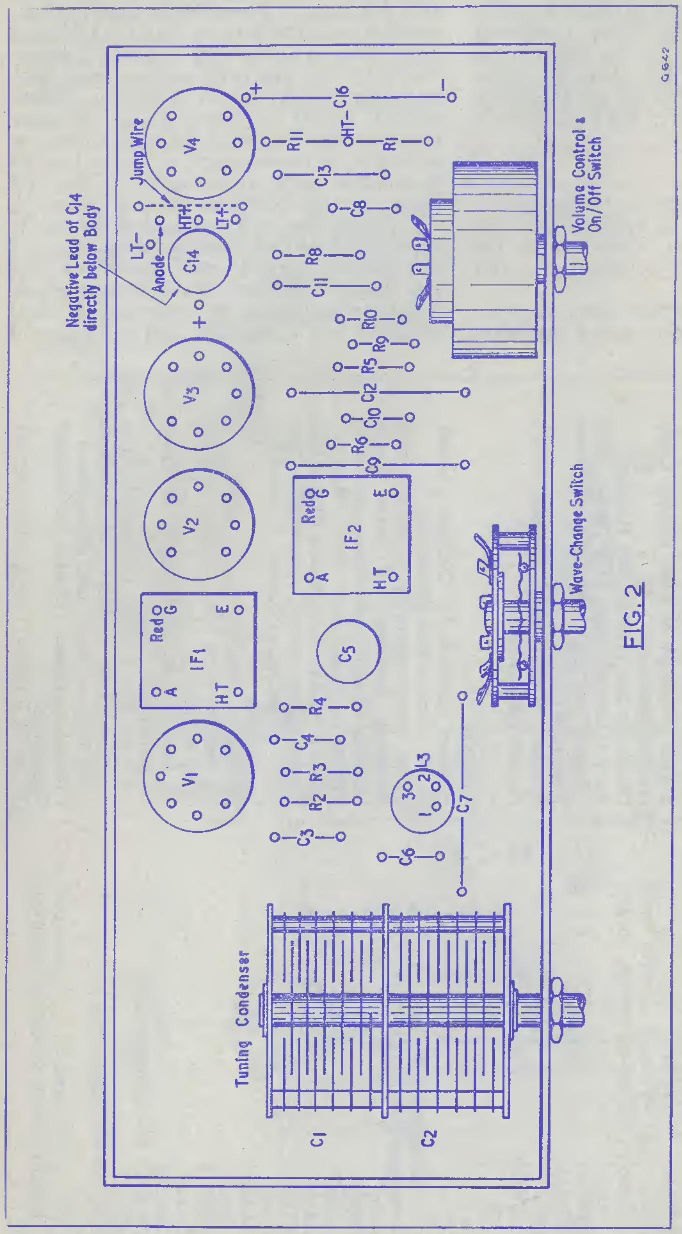

FIG. 2

Construction

The first part of the process of construction consists of fitting the major components to the printed circuit board. Soldering is not carried out at this stage. The first components to mount are the resistors and condensers. These components take up the positions illustrated in Fig. 2. The wire ends of the resistors and condensers are passed through the appropriate holes in the board, bent over and cut off on the underside approximately ⅛in away from the hole. Bending the wires over will hold the resistors and condensers in position quite adequately until soldering commences. Note that C_{14} is mounted vertically, its negative lead passing straight down through the board and its positive lead being bent down outside its case and passed through the adjacent hole. Care should be taken to ensure that the positive lead does not short-circuit to the case of this condenser. Short-circuits may be avoided by applying sleeving to either the lead or the case. C_5 is also mounted vertically, one lead being brought down its side in similar manner.

Next to be fitted are the valveholders. These may be held in position at this stage by gently bending over two opposite lugs on each valveholder. If desired, all the valveholder lugs may be similarly bent over, it being found that this greatly eases soldering later. Such a procedure is not, however, essential.

A bare tinned copper jumper wire, adjacent to V_4 valveholder, should next be fitted. This is secured in the same manner as the resistors and condensers (by bending its ends over and cutting under the board), and its position is shown in Fig. 2.

With certain exceptions, all the component leads and lugs which are inserted may now be soldered over to the copper pattern. The soldering process includes the centre spigots of the valveholders. The exceptions, which remain unsoldered, are the connections at the junction of R_{11} and R_1, and the forward (i.e. further away from the valveholders), lead of C_6.

The next step consists of inserting the oscillator coil tags into the group of three holes indicated in Fig. 2. Also connected at this stage is one end of condenser C_{15} to tag 1 (see Fig. 2), of the oscillator coil. The other end of C_{15} is soldered later to the wave-change switch. A length of bare tinned copper wire (or the stripped end of a length of insulated wire), is then connected to tag 3 of the oscillator coil. The other end of this wire will later connect to the wave-change switch. All the oscillator coil tags may now be soldered to the printed wiring.

A length of bare tinned copper wire (or the stripped end of a length of insulated wire), is next introduced into the same hole occupied by the forward lead of C_6, bent over and cut. This wire, and the condenser lead itself, may now be soldered to the copper of the board. The wire will later connect to the tuning condenser.

The next items to solder to the board are the flexible leads which connect to the batteries, the on-off switch and the speaker transformer. Identify the hole at the junction of R_{11} and R_1 which is not as yet soldered. This is the connecting point for the h.t. negative battery lead. Insert the stripped end of a suitable length of flexible wire into this hole and solder under the board, soldering over the leads from R_{11} and R_1 at the same time. Carefully record the lead function by tying a suitably inscribed label to it (or by noting its colour if four different colours for the supply leads are available). Identify the printed earth conductor at the rear of the printed panel. This conductor travels along the rear length of the board and may be recognised by the fact that it connects, amongst other points, to the spigot and pin 1 of V_1 valveholder. Identify in Fig. 2 the hole marked "L.T.−" (which passes through the earth conductor) and solder a flexible lead, passed through the board, to the conductor at this hole. This lead will connect to the l.t. negative terminal of the batteries and should be marked in a manner similar to that employed for the h.t. negative lead.

The next two leads to deal with are those of the l.t. positive and h.t. positive wires which travel to the on-off switch. Identify the hole marked "L.T.+" in Fig. 2. This hole passes through a printed conductor which travels to pins 1 and 7 of V_4, and pins 7 of V_3, V_2 and V_1. Solder an insulated lead passed through this hole to the conductor. The other end of this lead will later connect to the on-off switch, whereupon it will be referred to as the "*l.t. positive lead from the board*". Next identify the hole marked "H.T.+" in Fig. 2. This hole passes through a printed conductor which, amongst other points, connects to pin 3 of V_4. Into this hole fit and solder two insulated leads. One of these leads will later connect to the on-off switch and we shall refer to it as the "*h.t. positive lead from the board*". The other lead connects to the primary of the speaker transformer and should be of adequate length for this function. The final flexible lead to solder to the board is the remaining speaker transformer lead. This passes through, and is soldered at, the hole marked "anode" in Fig. 2, thereby making connection to the printed conductor which travels to pin 2 of V_4. The two speaker leads should now be twisted together. They will later be connected to the speaker transformer.

Fitting the Front Panel

The front panel is now fitted, being secured with the nuts and bolts provided. This panel should be earthed at both ends of the chassis by making connection to the printed earth conductor referred to above. A suitable means of making the requisite earth connections consists of fitting a solder tag at either end of the chassis under a panel-securing nut, and connecting this by a short piece of wire to the printed earth conductor at any convenient adjacent point.

It now becomes necessary to solder three 3in lengths of bare tinned copper wire to the volume control tags of the combined volume control and on-off switch. The combined volume control and on-off switch is then secured to the front panel (through the hole at the V_4 end of the chassis), whereupon it should take up the position illustrated in Fig. 3. The three leads previously fitted now pass through three holes corresponding in position to the tags in the board, these holes being approximately an inch behind the tags. As an aid to identification, the centre of these holes passes through a conductor travelling to the forward end of C_{11}, the other two holes being symmetrically positioned on either side. The three volume control leads are passed through the three holes, bent over, cut and soldered. The lug connecting to the metal case of the volume control is then soldered to the front panel at any convenient adjacent point.

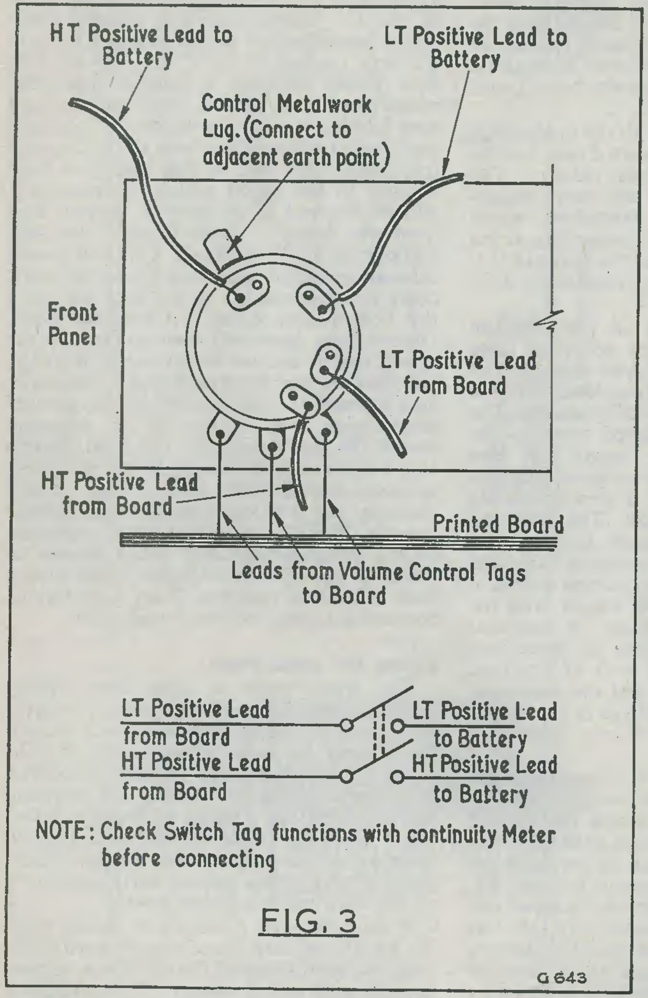

FIG. 3

Fig. 3. Connections to the on-off switch and volume control. It is necessary to refer to the text concerning this stage of the wiring

The next step consists of wiring up the switch. The connections involved are shown in Fig. 3. As may be gathered, the switch wiring consists of connecting the l.t. positive lead from the board (fitted earlier), to a contact of one pole of the switch; soldering the flexible l.t. positive battery lead to the other contact; connecting the h.t. positive lead from the board (fitted earlier), to one contact of the remaining switch pole, and of soldering the flexible h.t. positive battery lead to the other contact. It is of the utmost importance to ensure that the connections to the switch are made correctly, an error in this part of the wiring possibly causing h.t. to be applied to the valve filaments with consequent failure. **The tags shown in the wiring diagram of Fig. 3 apply to a particular make and model of switch only, and may not necessarily correspond, so far as tag positioning is concerned, with any alternative switch which may be employed by the constructor. In consequence, the constructor should check the tag function of the particular switch employed by himself with a continuity meter before finally connecting up the supply leads.** The circuit in the "inset" of Fig. 3 clearly shows the manner in which the on-off switch operates. The flexible l.t. positive and h.t. positive leads from the switch should be marked in the same manner as were the l.t. negative and h.t. negative leads.

The two-gang tuning condenser (which is fitted at the V_1 end of the chassis), and the trimmers, may next be fitted. The latter are mounted, with the aid of the bracket provided, in the manner shown in the photograph of the chassis. VC_2 should be at the rear, VC_1 in the middle, and VC_3 at the forward end of the associated bracket. The wire which was previously soldered to the forward lead of C_6 now has its free end connected to the fixed vanes of the forward gang of the tuning condenser, using the tag which is on the volume control side of the condenser. (A length of sleeving should be fitted over this lead before making the connection, if bare tinned copper wire was employed.) The non-earthy plate of VC_3 is connected to the fixed vanes of the forward section of the two-gang condenser via the tag on the other side. Next, identify the printed conductor which connects to the forward end of C_3. This conductor travels to a hole near the edge of the board underneath the rear section of the two-gang condenser. Connect an insulated wire from the conductor at this hole to the fixed vanes of the rear section of the tuning condenser. Connect the non-earthy plate of VC_2 to the fixed vanes at the same tag.

