Practical Electronics

AUGUST 1965

PRICE 2/6

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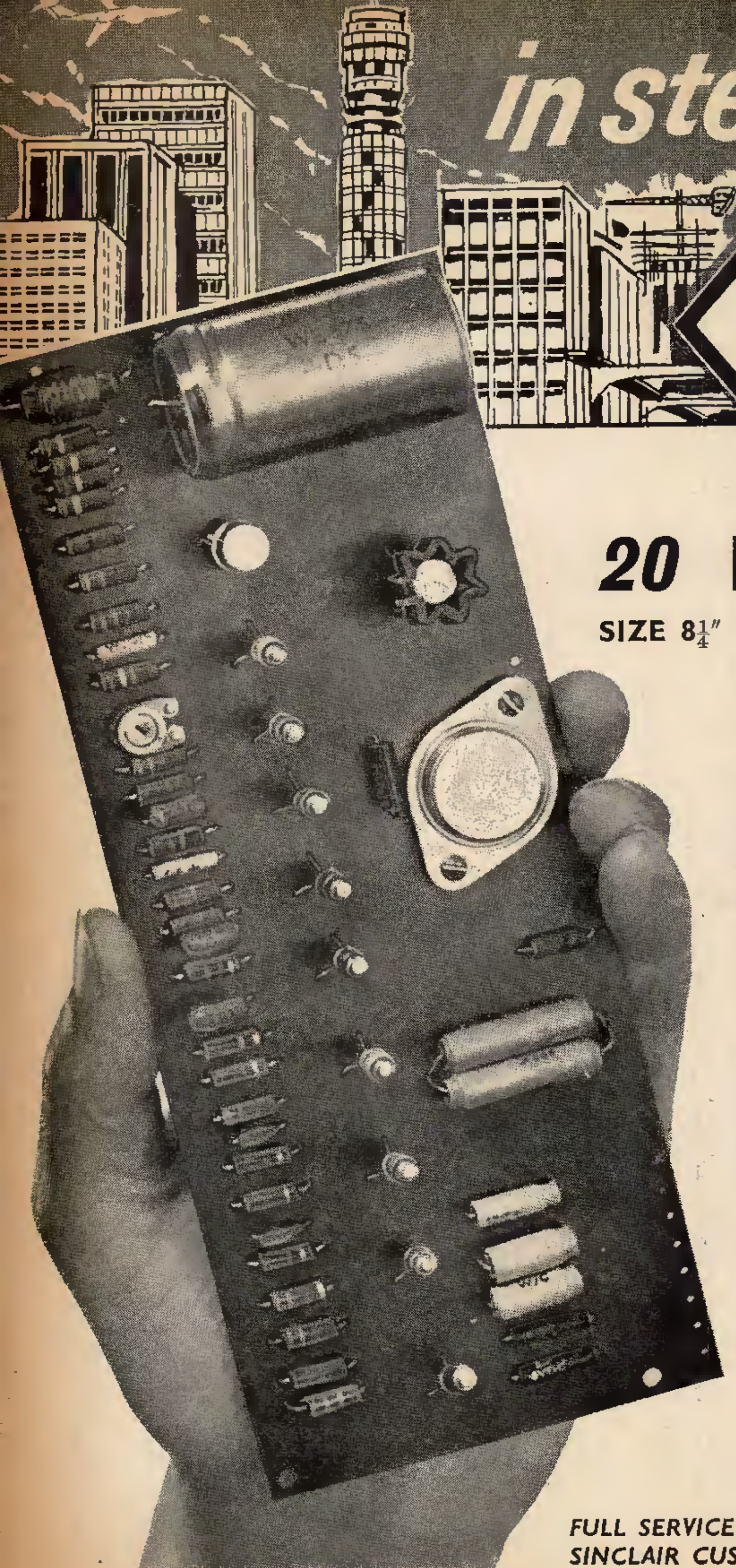

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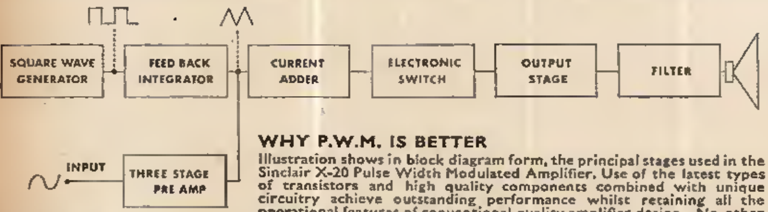