Next, fit the wave-change switch (at the centre of the front panel), and the ferrite frame aerial on the appropriate bracket, taking care to insulate the rod of the aerial from the brackets with the grommet provided. The long wave coil of the ferrite frame should be at the V_1 end of the chassis. The wiring to these components is shown in Fig. 4. It will be seen that one lead from the wave-change switch is shown as coupling to the "forward lead of C_3". We have already identified the printed conductor from the forward lead of this condenser and have connected to it the fixed vanes of the rear section of the tuning condenser. Another part of this printed conductor travels to a hole immediately beneath the wave-change switch, and it is to this point that the lead of Fig. 4 connects.

Also shown in Fig. 4 are connections made to C_{15} and the lead previously soldered into circuit with the oscillator coil tags. If bare tinned copper wire was employed for the lead this should be fitted with sleeving. The remaining connections shown in Fig. 4 are made to the ferrite frame coils and to the non-earthy plate of VC_1, these being illustrated clearly in the diagram.

Next to be fitted are the two i.f. transformers. These should be positioned as shown in Fig. 2, taking care to ensure that the tags marked red are inserted into the correct holes. The i.f. transformers may now be soldered to the copper pattern. The mounting lugs of the transformers should be soldered with as much care as was applied to the connecting tags. This is because the mounting lugs complete some of the earth circuits on the board.

Finally, the battery plugs should be connected to the ends of the flexible leads. The appropriate pins on these plugs may be readily ascertained by referring to the identification printed on the battery cartons.

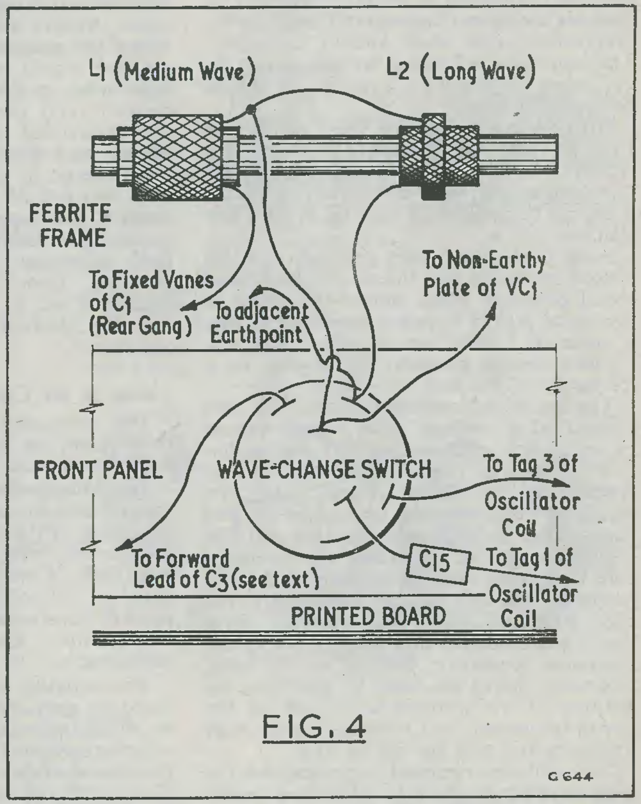

FIG. 4

Fig. 4. Connections to the wave-change switch and ferrite frame

Testing the Receiver

The receiver is now ready for test and alignment. Before proceeding further, it is necessary to temporarily connect the speaker transformer primary to the appropriate leads from the chassis, and to connect its secondary to the speaker. It is desirable, also, to temporarily earth the speaker frame to the receiver chassis.

Before connecting up the batteries it would be advisable to check the receiver circuit with a high resistance ohmmeter. With all valves plugged in, there should be a low resistance indication between the l.t. battery plug pins when the receiver is switched on, and an open-circuit when it is switched off. The h.t. battery plug pins should also show an open-circuit when the set is switched off. When the set is switched on, the only current-drawing component in the h.t. circuit is C_{16}, and this may give a momentary "kick" to the ohmmeter needle when initially connected. The continual polarising current drawn by C_{16}, when the receiver is switched on, should be negligibly small.

After having carried out these checks, the batteries may be connected up and the receiver switched on. The filaments should then light up and, with volume fully advanced, it should be possible to pick up at least one signal.

Alignment should next proceed, and this is done preferably with the aid of a modulated signal generator whose output is coupled to the signal grid of V_1 via a condenser having a value of 1,000pF or so. The i.f. transformers should primarily be aligned to a frequency of 470 kc/s.

The aerial and oscillator circuits are next aligned. The medium wave circuits should be set up first, commencing with the oscillator. With the signal generator loosely coupled to the ferrite frame aerial, the oscillator circuit should be aligned to give correct dial readings near the high and low frequency ends of the band, the oscillator core then being used for padding at the low frequency end and VC_3 for trimming at the high frequency end. The medium wave signal tuned circuits may then be set up for maximum sensitivity, padding at the lower frequency end of the band by adjusting the position of the medium wave coil on the ferrite frame rod, and trimming at the high frequency end with the aid of VC_2.

No oscillator alignment is provided for the long wave band, and dial calibration should be reasonably correct over the range 1,200 to 1,800 metres. Signal frequency alignment is carried out by padding at the low frequency end by moving the long wave coil along the ferrite frame rod, and trimming at the high frequency end by means of VC_1.

In all cases where a modulated signal generator is used, the output should be kept to a low level in order to avoid overloading the a.f. output valve. A loose coupling to the ferrite frame may be achieved by holding a lead from the signal generator output close to the ferrite frame or by coupling the output to a small coil held near the end of the ferrite frame. A direct connection must not be employed, as this will throw the signal frequency circuits completely off tune, and make alignment impossible.

If a signal generator is not available, alignment may be carried out by primarily picking up a signal, tuning to maximum signal strength with this, and aligning the i.f. stages for maximum volume. So far as is possible, signal level should be reduced as alignment proceeds by orientating the receiver (and thereby taking advantage of the directional properties of the ferrite frame), and it may be necessary, for final adjustments, to work with a signal weaker than that initially employed. The i.f. transformers are supplied pre-aligned, and the process just described should result in their final alignment at a frequency not far removed from the nominal 470 kc/s. Oscillator and r.f. alignment is then carried out with received signals whose frequencies are known.

Fitting to the Cabinet

The procedure involved in fitting the receiver to the cabinet is extremely simple and should incur few problems.

The loudspeaker and loudspeaker transformer should primarily be fixed to the underside of the cabinet panel by means of the captive bolts provided. The chassis is next fitted in position by securing its front panel to that of the cabinet. The speaker, speaker transformer and chassis then take up the position shown in the appropriate photograph.

The speaker transformer may now be wired up permanently. A solder tag should be fitted under one of the lower speaker securing nuts, and a lead taken from this tag to any convenient earth point on the chassis. The knobs and tuning scale should also be fitted at this stage. Finally, the batteries are secured in the cabinet and the panel lowered into place.

The "Regent" receiver is now complete and is immediately ready to provide many hours of broadcast entertainment.

OLD ROYAL OBSERVATORY, GREENWICH

The 24-hour clock outside the gates of the Old Royal Observatory is to be stopped for a few weeks during alteration to the entrance gates and railings. The clock will be re-started by July 6th, the date on which Her Majesty the Queen will re-open Flamsteed House.

TRANSISTOR COMPONENTS test set

By A. T. CADWALLADER

This test set has been designed to enable quick checks to be made on low voltage components used in transistor devices.

The following checks may be carried out.

(1) *Transistors*
Collector leakage current I'_{co} and current gain β.

(2) *Diodes*
Forward and reverse currents at known voltages.

(3) *Capacitors*
Leakage current at the working voltage, and capacitance from 1–150μF.

(4) *Resistors*
The value of resistance 10Ω–180kΩ.

(5) *Voltage*
0–6 and 0–60 volts f.s.d. at 166kΩ per volt.

(1) Transistors

This circuit (Fig. 1) has previously been discussed* in this publication. It provides a simple means of measuring the collector leakage current I'_{co}, and the earthed emitter current gain β or α.

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*See page 349 December 1958 issue—"A Simple Pocket Transistor Tester", by W. E. Griffiths.

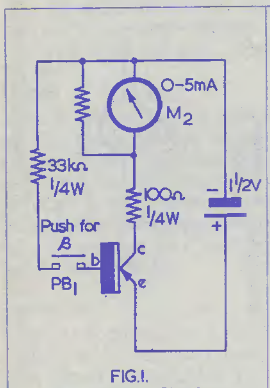


FIG.1.
Transistor Test Circuit.

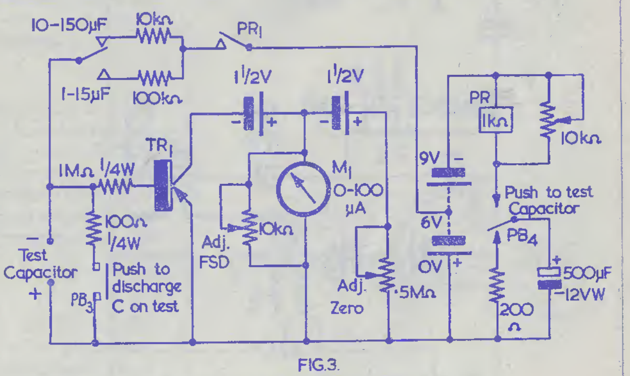


FIG.3.
Capacitor Test Circuit.

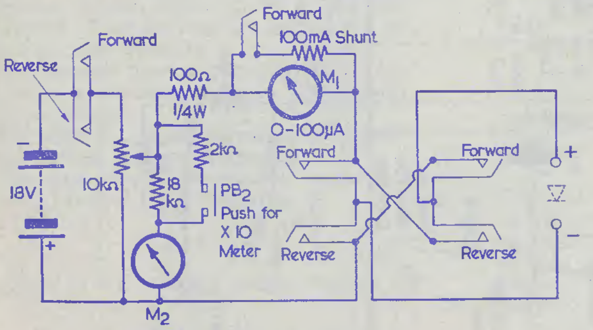


FIG.2.
Diode Test Circuit.

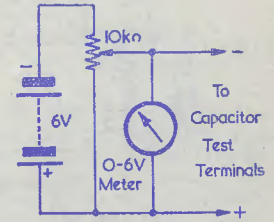


FIG.4.
Capacitor Calibration Set-up.

M749

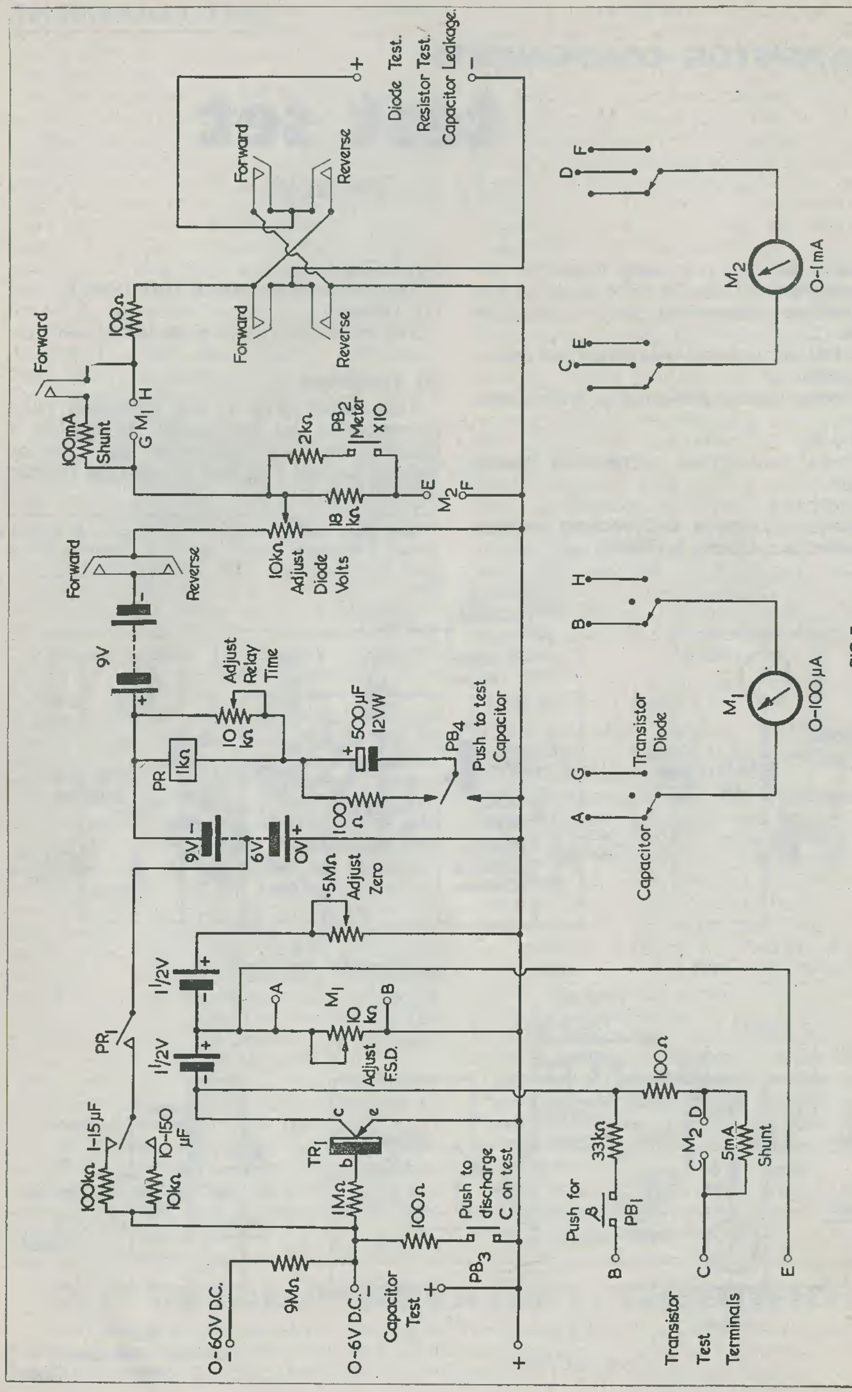


FIG.5. Complete Circuit Diagram

Method of Testing

The transistor is placed in the terminals and the collector leakage current read directly off M_2. The push button PB_1 is operated, and the meter will now read directly in current gain. The meter is calibrated 0–5mA for I'_{co}; and 0–150 for β, which represents a gain of 30 for 1mA.

(2) Diodes

This is a simple test to measure the forward and reverse currents of all types of diodes, at known low voltages (Fig. 2).

The method of calibrating the meter M_1 will be left to the discretion of the builder of the test set, depending on the type and number of diodes to be tested. The following two methods enable the diode to be tested to manufacturer's information.

(*a*) The meter may be directly calibrated in milliamperes; this will enable the forward or reverse resistance at any known voltage to be calculated.

(*b*) If the forward and reverse resistances are known for given voltages, normally +1 and −10 volts, then the meter can be calibrated with two scales, reading forward and reverse resistance and coloured for easy identification.

Method of Testing

The diode voltage is turned down to zero and the diode placed in the test terminals, ensuring that the red end (cathode) is connected to the negative terminal. The lever key is then operated to the "forward" position and the forward voltage adjusted on M_2; the current or resistance may then be read directly off M_1.

Capacitors

This test circuit (Fig. 3) is, as far as the author knows, entirely new. The capacitor under test is charged for a known time via a resistor at a known voltage. The P.D. on the capacitor is then measured on a transistor voltmeter. Leakage tests are carried out on the diode test terminals.

The known time is provided by a high speed relay, operated in series with a large value capacitor.

The capacitor is discharged via a resistor when the test button is released.

The voltage on the capacitor under test may be expressed in the equation:

$$u=V\left(1-e^{-\frac{t}{CR.}}\right)$$

Where V is the charging battery voltage in volts;
t is the time of charging in seconds;
C is the capacitance under test in µF;
R is the charging resistance in MΩ;
e is the exponential function 2.718.

$$\text{i.e. } u=6\left(1-e^{\frac{-t}{CR}}\right)$$
$$=6\left(1-e^{\frac{-.25}{.1}}\right)$$
$$=6\,(1-e-2.5)$$
$$=6\,(1-.0821)$$
$$=6 \times .9179$$
$$=5.5182 \text{ volts}$$

The value of e^{-x} is derived from tables of exponential functions.

Meter Calibration

Here again there are two possible methods of calibrating the meter.

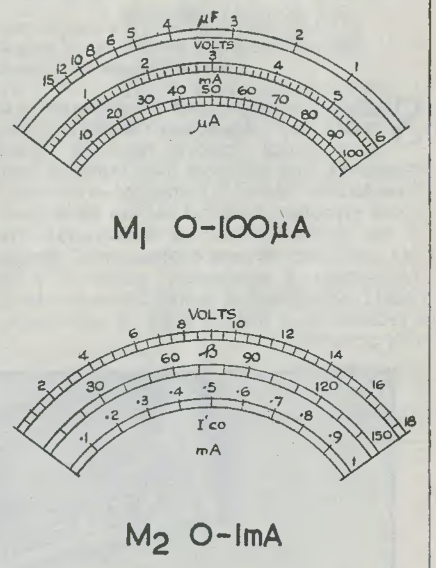


FIG.6. Meter Calibrations

(*a*) This method does not require the timing charge relay to be set up to give an accurate time. The meter may be marked directly from capacitors, the value of which are known. The relay timing control may need to be altered to enable the required range to be read on the meter. The meter must first be adjusted to zero and full scale deflection with the appropriate controls.

(*b*) The formula and method given above may be used to derive values to calibrate the meter. The charge on the capacitor may be calculated for each value to be marked on the meter scale. The resultant voltage is then injected into the test terminals, without operating any controls. (See Fig 4.)

The values in table 1 have been calculated as above, assuming a value for t of 0.25 seconds and V of 6.0 volts, with scale markings of 1, 2, 3, 4, 5, 6, 8, 10, 12, 15μF. The value of RC will be 100kΩ multiplied by the scale marking. Only one set of scale markings are required by the two ranges (1–15μF and 10–150μF).

Relay Calibration

On completing the meter calibration as in (*b*) above, all that remains is to adjust the relay timing to 0.25 seconds.

The simplest method of doing this is to select a capacitor of known value (60μF). The capacitor is placed in the test terminals after adjusting for zero and full scale deflection, and operating the capacitor test button PB$_3$. If the reading is too great, then the relay operating time must be too long. The 0–10kΩ potentiometer shunting the relay winding is then adjusted such that a greater amount of current is passed through the "pot". The relay will then release earlier.

RADIO

A REAL MINIATURE

BY J. M. E. SMITH

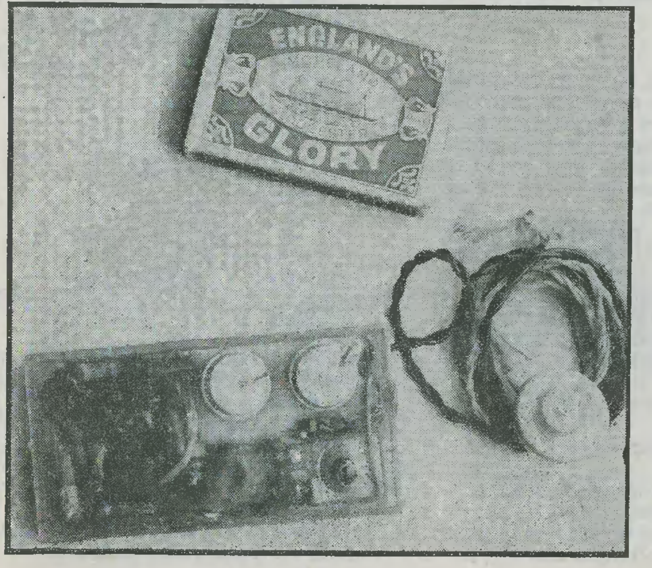
(*This article describes a pre-tuned transistor receiver in which extreme compactness has been achieved by the use of simple circuitry and by further reduction in size of "miniature" standard components.—Editor.*)

Several articles have appeared in recent years describing the construction of so-called "pocket receivers" using transistors, and although their bulk has been considerably reduced compared with traditional portables, full use has not been made of the diminutive size of transistors. The sets described have not been small enough to warrant a permanent niche in one's pocket, and therefore it was decided to build a receiver in as small a space as was reasonably possible.

The result was a three-transistor one station pre-selected set built into a smaller space, including batteries and earphone, than that occupied by a packet of ten cigarettes. The small size of the receiver may be judged from the accompanying photograph.

The circuit uses standard components throughout, and R–C coupling was decided upon in order to save space. It is built into a small plastic box, size 3 x $1\frac{1}{2}$ x $\frac{1}{2}$in, as sold by most large stores for containing needles, pins, etc. Slight modification is required to enable the coupling condensers to fit into the space allocated. This is achieved by holding each 0.05μF condenser in turn over a candle flame until the wax becomes soft, when it can be peeled off, thus leaving the condenser itself exposed. Wrapping with a layer of p.v.c. insulating tape will then prevent damage.

The coil is the top section of a medium wave Osmor miniature aerial coil, the section being cut off with a small saw just below the winding. Two 1.5 volt Mallory RM625 batteries provide the power, and these may be either soldered into circuit or connected, as in this case, by means of pressure contact with the battery leads. A small piece of foam rubber underneath the batteries provides the pressure and also retains them in position. The box lid slides off for battery renewal.



This photograph shows the compactness and extremely small size of the 3-transistor receiver built by the author and described herewith.

Circuit of the miniature transistor receiver.

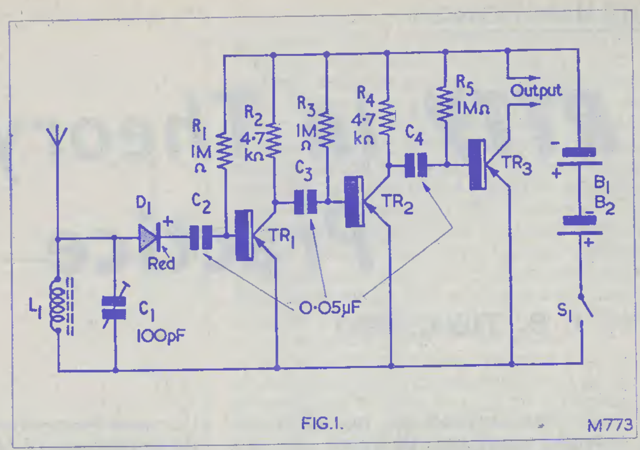


FIG.1.

Components List (Fig. 1)

L$_1$	Osmor M.W. coil, type QA8, modified
D$_1$	OA71 Mullard crystal diode
TR$_1$, TR$_2$, TR$_3$	PNP junction transistors, "Red-Spot"
C$_1$	100pF pre-set trimmer
C$_2$, C$_3$, C$_4$	0.05μF 150WV Hunts
R$_1$, R$_3$, R$_5$	1MΩ $\frac{1}{8}$ Watt
R$_2$, R$_4$	4.7kΩ $\frac{1}{8}$ Watt
B$_1$, B$_2$	Mallory RM625
S$_1$	On-off, miniature, slide-action switch. Bulgin S591 or equivalent
Personal earphone	
External transformer (optional) Ardente D239	

continued on page 856

Fig. 2. *Connecting the optional external transformer into the earphone leads*
Fig. 3. *Underside view of component layout. The on-off switch is bolted to the front panel, away from the reader*

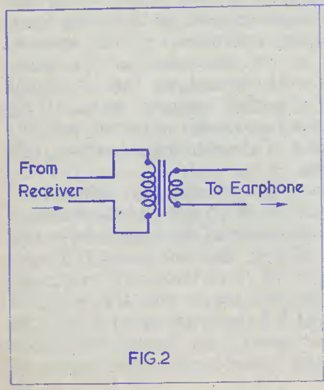


FIG.2

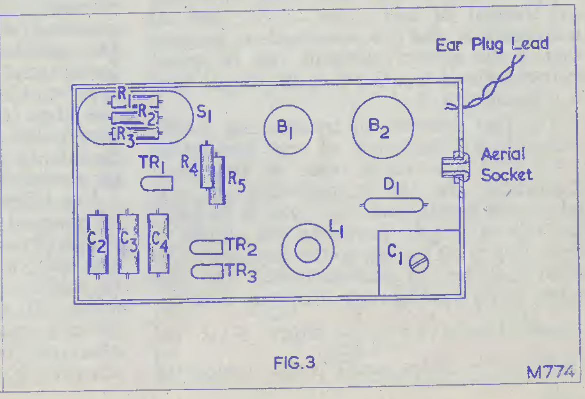


FIG.3

RTTY In Theory and Practice

by J. B. Tuke, G3BST

PART 2

In the first article we discussed the voltage waveform delivered by the keyboard contacts of a teleprinter, finding that it was a square wave, having half cycles of varying length from 20 milli-seconds upwards, in 20 milli-second steps. Our concern in this article is the transmission of the signal to a distant receiving terminal either by line or by radio, and a discussion of any distortion that may be introduced, having regard to the fact that a practical communication system must operate on a restricted bandwidth.