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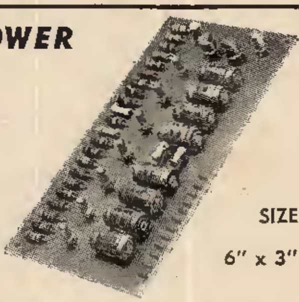

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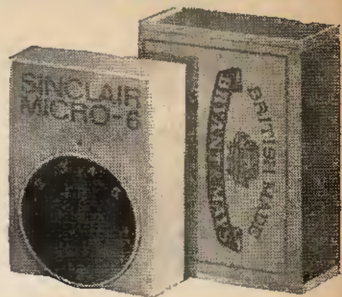

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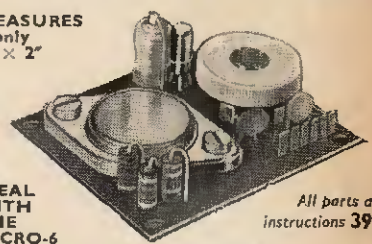

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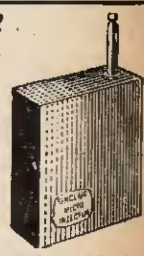

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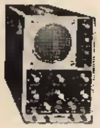
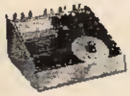
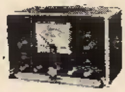



SCOPE, IO-12U — POWER SUPPLY, IP-20U

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VOL. 1 No. 10
AUGUST 1965

Practical Electronics

A BROAD OUTLOOK

THREE international exhibitions held in London, and running in part concurrently during the latter part of May and beginning of June, offered as diverse a choice of interests as one could wish for.

The International Packaging Exhibition at Earls Court brought one the factory floor atmosphere with the food and confectionery industries perhaps predominating. The World Fishing Exhibition at Olympia provided a strong salty flavour of the open seas, and against this the Hospital Equipment Exhibition in the adjoining hall offered a contrast with its clinical setting.

Quite different, yes—but yet there *was* a common link. It was soon plain to see that in all these fields extensive use is already being made of electronic instrumentation and automated systems; and it was equally clear that future improvements in efficiency depend very much (and in some cases, entirely) upon the increased adoption of electronics.

* * *

Sea fishing is a highly competitive business, and the modern trawler relies upon electronics not only for navigational aids and communications, but as a means for locating the fish. Some modern fish-recording echo sounders can detect a single fish at 200 fathoms, and new sector scanning techniques promise to give even better results over the conventional asdic or sonar systems.

It was not surprising to see how heavily dependent upon automated equipment the food confectionery, cosmetics and other industries have become. For example, electronic checkweighers can weigh 3,000 packages per hour, rejecting over or under weights, while servo systems automatically correct the filler machine. Other electronic systems are employed to detect metal in foodstuffs, to sort peas, nuts, rice, etc., according to colour, and to count articles of irregular shapes.

An automatic patient monitor that will measure and record the blood pressure, pulse rate, and temperature of up to ten patients simultaneously was seen at the Hospital Equipment Exhibition. An automated drip feed system for transfusions, and instruments for remote control temperature measurement were just two further indications that automation is reaching into the hospital service.