From the amateur's point of view, the transmission over "line" will probably be restricted to a few feet or yards of wire but it is instructive and enlightening to consider the difficulties involved in line transmission since some of the effects will be present with a radio link as well.

Let us consider the difficulties that may arise in transmitting a continuous "Mark-Space" repetitive combination—such as might arise if the letter Y were depressed. We will consider the transmission of this combination because we know that if we can convey this character successfully, all other characters can also be dealt with, since they will consist of half-cycles longer than 20 milli-seconds, and it is reasonable to suppose that if the shorter elements can be transmitted without trouble, then the longer ones will follow suit.

The first criterion in transmitting intelligence, is the frequency of that intelligence —or, if it is variable, then its maximum frequency. In the transmission of our teleprinter signal, each half cycle is 20 milli-seconds in length (providing the system is operating at 50 bauds), so the complete cycle must last for 40 milli-seconds. The frequency of a waveform can be found from the simple formula $F=\frac{1}{T}$ where F is the frequency in cycles, and T is the "period" of the wave form—that is—the time taken for the completion of one cycle. The frequency of the teleprinter signal is therefore $\frac{1}{0.04}=25$ c/s. It must again be noted that this is the maximum fundamental frequency that can occur. Our line or radio link must therefore handle a maximum frequency of 25 c/s (square wave), but no higher.

If the frequency were sinusoidal, that would be all there is to say about it, but unfortunately, as it is a square wave, there is a great deal more to mention! Fourier's analysis tells us that a square wave consists of the fundamental frequency plus all the odd harmonics up to infinity, the amplitude of the harmonic being the reciprocal of the order of the harmonic—i.e. the third harmonic will have an amplitude of 1/3 of the fundamental, the fifth harmonic an amplitude 1/5 of the fundamental, and so on. It follows, therefore, that to transmit a perfect square wave without altering its shape (which is to introduce distortion), will require a line or radio system having an infinite bandwidth. This is likely to be highly popular on the amateur bands! But, is it necessary to transmit a perfect square wave—does the receiving mechanism insist on this wave form for satisfactory operation? The answer, fortunately, is no—we can get by quite satisfactorily with something that is rather less than the perfect square wave. This means that the bandwidth required will not be infinite, but a definite figure which can be worked out.

Fig. 1 shows (A) a square wave which may be assumed to be of 25 c/s. Underneath is shown (B) a sine wave of the same frequency, and then, in Fig. 2, the sine wave (C) with the addition of the third harmonic only, and finally (D) the sine wave with the addition of third and fifth harmonics only. It will be observed that even with only these two harmonics, the waveshape soon begins to approach something like a square wave, although it is a little slow on the "rise time" and a little bit shaky along the top. We shall now look once again at our teleprinter receiving mechanism and decide to what extent the waveshape may be distorted by cutting off its harmonics before printing will be upset.

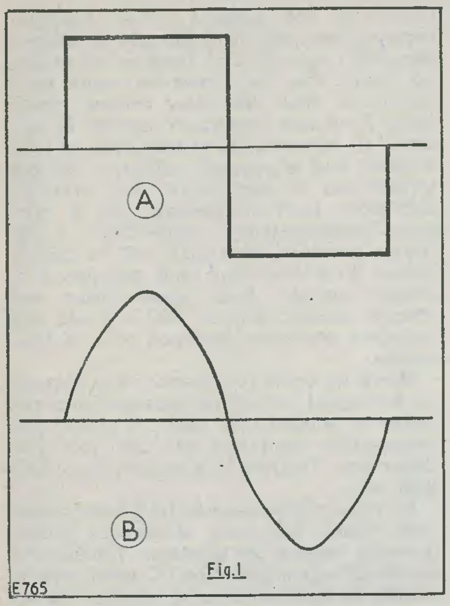


Fig. 1

Referring to the machine itself and to the first article in this series will remind us that the selection of the type character depends initially upon the movement of a finger (one of five), this movement being occasioned by the action of a striker blade attached to the electromagnet. This finger movement is made via a pin, which moves from one finger to another in turn. Obviously it is only when the striker blade is actually in contact with the pin, that its position is important —while the pin is moving from one finger to another, the striker blade can be in either "Mark" or "Space" position, or even hovering uncertainly between the two—but it must be in the correct position during the strike. The strike cannot last the *whole* 20 milli-second period, otherwise there would be no time for the pin to move from one finger to the other, which is equivalent to saying that part of the received square wave may be absent without upsetting the operation.

If the printer is in good mechanical order, an appreciable part of the signal may be missing—as much as 30%—since the mechanism only requires a correct signal for 70% of the total 20 milli-seconds allotted to the individual pulse. If the machine is really "on top line" even better figures can be realised, but the amateur would be wise to limit distortion of the waveshape to a maximum of 30%. We must therefore include sufficient harmonics in our received wave from the transmitting printer to ensure that 70% *at least* of the signal is received as sent—and reference to Fig. 1 will show that the inclusion of the third harmonic only will in fact provide this, though some distortion is introduced, and that the inclusion of the fifth harmonic as well will leave a safe margin to allow for additional distortion which may occur in other parts of the system.

Since the fundamental frequency is 25 c/s (maximum) the fifth harmonic will go up to a maximum of 25 x 5=125 c/s. The line or radio link will therefore have to provide for the transmission of frequencies up to 125 c/s without appreciable attenuation. If the system will transmit additional harmonics as well, so much the better. Under practical conditions, one does not design a system to deliberately introduce 30% distortion—instead, one endeavours to transmit the signal with as little distortion as possible consistent with a reasonable bandwidth, since additional distortion of the signal is likely to occur in filters or terminal units —and it is quite possible that the printer itself is not in perfect adjustment, in which

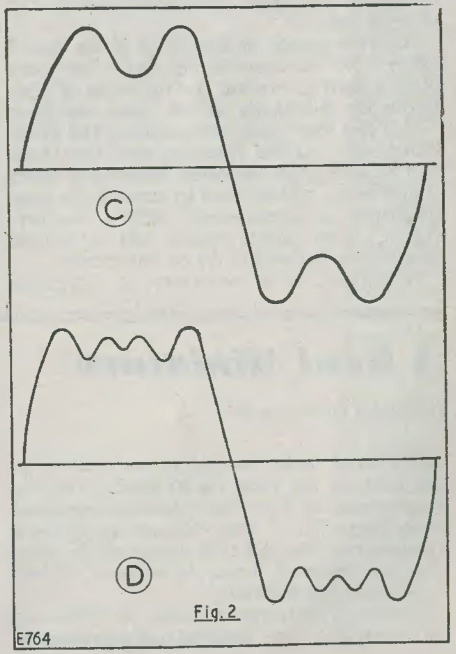


Fig. 2

case it will not print correctly with large distortion percentages. But it is as well to know the *maximum* possible distortion which may be permitted between transmitter and receiver in order to assist in the calculation of required band widths.

It is worth noting at this point, the inherent efficiency of the system. To convey written intelligence at a speed of 66 w.p.m. for a bandwidth of 125 c/s or less, is no mean feat, comparing favourably with hand-operated c.w. and putting A3 completely out of the picture.

One of the items that will introduce distortion is, then, insufficient bandwidth, but it is not the only one, so now let us examine other possible causes.

Firstly, the transmitter (i.e. the sending teleprinter) must introduce a small amount, since the transmitting contacts cannot move from Mark to Space, and vice versa, in zero time. Therefore a perfect square wave cannot be generated, but while some slight distortion is inevitable from this cause, it should be kept to the lowest possible figure by correct adjustment of the mechanism.

The motor speed must also be accurate. If the motor is fast or slow, transmitted signals will run ahead of, or lag behind, the movement of the striker blade in the receiving printer—so that signals will appear progressively distorted as transmission of the character proceeds. The governors on most printers are very reliable, but it is a good idea to check the speed occasionally with the stroboscope.

Another source of distortion is the use of filters. At the transmitting end a low pass filter is used to prevent the radiation of high frequency sidebands as we shall see later—and this filter must not attenuate the lower harmonics. At the receiving end, the Mark and Space signals are often received as tones—and filters will be used to remove the tone frequency in conjunction with a rectifier. Again, such filters must not attenuate frequencies below 125 c/s to any extent.

Sometimes it is necessary to introduce relays in the system. Most telegraph engineers shudder at the thought of relays in teleprinter systems and there is, of course, no doubt that they must introduce some distortion, since the relay tongue cannot move from one contact to another in zero time. If, however, the correct type of relay is used, and is properly adjusted, the distortion can be kept small, and since the alternative to a mechanical relay is often some comparatively complicated valve-trigger circuit, a relay may well be chosen, subject to correct type and adjustment as already stated. High speed relays will operate satisfactorily at 100 c/s and will introduce negligible distortion on a 50 baud system.

When we come to consider what happens to the signal during its passage from one place to another, by radio, we find that propagation conditions can also introduce distortion. This will be discussed more fully later on.

Practical transmission of teleprinter signals over "line" will not, as already stated, normally concern the amateur. The effect of bandwidth upon distortion of signals will, of course, be exactly the same whether we are considering a line or a radio link. The next step, therefore, will be the choice of a suitable radio-link system—one which will carry frequencies up to 125 c/s and also—and this is equally important—maintain the d.c. component as well. We have not mentioned this up till now, since direct "line" connection or connection via relays will automatically preserve this. The zero frequency requirement is just as important operationally as the upper frequency requirement, since, when the printer is "at rest" the continuous Mark signal must be conveyed to the receiving printer, as it is the presence of this "Mark-Hold" that prevents the receiving printer from racing, holding it in readiness for printing.

The choice of the best radio-link system and the method by which signalling is effected will be the subject of the next article.

A Real Miniature

continued from page 853

An aerial socket is fixed to the end of the set next to the hole ($\frac{1}{16}$in) drilled for the earphone lead. Excellent results are obtained with about 9in of heavy gauge copper wire plugged into the socket as an aerial. In poor districts, however, it may be necessary to use a slightly longer aerial.

Improved performance may be obtained by inserting an external inter-transistor transformer in the earphone lead as shown in Fig. 2. When the transformer is employed sufficient aerial pick-up will be achieved in some districts by merely touching the aerial socket with a finger.

A hole drilled into the sliding lid of the box above the trimmer condenser enables a screwdriver to be inserted to tune in the local station. In strong signal strength areas, overloading of the earphone may be offset by slightly detuning the receiver.

This little set has been used with considerable success both at home and on the Continent.

RADIO topics

BY RECORDER

THE EXIGENCIES INVOLVED IN MAGAZINE production are such that I was unable to read my predecessor's final remarks in the April issue, until I had completed my own first contribution. As readers will remember, "Commentator" took over from "Centre Tap" due to the latter's ill-health. I need hardly say that we all look forward to seeing "Centre Tap" take up his rightful position in these columns again.

"Commentator" also said that I will not mind in the least if readers disagree with my views—that is quite definitely true. There's nothing like a bit of an argument every now and again to keep things up to the mark!

A Naughty Story

One of the things I have continually told people over the years is that the trimmers mounted on the chassis of a television turret tuner should on no account ever be touched. These trimmers are set up at the factory with special equipment, and the tuner should always be returned to the makers if they need to be reset.

Recently, however, and without benefit of anything more elaborate than a testmeter, I broke this rule. I had just come by a rather old television receiver which happened to be one of the first models introduced, by the manufacturer concerned, for Band III reception. The turret drum had all the Band I coil segments fitted, together with those for Channels 8 and 9. I wanted the receiver to operate on Channels 5 and 10, but my attempts to obtain a set of Channel 10 coils were unsuccessful. Apparently, only a few tuners of the type concerned had been made, and spares were well-nigh impossible to obtain.

I decided that the best thing I could do was to try and retune the Channel 9 coils already in the tuner to Channel 10 myself. To my gratification, the process turned out to be quite simple, and it gave very satisfactory results. I first of all connected an aerial to the receiver in which the tuner was fitted and switched the latter to Channel 9. My next problem was to raise the frequency of the Channel 9 oscillator coil by the necessary 5 Mc/s to bring in Channel 10. Unfortunately, the brass core in the oscillator coil did not have sufficient tuning range for this step-up in frequency, and so I removed the Channel 9 oscillator and band-pass segment from the turret then experimentally "opened out" the oscillator coil a little. This still did not provide the desired increase in frequency and, reflecting that the inductance of a straight piece of wire is important at Band III, I therefore disconnected one end of the coil from its tag, shortened it by approximately 1/10in, and soldered it up again. That did the trick! I was now able to get the transmitted Channel 10 signal bang in the middle of the fine tuner sweep with, as it so happened, the brass slug of the oscillator coil fairly near the centre of its tuning range.

The Channel 10 picture I received was rather noisy, and so my next job consisted of getting the r.f. tuned circuits resonating at Channel 10 as well. The r.f. circuits in the tuner were quite conventional, consisting of a single tuned coil between the aerial and the cascode input grid, and a band-pass pair between the cascode output anode and the signal grid of the mixer. The coupling between the coils in the band-pass pair is, in most tuners, extremely critical, being designed to give a band-pass response which is just about 4 to 6 Mc/s or so wide at the "3dB down" points. I decided therefore that I would be asking for trouble if I started pulling the individual coil turns around as I had done with the oscillator coil; such a process would almost certainly completely upset the coupling factor existing between them.

In a conventional tuner, as this was, both coils of the band-pass pair are connected to chassis trimmers, and I decided to see if I could adjust these to tune the coils up to Channel 10, the idea being that such an adjustment should not upset the coupling factor between them overmuch, and that the change in trimmer capacity should not adversely affect Channel 5. The process turned out to be a complete success. I adjusted both trimmers for optimum picture on Channel 10 (finishing off adjustments with an inefficient aerial—actually a few feet of wire plugged into the centre connector of the aerial socket—to cause the set to work at maximum sensitivity), and discovered that the requisite 5 Mc/s shift was well within their tuning range. I then switched back to Channel 5, returned the trimmers to their original setting whilst observing the Channel 5 picture, and found that (even with the inefficient aerial), the change in trimmer setting had not the slightest effect on reception of this channel. I returned the set to Channel 10 and reset the trimmers to their new position, comforted by the feeling that no visible degredation of picture would result on the very much lower-frequency Channel 5.

Finally, I gave the Channel 9 aerial coil core a tickle to bring it up to Channel 10. Tuning here was rather flat, but I was able to find a position of optimum signal strength within the tuning range of the core.

And so the job was completed. The set has, incidentally, been working perfectly since I made the modification. A minor point is that, after I had got the Channel 9 coils working on Channel 10, I slipped them into the vacant Channel 6 position on the turret, so that it was only necessary to index the turret from one position to the next when changing from Band I to Band III.

I must confess that I had some doubts before I started on the conversion of the tuner as to whether I wouldn't wreck it in the process. And I must point out that this is certainly not the sort of treatment you can give to *all* television tuners: a few of these are liable, indeed, to break into instability if the band-pass trimmers are moved. However, I had the alternatives of attempting the modification or having a useless tuner on my hands, and I feel that my actions were justified.

Before I adjusted the trimmers, by the way, I took great care to make a note of their positions. Not only did I count the number of threads protruding above the chassis on the adjusting screws but I even recorded the angles of the screwdriver slots as well. Nothing like being safe!

Coin-in-the-Slot TV

I see that coin-in-the-slot television has been launched in Canada. The company backing this project, Trans Canada Telemeter Ltd., has set up a production centre in a Toronto suburb. Programmes (or a de-scrambling signal) are sent out on telephone wiring to the subscribers' homes. The programmes carried are mainly current films uninterrupted by advertisements, it being felt that viewers would prefer to see such films in the comfort and privacy of their own homes rather than in the cinema. The fee for a full-length film is less than a dollar, and there is an installation charge (for, amongst other things, the coin-box which takes the money!) of five dollars.

According to newspaper reports the scheme looks like being a success. American viewers are, apparently, more than fed up with the old films that make up part of their normal television diet, and are suffering also from a surfeit of commercials. In addition, it is still cheaper to see a new film on the telly at home, after putting the requisite coins in the slot, than to go to the local cinema.

This sort of venture always raises doubts in my mind. From the purely technical point of view, what happens for instance if the receiver develops an intermittent fault just after a programme has started, the intermittent clearing when a representative from the programme company appears? From the entertainment point of view, is the same amount of enjoyment to be obtained from watching a monochrome picture on a small screen as distinct from watching it in colour on a full-size cinema screen? Again, if CinemaScope films are to be presented, with the CinemaScope aspect ratio, won't the fact that only some two-thirds of the lines actually carry the picture (the remainder being blacked off), result in seriously reduced vertical resolution? There certainly seems to be a lot of snags in the scheme which would put *me* off, for a start.

The feature I think most unattractive is, however, rather more difficult to explain. It has to do with the fact that one has to pay, by the hour, for something which one has become used to obtaining for nothing (apart from, say, a licence fee), by the simple process of sticking an aerial up in the air. Admittedly, in the Toronto case, it appears that the pictures are sent by wire and so my objections don't hold full strength. Other schemes, nevertheless, including one if I remember correctly voiced in Britain several years ago, consist of putting scrambled pictures *on the air*, the viewer having to put his coins in the slot to obtain the requisite number of hours' unscrambling time. I definitely object to this latter idea. The airways should be free.

Ham Hop Club

And, finally, a few brief words about the International Ham Hop Club, these being culled from a letter received from the Hon. Gen. Sec., Mr. G. A. Partridge, G3CED.* Membership of the I.H.H.C. now totals 341 members in no less than 37 countries. Two prominent members of the Club are visiting Europe this year to carry out extensive Ham Hop tours. One, Mr. John F. Dormois, W0GDH, of Kansas City, the Club's World President, arrives in May; whilst Mr. K. Mitchell, ZS1IR, National Representative for South Africa, arrives in England in May and will be touring through most European countries. I feel that the I.H.H.L. is doing yeoman service in spreading the true amateur spirit, and I wish them the best of success in the future.

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* Radio amateurs interested in exchange holidays should refer to the I.H.H.C. advertisement elsewhere in this issue.

International Co-ordination of Time and Frequency Services

IT HAS BEEN AGREED BY THE AUTHORITIES concerned that the Time and Frequency transmissions of the United States and the United Kingdom shall be co-ordinated.

The purpose of this synchronisation is to provide a uniform system of time and frequency transmissions, which is needed in the solution of many scientific and technical problems in such fields as radio communications, geodesy, and the tracking of artificial satellites.

Participating in the project are the Royal Greenwich Observatory, the National Physical Laboratory, and the Post Office Engineering Department in the United Kingdom, and, in the United States, the U.S. Naval Observatory, the Naval Research Laboratory, and the National Bureau of Standards. This programme follows previous co-operative efforts of these agencies to achieve uniformity and simplification in procedures.

The transmitting stations which are included in the co-ordination plan are GBR and MSF at Rugby, England; NBA, Canal Zone; WWV, Beltsville, Maryland; and WWVH, Hawaii.

Co-ordination began in January. It is expected that by the end of 1960 the time signals from all the participating stations will be emitted in synchronisation to one thousandth of a second. Such accuracy has been needed for some time in tracking artificial satellites on a world-wide basis.

The following time signal services are involved:

U.K.	Rugby, GBR, 16 kc/s.
	Rugby, MSF, 2.5, 5 and 10 Mc/s, 60 kc/s.
U.S.A.	Beltsville, WWV, 2.5, 5, 10, 15, 20, 25 Mc/s.
	Canal Zone, NBA, 18 kc/s.
	Hawaii, WWVH, 5, 10, 15 Mc/s.

Rugby GBR

The service of international radio time signals controlled by the Royal Observatory, and transmitted by the Post Office radio station GBR at Rugby on a frequency of 16 kc/s, was inaugurated in 1927. Since 1942, the signals have also been emitted by various short-wave transmitters in order to ensure, in association with GBR, a reasonable measure of world coverage. The frequencies employed are changed as required every two or three months in accord with the predicted ionospheric conditions. The signals comprise a five-minute series of seconds dots (approximately one-tenth of a second long), with the minute signals lengthened (approximately half a second long), from 0955 to 1000 G.M.T. and from 1755 to 1800 G.M.T. Each transmission is preceded by a morse announcement (GBR BGR TIME four times) and a tuning dash. The GBZ transmitter at Criggion (19.6 kc/s) serves as a standby in case of non-availability of GBR.

Rugby MSF

The MSF standard frequency transmissions have been in operation since 1950. Transmissions on 2.5, 5 and 10 Mc/s are continuous except for a break between 15 and 20 minutes past each hour. In addition, there is a transmission on 60 kc/s from 1429 to 1530 G.M.T. The present MSF schedule provides in each quarter hour ten minutes of seconds pulses (the minute pulses being lengthened), four minutes of unmodulated carrier, and one minute of speech announcement. The pulses consist of five cycles of the 1000 c/s tone, which is derived by dividing the frequency of the quartz ring standard controlling the carrier wave. They thus have the full precision of this standard and the rate defined by the time signals corresponds to the carrier frequencies.

Co-ordination of GBR and MSF

The carrier frequencies of all the MSF transmitters and also of GBR are controlled by the same ring crystal oscillator and are calibrated to an accuracy of ± 2 in 10^{10} by the caesium standard at the National Physical Laboratory.

From 1st April the master oscillator will also be used to control the time signal dots of GBR and its associated short wave transmitters. Owing to differences in the control circuits, there will be small differences between the times of emission of time signals on the various transmitters, but these should remain sensibly constant. It is hoped that this co-ordination between the MSF and GBR services will enhance their value and prove of great convenience to users.

The reserve station GBZ at Criggon is being equipped with control equipment to maintain the international radio time signals in case of major breakdown at Rugby.

Co-operation with the U.S.A. Services

The master oscillators controlling the carrier frequencies and time signal dots of the United States services from WWV, Beltsville, Maryland; NBA, Summit, Canal Zone, and WWVH, Kihei, Hawaii, will be adjusted to the same common standard agreed between the U.S. Naval Observatory and the Royal Greenwich Observatory. Calibration of the oscillators will be in terms of caesium standards in the U.S.A. which are compared by radio with the caesium standard at the National Physical Laboratory.

Joint Control of the Signals

Time signals must be adjusted to give the standard of time commonly employed, namely G.M.T. (Greenwich Mean Time), which is equivalent to the astronomical time called U.T.2 (Universal Time 2). Complications arise from the fact that U.T.2 is not strictly uniform but is subject to small unpredictable changes. The frequency of a caesium standard remains unchanged, but if the frequency is measured in terms of U.T.2 (cycles per U.T.2 second) the measures will show light variations owing to the small irregularities in the length of the second of U.T.2. Towards the end of each year, the U.S.N.O. and R.G.O. will assess the frequencies of the U.S. and U.K. caesium standards in terms of the current value of U.T.2 as determined by astronomical observations. These values will be adopted and used in both countries for the control of the frequencies of the radio transmitters and the "rate" of the time signals.

During the year, unpredictable variations in U.T.2 may lead to a divergence between the radio time signals and U.T.2. The time signals will be kept in step with U.T.2 by means of adjustments of 50 milliseconds made simultaneously on all transmissions, when required, at 0000 G.M.T. on the first of a month. It is not anticipated that the number of adjustments will normally exceed two per year.

Corrections to the time of emission of the time signals will, as formerly, be determined independently by the U.S.N.O. and R.G.O. and published in the respective Bulletins.

Astronomical Observations

Astronomical observations for the determination of time are made at the R.G.O. with a photographic zenith tube, and by the U.S.N.O. with similar instruments, but differing in detailed design, at Washington and Richmond, Florida. The instrument at Herstmonceux was designed by the Observatory in collaboration with Sir Howard Grubb, Parsons & Company Ltd., who made it and have since produced similar instruments for observatories elsewhere. It has been in regular use since November 1955. All essential parts were designed to keep the instrumental errors within a tolerance of one millisecond (one thousandth of a second). Experience has shown that the probable error of a typical night's work, including instrumental errors, the uncertainties arising from errors in the tabulated positions of the stars and from atmospheric irregularities, is about 3 milliseconds.

Clocks

The P.Z.T. observations are used to assess the errors and rates of the master clocks, which are housed in individual temperature controlled cellars under the new West Building at Herstmonceux. All the clocks are of the quartz crystal type, and they are automatically checked, not only among themselves, but also with similar quartz clocks at the N.P.L. and at the P.O. Laboratories, which are connected to Herstmonceux by permanent Post Office lines. Comparisons made at the N.P.L. between the quartz clocks and the caesium atomic resonator are used in comparing the astronomical observations with the caesium frequency standard.

Radio reception and time measuring equipment in the Time Service Control Room at Herstmonceux is used to monitor the radio transmissions and thus to determine the errors of the radio time signals.

Conclusion

It is hoped that the new co-ordinated service will prove of great convenience and value to the many users of precision time signals. The surveyor working overseas and the scientists tracking artificial satellites will have a wide choice of transmissions available. When conditions make it difficult to use a particular signal, they will be able to tune to one of the other co-ordinated transmissions, knowing that both are referred to a common system.

TOBACCO TIN UNITS

by R. S. Wood

Unit 1. Transformer Unit for Carbon and Moving Coil Microphones

EMPTY 2OZ. TOBACCO TINS MAKE VERY convenient cases for small units. The size is approximately 4¼in x 3in x ⅞in, and if the depth is insufficient, two tins can be joined together lid to lid with small nuts and bolts at the corners.

Small holes are best made with a twist drill after centre-punching, but as the material is rather thin it is wise to support it on a piece of scrap wood while drilling. Larger holes can be made with a punch or, if this is not available, by using a twist drill, opening the hole out with snipe-nosed pliers or any tapering piece of metal to the required size and then removing the burr with a rat-tail file.

The connections on my units are jack plugs and sockets, but co-axial plugs and sockets are equally suitable.

The transformer used in the original was taken from an ex-government headset matching unit designed to allow low impedance phones to be connected to a high impedance output. This matching unit consists of a jack socket, the "business end" of a jack plug and the transformer which is contained in a cylindrical metal casing with two tapped holes in the base for fixing and three leads projecting from a paxolin top. The three wires are clearly marked: Yellow wire marked "L" (low impedance), Red wire marked "H" (high impedance), and the Black wire marked "G" (Ground or Earth).

This transformer is just a little too large to allow the lid to close, so it is advisable to drill the fixing holes a little oversize. Gentle hammering of the metal casing will also help to make it fit (but don't overdo it!).

After drilling the base ends of the tin as shown in Fig. 2, the transformer should be mounted with a solder tag on the inside of the tin, held by the screw nearest to the grommet for the output lead. This solder tag will act as an anchorage for the braiding of the output lead.

S_1, S_2 and the input jack socket are now fitted in position and wired as follows: from the "earthy" side of the input socket and the black wire (G) of the transformer to the solder tag, from the insulated side of the input socket to one side of S_2 and thence to the centre pole of S_1. The centre wire of the output lead is connected to the red wire (H) of the transformer and the braiding soldered to the solder tag.

Two fairly stiff pieces of insulated wire should now be soldered to the bulb, one to the brass casing and the other to the solder blob, and the whole of the base of the bulb well covered with insulating tape. One of

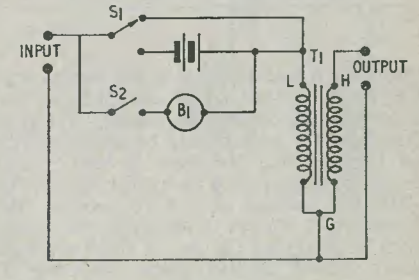

FIG. 1

THEORETICAL CIRCUIT

Components Required

S_1—1-pole 2-way switch
S_2—On-off switch
T_1—Microphone transformer (see text)
B_1—3.5V m.e.s. bulb
3 volt battery (Ever Ready No. 1839)
Screened lead
J_1—Jack socket
2 rubber grommets
Connecting wire
1 hinged 2oz. tobacco tin

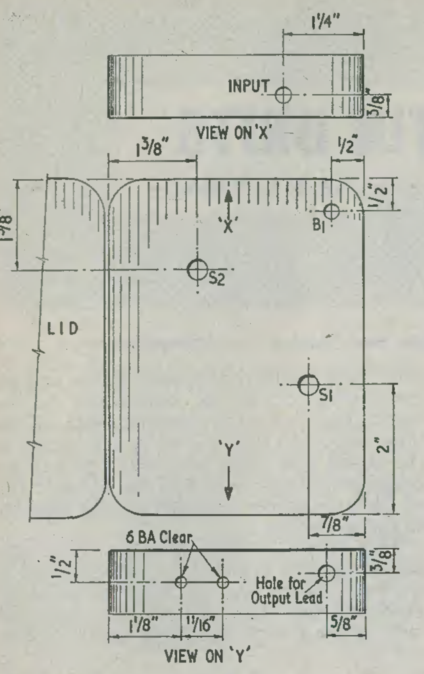

FIG. 2

CHASSIS AS SEEN FROM BASE OF TIN

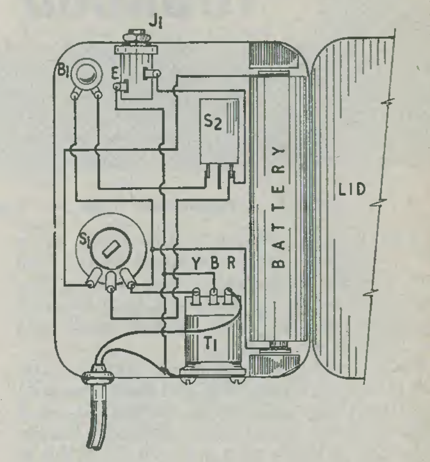

FIG. 3

COMPONENT LAYOUT AND WIRING

these wires is then soldered to the vacant side of S_2 and the other to one side of S_1 to the yellow wire (L) of the transformer. The two wires from the bulb should be cut to length and bent so that the bulb is held in an upright position facing the rubber grommet.

All that remains now is to connect the battery which should fit snugly in the space at the hinge side of the tin. A small piece of sponge rubber (rubber carpet underlay is ideal) is stuck to the tin at each end of the battery space; this performs the dual purpose of insulating the battery connections from the case and providing sufficient pressure to ensure that the two cells inside the cardboard tube are in contact. Two wires are now connected to the outside poles of S_1, one being taken to L and one end of the battery, and the other to the free end of the battery.

To ensure that the bulb stays in position, another small piece of sponge rubber is stuck to the inside of the lid opposite the bulb grommet, and the unit is now complete.

The operation of the unit is obvious from the circuit diagram (Fig. 1): with S_1 in the upper position, a moving coil microphone plugged into the input socket is connected across the primary winding of the transformer; and with S_1 in the lower position, a carbon microphone is connected to the primary via the energising battery. With S_1 in the lower position, S_2 and the bulb will give a visual check on the battery.

The unit can also be used to match low impedance headphones to a high impedance output when S_1 is in the upper position.

Unit 2. Crystal Set or Tuner

The tuner consists of an acceptor circuit in the aerial lead followed by a normal rejector circuit and crystal diode. The value of the trimmers is best found by trial and error. The coils are mounted with 6BA nuts and screws and are offset from the inside of the tin with three washers to allow clearance for the tensioning washer for the adjustable iron core. The iron core adjustment in the coils is terminated by a hexagonal head, but a saw-cut across this will allow screwdriver adjustment.

Connections are as follows: join from the aerial socket to the top of C_1, from the bottom of C_1 to the top of L_1, from the bottom of L_1 to the top of L_2 and thence to the top of C_2, from the bottom of L_2 to the earth socket, thence to the bottom of C_2 and thence to the "earthy" side of the jack socket. The crystal diode is now connected between the top of C_2 and the insulated side of the jack socket.

Tuning is carried out by first joining the aerial to the junction of L_1 and L_2, and adjusting the core of L_2 and the trimmer C_2 for maximum volume. Then connect the aerial to the aerial socket and adjust the core of L_1 and the trimmer C_1.

When using this unit as a tuner for an amplifier with an earthed chassis, there is no need for an earth connection to the earth socket of the unit as this will be made through the braiding of the screened connecting lead.

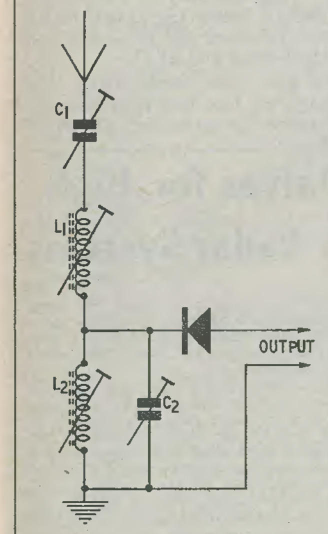

FIG.4

THEORETICAL CIRCUIT

Holes A & E are drilled to take wander plug sockets
Holes Y & Z — 6 BA clearance
Holes Y spaced for fixing twin trimmer
Holes X 5/16" dia spaced for trimmer adjustment
Holes C 5/16" dia for iron core adjustment
Hole J for Jack Socket

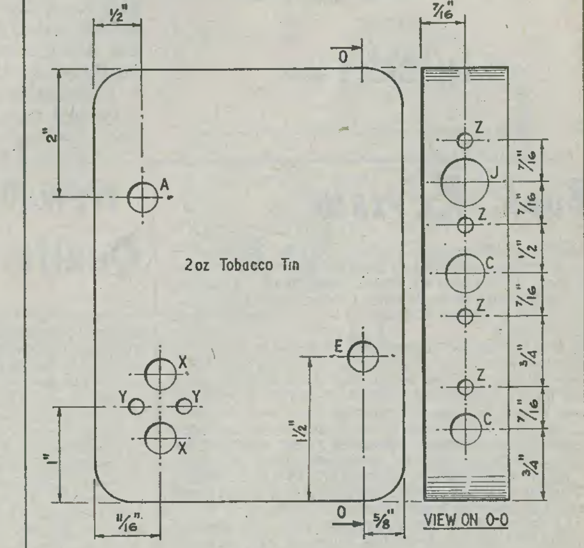

FIG.5

CHASSIS AS SEEN FROM THE BASE OF THE TIN

Components Required

L_1 and L_2—M.W. coils with adjustable iron core (obtained from J. E. Annakin, 25 Ashfield Place, Otley, Yorks.
C_1 and C_2—Twin trimmer—250–500pF per section.
Germanium crystal diode—GEX34 or similar
Jack socket
6BA nuts, screws and washers
1 snap-lid 2oz. tobacco tin

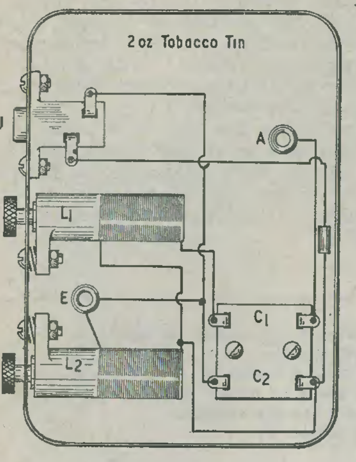

FIG. 6

COMPONENT LAYOUT & WIRING

Unit 3. Tone Control Unit

This is based on the Mullard 5–10 tone control circuit and will fit neatly into two snap-lid tins joined lid to lid.

The two lids are first fixed together, back to back, with a 6BA nut and screw in each corner and with two half-inch holes made at one end; the rough edges of these should be covered with grommets or adhesive tape to protect the leads from the tagboard to the controls and input jack socket.

Holes are now drilled in one of the tins as shown in Fig. 9 and the two potentiometers and jack socket fitted. Only one hole is made in the other tin, and this is drilled to correspond with the jack socket hole. This hole is grommeted to take the output lead.

The tagboard is now assembled as shown in Fig. 8 and bolted to one side of the double lid, with the C_1 end clear of the two half-inch holes and with the underside of the tags insulated from the tin with sponge rubber or insulating tape. The tins may be earthed by taking a lead from a solder tag under one of the fixing screws to either the left-hand end of R_6 or the right-hand end of C_2.

Connections are now made from the tagboard through the two half-inch holes to the bass and treble controls and the input socket. The lids and the tin with the controls are now snapped together so that the leads from the tagboard emerge on each side of the input socket. All that remains now is to connect the screened output lead to R_2 and C_2, lead it through the grommet and snap the lot together.

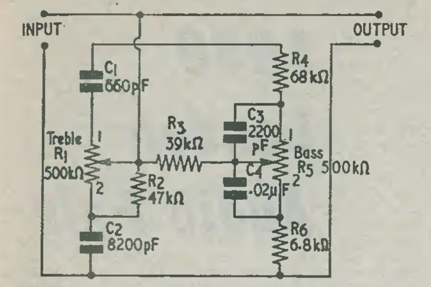

FIG. 7

THEORETICAL CIRCUIT

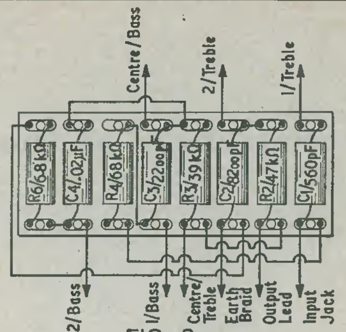

FIG. 8

TAGBOARD CONNECTIONS

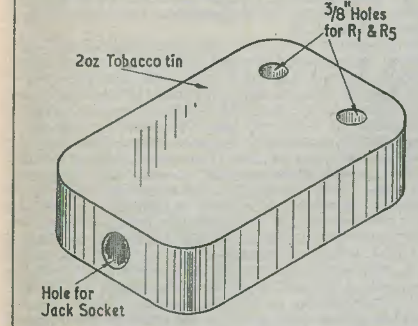

FIG. 9

UNIT 3—TONE CONTROL UNIT

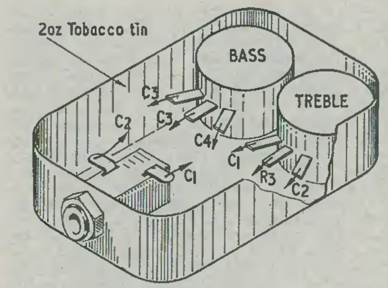

FIG. 10

G618

This unit can be used to control both bass and treble when feeding an amplifier from a radio tuner, electronic organ, electric guitar and even a crystal tuner, provided that the amplifier has sufficient reserve to compensate for the inevitable losses in the control unit.

Components Required

R_1—500kΩ variable
R_2—47kΩ
R_3—39kΩ
R_4—68kΩ
R_5—500kΩ variable
R_6—6.8kΩ
C_1—560pF
C_2—8,200pF
C_3—2,200pF
C_4—0.02μF
8-way tagboard
6BA nuts and screws
1 Jack socket
Screened lead
Connecting wire
Rubber grommet
2 Snap-lid 2oz. tobacco tins

Book Review

BASIC AUDIO (Vols. 1, 2 and 3). By Norman H. Crowhurst. Published by John F. Rider Publisher Inc., 116 West 14th Street, New York. Available in England from Messrs. Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price 23s. each volume.

It is the usual practice of this reviewer to count the diagrams, drawings, illustrations or photographs in books he has to write about, but when this group of three books was looked through with that purpose in mind, it soon became obvious that there were so many of them that readers might think the books consisted of nothing but pictures! Just the same, much of the reading has to be done by examining clever drawings, lots and lots of them and often several to a page, which, it must be conceded, convey meanings or amplify what the text explains in a most ingenious manner.

The author is no mean exponent when it comes to tackling the task of discussing audio in any shape or form—he has been doing it for a long time both in this country and in America, so this latest production carries the full weight of his knowledge and experience. The three volumes have 114, 122 and 113 pages respectively. Each of them can be obtained separately and read as such, though it is, of course, better to have all three together.

The first volume deals with the nature of sound, acoustics, microphones, loudspeakers, baffles, horns, impedance matching, crossover networks and multiple speaker systems, resonance and response.

In the second volume the subjects covered are audio amplification, transistorised circuits, interstage coupling, noise and distortion, frequency response, power amplification, push-pull stages, phase splitter circuits and audio transformers.

The third volume completes the treatise by discussing feedback fundamentals and applications, power supplies, shielding, audio transmission lines, audio oscillators, recording, electro-acoustics, and stereophonic sound.

W. E. THOMPSON

New Valves for High Quality Radar Systems

A new "Q"-band magnetron and a new "X"-band klystron, both intended for use in high quality radar systems, have been introduced by Mullard and were shown for the first time at the Instruments Electronics and Automation exhibition.

The magnetron, type JP35-80, has been designed for very short pulse operation and is especially suitable for high-definition, short range radar. It operates at a fixed frequency in the range 34.512 Gc/s to 35.208 Gc/s, and will deliver a nominal peak power output of 80kW (60kW minimum) at a pulse current of 17.5A.

Features of the valve are its low anode voltage requirements (maximum pulse voltage is 17kV); the use of a dispenser type cathode to help ensure a long working life; and the incorporation of a getter to provide good shelf life.

The design of the waveguide output system and mounting flange enables the valve to be used in applications requiring a pressure seal. A low velocity air flow is sufficient for cooling purposes. The valve is packaged, and has an overall weight of 7.5lb. Its physical dimensions are 20.1cm x 10.1cm x 13.5 cm.

The klystron, type KS9-30, is designed primarily for use as a local oscillator in high quality "X"-band radar systems. It has a wide mechanical tuning range of 8.5Gc/s to 9.6Gc/s and over this band will deliver a minimum output of 30mW.

Features of the KS9-30 are its rugged construction and high frequency stability. The latter is achieved chiefly through the construction of the tuning cavity, which, although an integral part of the valve, is external and thus is isolated from the effects of variations in beam current.

The KS9-30 is electrically and mechanically equivalent to the American type VA203B.

A Constructor at the 1960 London Audio Fair

THE LONDON AUDIO FAIR OCCUPIES ITS OWN SPECIAL niche amongst the electronic exhibitions which are held in this country. Not only does it cater for the requirements of the engineer but it also attracts the attention of the serious musician. It is in the field of high fidelity reproduction that the art of music and the science of electronics are amalgamated, the Audio Fair having the unique distinction of catering equally for both the interests which make up this composite whole.

This year's Fair was opened by Julie Andrews at the Hotel Russell, in Russell Square, on Thursday the 21st April. The now familiar presentation pattern common to the previous Fairs was employed: exhibitors had stands, or "booths", on the ground floor of the hotel, where they displayed their products and handled many of the technical and sales queries, whilst the individual rooms on the first, second and third floors were devoted to demonstrations of the equipments. The rooms at the Hotel Russell are comfortably large being well suited for this purpose. There did not appear, during the time of the writer's visit at any rate, to be so much jamming and crowding as has been evident in previous exhibitions of this type.

As is always the case at the Audio Fair, all the equipment shown was of a quality which ranged from good to truly excellent. Speaking in general terms, the exhibits followed the audiophile's rule-of-thumb dictum: the performance of audio equipment being roughly proportional to its cost, a statement which, as readers of this magazine will immediately point out, carries the proviso that the home-constructor obtains a special discount not available to his fellow enthusiast who buys his equipment factory made!

Stereo

As was to be expected, stereophonic reproduction took pride of place at the Fair. The basic format of stereo amplifier design is very similar to that of monophonic equipment, in so far that it is usual to have a main power amplifier preceded by a small control unit, or pre-amplifier, providing all the necessary controls. Two-part stereo amplifiers were exhibited, amongst others, by C. T. Chapman (Reproducers) Ltd., Rogers Developments (Electronics) Ltd., H. J. Leak & Co. Ltd., The Lowther Manufacturing Co., Armstrong Wireless and Television Co. Ltd., and Jason Motor and Electronic Co. Stereo equipments which had the main amplifier, pre-amplifier and control circuitry housed in a single cabinet were shown, again amongst others, by Pamphonic Reproducers Ltd., Trix Electrical Co. Ltd., and, once more, Jason Motor and Electronic Co. Mullard Ltd., well known to the amateur constructor for their amplifier designs, exhibited a wide range of their high fidelity equipment. In all instances, manufacturing finish and appearance were of a very high order. Particular attention to styling has, for instance, been paid to the Leak equipment, this company's "*Point-One*" Stereo Pre-amplifier having been especially designed for easy cabinet fitting. The front panel has a considerable overlap over the backward protrusion of the chassis, with the result that rough edges on the cabinet cut-out made to accept it are completely masked. The pre-amplifier is capable of being secured in place within thirty seconds by means of a special U-bracket and wing nut. There are no fastenings visible from the front. The Rogers Development Mk. II Stereo Control Unit employs push-button selection of programme source and, here again, styling is of a high order, the unit having been selected by the Council of Industrial Design for Design Index and for display in the Design Centre. The two-gang volume control on the Rogers unit has both tracks matched within 1dB.

An integrated (i.e. main and pre-amplifier in one housing) stereo amplifier not mentioned above was shown by Teppaz S.A. of France. This has the interesting feature that an approximation to the response curve offered by the amplifier is visible from the front in the form of a "curve" superimposed on a graph. A transparent rectangular window, rather like that of a tuning scale, is let into the front panel, behind which is fitted a scale whose vertical co-ordinates represent gain and whose horizontal co-ordinates represent frequency. Immediately in front of the scale is a white plastic covered springy wire which is fastened securely at the centre of the scale and which extends to either end. When the tone controls are in the centre of their travels, this wire, which provides the response "curve", is horizontal along its whole length and indicates equal amplification at all frequencies. When either the treble or bass tone controls are adjusted from their central positions the wire at the appropriate end of the scale is automatically raised or lowered, whereupon the resultant "curve" approximates to the response resulting from the altered tone control setting. A rather surprising incidental feature of the Teppaz equipment is the use of sliding instead of rotational controls. The volume control on the Teppaz stereophonic amplifier, for example, is provided by a knob which projects from a long horizontal slot extending over nearly a third of the front panel width. Volume is then adjusted by sliding this knob to the left or to the right. A slot of equal width is used for the balance control.

An interesting exhibit from Wellington Acoustic Laboratories was a transistorised stereo pre-amplifier for insertion between modern moving-coil or magnetic pick-ups and amplifiers having insufficient gain for the low outputs offered. This pre-amplifier houses its own 9-volt battery supply, and the only control provided is an on-off switch. (A socket is fitted for remote switching, if desired.) A special low-noise circuit is used and, due to the integral battery supply, there is no difficulty with hum pick-up. It is claimed that battery life under normal conditions of use is commensurate with shelf-life. The frequency response of the pre-amplifier is within 0.5dB from 25 c/s to 25 kc/s, with a balance between channels of better than 1dB and a cross-talk ratio of -60dB at 1,000 c/s. A gain of 38dB in either channel is available with low impedance inputs and the two separate channels may be employed to handle independent mono signals from sources other than pick-ups.

A somewhat unconventional departure from normal stereo speaker and enclosure design was exhibited by Lowther Manufacturing Co. The Lowther reproducer, described as the "*Acousta-Twin*", employs two of their PM6 units in a single cabinet. These two speakers work into completely separate folded horns whose "mouths" appear at the top rear corners of the cabinet on the left and right sides. Thus, the sound from each channel is projected to right and left-hand sides of the cabinet. Fitted behind the horn apertures are Perspex reflectors which may be folded against the sides of the cabinet when not in use, or opened out at right angles for stereo reproduction. A proportion of each speaker output is projected backwards and upwards from the top rear of the cabinet, adjustable reflectors to assist in directing the sound again being provided. In use, the "*Acousta-Twin*" is intended to be positioned against the centre of a wall, whereupon the left and right-hand lobes of sound are partially reflected into the room, the smaller amount of sound projected from the rear top of the cabinet tending to diffuse the channels more smoothly over the apparent sound source area than would be provided by the use of two side apertures alone. The basic principle of operation was described to the writer by a Lowther representative as "reproducing at the speaker the lobes of the stereo microphone".

Standard Telephones and Cables Ltd. were active at the Fair, one of their exhibits being a 3-valve stereo amplifier suitable for the home constructor. This amplifier takes advantage of a newcomer to the Brimar range of valves, the ELL80. The ELL80 is a double output-pentode and, in combination with a 12AX7 double-triode and an h.t. rectifier, enables stereo amplification to be obtained with three valves.

Tape Recording

There was evidence of considerable interest in tape recording at the Fair, and a large number of complete equipments, intended for professional or domestic applications, were shown.

In the professional class were the single-channel Ampex 601 portable recorder, and the 601-2 double-channel portable recorder. Also intended for double-channel is the Ampex 351-2 equipment which operates at 15 in/sec as against the $7\frac{1}{2}$ in/sec of the recorders previously mentioned. A fascinating demonstration of three-channel stereo, using the Ampex 300-3 equipment was also given. The Reflectograph Professional-Type tape recorder and the newly introduced Reflectograph Model B recorder were shown by Multimusic. The Model B recorder will reproduce stereo with the aid of an additional amplifier. The recording of stereo is not possible with this unit at present but it is stated that simple conversion facilities will be available at a later stage. Similarly within the professional category is the Ferrograph "Tape Deck". This very well-known unit has the same above-panel basic layout familiar to those who have handled it in the past, and the current model features, amongst other things, an accurate cue indicator scaled in revolutions of the take-up reel, a head-cover which hinges back by 90 degrees to further simplify tape loading, and a third head position which is capable of taking standard or stereo heads. The 3-motor principle is retained.

A fascinating field was offered by miniature transistorised recorders. Notable among these was the Steelman Transitape unit which employs seven R.C.A. 405 transistors and three crystal diodes. Recording speeds are $1\frac{7}{8}$ in/sec and $3\frac{3}{4}$ in/sec, the latter giving a frequency response of 150 c/s to 7.5 kc/s. A crystal microphone is employed and playback is possible via a 4in speaker incorporated in the unit, personal phones, or an external speaker. Six mercury cells are employed for the amplifier circuits, and seven for the tape deck motor. A separate mains adaptor can be fitted to the recorder thus conserving the batteries when mains supplies are available. Overall dimensions are $6\frac{1}{2}$ x $9\frac{3}{4}$ x $2\frac{7}{8}$in, and weight, less batteries, is under $6\frac{1}{2}$lb. Another miniature was exhibited by Fi-Cord Ltd. Tape speeds on the Fi-Cord recorder are $1\frac{7}{8}$ in/sec for voice reproduction and $7\frac{1}{2}$ in/sec for higher fidelity recording, whereupon the signal impressed on the tape is 50 c/s to 12 kc/s within 3dB. A small loudspeaker is fitted to the Fi-Cord for playback and monitoring, and power is provided by four 2-volt accumulators which may be recharged from the mains or a 12-volt car battery with the aid of an ancillary unit. The size of the Fi-Cord is $9\frac{5}{8}$ x 5 x $2\frac{3}{4}$in, and weight is $4\frac{1}{2}$lb.

There were a number of stereo tape recorders which fall into the "domestic" classification due to the fact that they record and play back stereo over their own internal circuits. The Ampex model 970 is in this class, its two internal speakers being positioned at either end of the cabinet with adjustable baffle reflectors to control the effective spacing and direction of sound. The Chitnis recorder type 9/S4K is also capable of stereophonic recording. In this case, however, the two playback outputs are fed to outlet sockets for connection to external speakers. Monitoring is possible via the built-in speaker.

The slowest recording speed available at the Fair? This was provided by the Stuzzi Tricorder 3-speed recorder, and was $\frac{15}{16}$ in/sec.

Other Exhibits

High fidelity reproduction would not, of course, be possible without the requisite valves and transistors. Mullard Ltd. were well to the fore in this instance. Mullard home constructor designs are well known amongst amateurs, and the capabilities of these designs were convincingly displayed in this company's exhibits at the Fair.

Also well known to the home constructor is the Jason Motor and Electronic Co., which offers many items in the form of kits at a lower cost than the completely manufactured equivalents. Typical of such kits exhibited at the Fair were the Jason Audio Generator AG10, offering 10 c/s to 100 kc/s at sine or square wave, the 23-range Valve Voltmeter EM10, the Oscilloscope OG10, and a very wide range of v.h.f. tuners, the last including switched-station models.

An instrument which aroused considerable interest was the Grampian Reproducers Ltd. "*Vibromajor Music Amplifier*", this being intended for amplification of electric guitars and the like. The Vibromajor has the novel feature of being able to apply vibrato to the signal it handles. This vibrato may be varied both for depth and frequency, the latter ranging from 5 to 15 c/s. The unit has its own speaker, together with facilities for connection to a second speaker. Peak output power is 25 watts.

Finally, mention must be made of a new development by Standard Telephones and Cables Ltd. in the v.h.f. field. S.T.C. have now introduced crystals, having frequencies 10.7 Mc/s below the signal frequencies of Band II transmitters, mounted three at a time in a single B7G glass envelope. These triple-crystal units may be employed to control the oscillator frequency of a v.h.f. receiver, the crystal frequencies offered in a single unit being applicable to the transmitters in the locality where the receiver will be used. In consequence, it becomes possible to employ the units in a receiver having switched-station selection without the complications of a.f.c.

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1T4	4/6	12AH8	10/6	DL92	6/9	EY51	9/6
3S4	6/9	12AT7	7/6	DL94	7/6	EZ40	6/6
3V4	7/6	12AU7	7/6	DL96	8/–	EZ80	6/6
5U4G	6/–	12AX7	9/–	EB91	4/6	EZ81	7/–
5Y3GT	7/6	12BH7	10/6	EBC41	9/6	PL81	13/6
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6AK6	6/6	12K8GT	13/6	ECC81	7/6	PY81	8/–
6AL5	4/6	12Q7GT	6/6	ECC82	7/6	PY82	7/–
6AM6	4/–	25A6G	10/6	ECC83	7/6	PCC84	9/6
6AT6	7/6	25L6GT	9/–	ECC84	9/–	PCF80	9/–
6BA6	8/6	35Z4GT	8/6	ECF82	11/–	PCF82	11/–
6BE6	7/6	35L6GT	9/6	ECH81	10/6	PCL82	7/6
6BR7	10/6	5763	10/6	ECH42	8/6	R19	12/6
6BW6	8/6	DAF91	6/6	ECL80	9/6	U76	8/6
6J7GT	8/6	DAF96	8/–	EF41	8/6	UBC41	10/–
6K7G	7/6	DF91	4/6	EF80	8/–	UCH42	10/6
6Q7G	7/6	DF96	8/–	EF86	11/–	UF41	10/–
6SL7GT	8/–	DH76	8/6	EF91	4/–	UL41	8/–
6SN7GT	8/6	DH77	7/6	EF92	5/6	UY41	8/–
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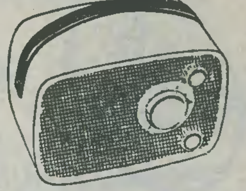

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A specially formulated alloy to reduce the wear of soldering iron bits. Contains 5 cores of non-corrosive Ersin Flux and is ideal for all soldering purposes.

SIZE 1 CARTON 5/-
Available in three specifications.

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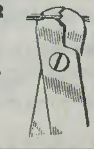

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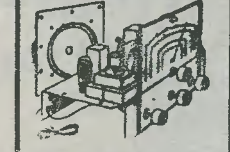

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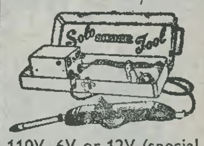

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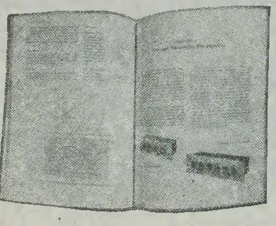

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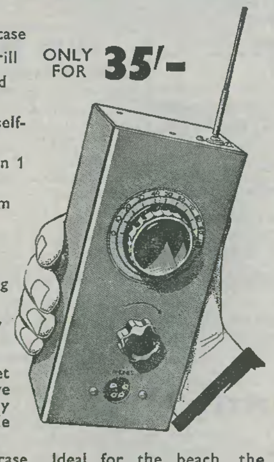

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MAJOR—2 *(Two-Transistor Pocket Radio)*

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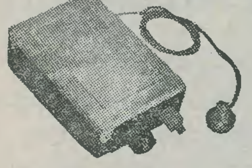

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- ★ 4-stage reflex
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- ★ $4\frac{1}{2} \times 3 \times 1\frac{1}{4}''$
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RECEPTION GUARANTEED ANYWHERE!

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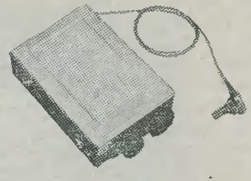

(As described in R.C., Sept. '59)

- ★ 5-stage Reflex Circuit
- ★ No Aerial or Earth
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- ★ 3 Ediswan Transistors.
- ★ Medium Wave Tuning
- ★ Size $4\frac{1}{2} \times 3 \times 1\frac{1}{4}''$
- ★ Personal phone included.

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XC101 325mW in Push-Pull	**32**/– pr.
XA104 6 Mc/s osc/mixer, R.F.	**18**/– ea.
XA103 4 Mc/s R.F., I.F. amp.	**15**/– ea.
XB104 Audio Output Driver	**10**/– ea.
XB104 Pairs, 250mW Output	**20**/– pr.
XA102 9 Mc/s osc/mixer, R.F.	**26**/– ea.
XA101 5 Mc/s, R.F., I.F., amp.	**23**/– ea.
XC131 Matched prs., 500mW	**34**/– pr.
XC141 12 Watts Push-Pull	**30**/– ea.
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SB078 20 Mc/s Short Wave, R.F.	**10**/– ea.
SB305 25 Mc/s Radio Control	**15**/– ea.
SB231 30 Mc/s Radio Control	**22/6** ea.
SB231 35 Mc/s, H.F. osc/mixer	**30**/– ea.

Above are direct equivalents of SB344; SB100; SB101, etc.

MULLARD	
OC72 Power Driver	**16**/– ea.
OC45 6 Mc/s, R.F., I.F.	**18/6** ea.
CO71 Audio Driver	**10**/– ea.
OC72 400mW Push-Pull	**30**/– pr.
OC170 70 Mc/s Short Wave	**35**/– ea.
OC139 N.P.N. 4 Mc/s	**66**/– ea.
OC140 N.P.N. 6 Mc/s	**72**/– ea.
OC16 Power Output	**54**/– ea.
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Red Spot Audio Driver	**5**/– ea.
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NEWMARKET	
V15/10P Power Output, 2 watt	**15**/– ea.
V15/20P High Gain Power	**39**/– ea.
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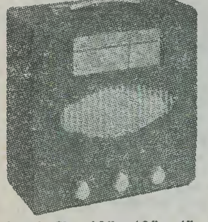

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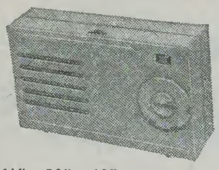

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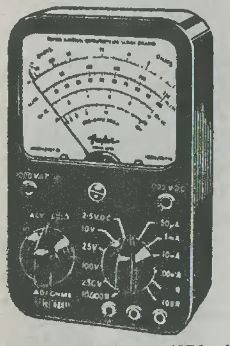

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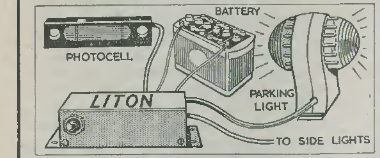

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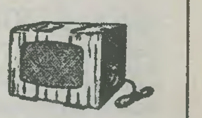

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