* * *

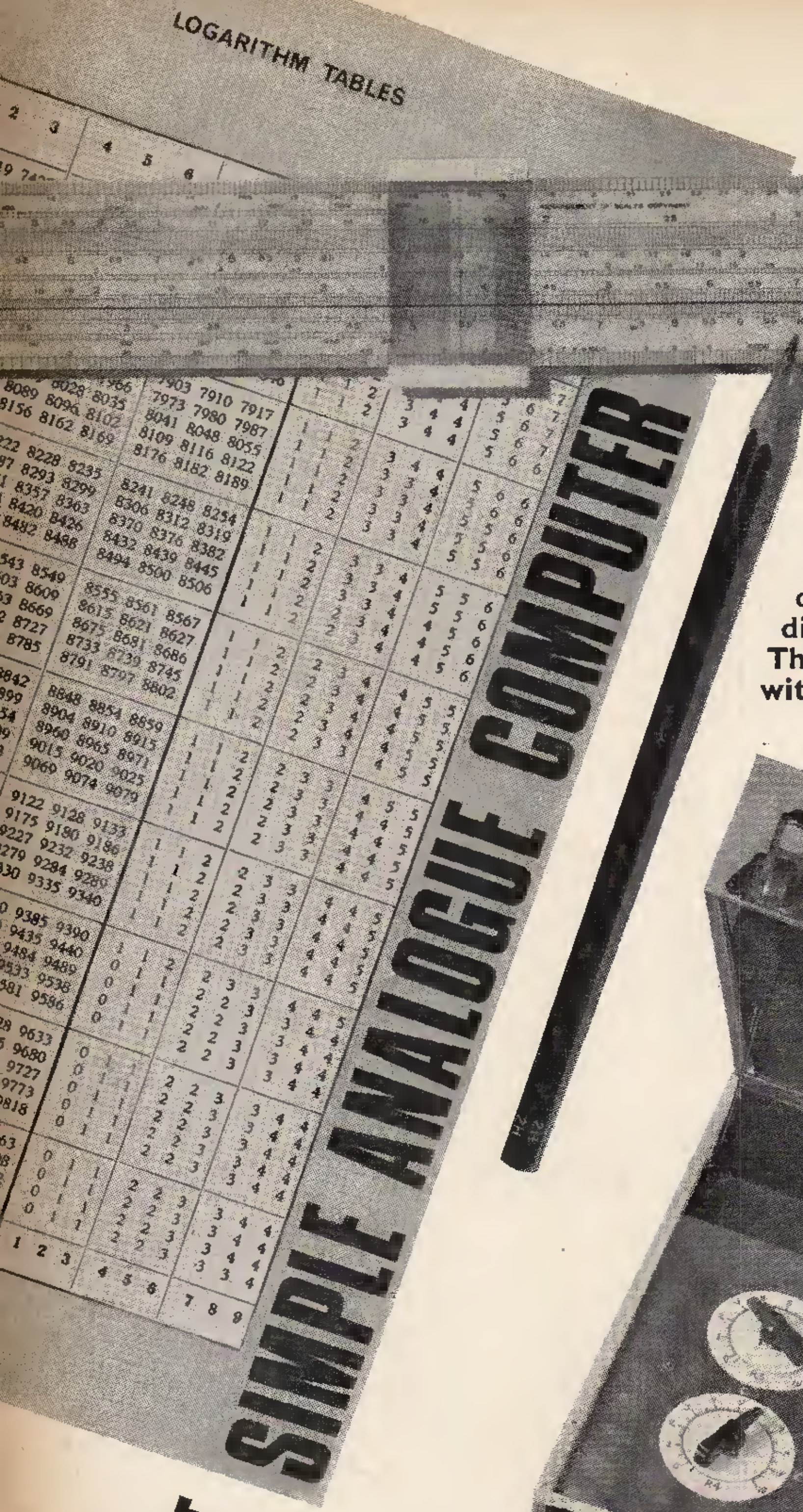
Here we have merely touched upon a few of the current uses of electronics in just three fields. We think it has been made clear that the student of electronics has much to gain by visiting exhibitions such as these. In so doing, not only will he keep in touch with technical advances of immediate interest, but in the process he will acquire an insight into many other fascinating facets of the modern world. Nothing like an interest in electronics for broadening the mind!

THIS MONTH

Our September issue will be published on Thursday, August 12.

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., including postage for one year, to any part of the world, 36s.

SIMPLE ANALOGUE COMPUTER



This instrument is capable of carrying out the arithmetical operations of multiplication and division with reasonable accuracy. The evaluation of powers and roots with log. scales may also be achieved.

by H. WEBSTER

ALTHOUGH popularly associated with formidable arrays of electronic instruments capable of incredibly complex calculations, computers in one form or another have been with us for a very long time. We have only to recall the familiar abacus or bead bar of our childhood to realise that our acquaintance with computers started at a very early age.

Modern computers are of two major types: the *digital*, which depend on the way we use numbers, and the *analogue*, in which numbers are represented by physical quantities such as length and current. A simple example of a digital computer is the abacus while a good example of the analogue computer is the slide rule.

Although elaborate computers are beyond the scope of the average constructor, quite simple instruments can be made using everyday components. The simple analogue computer described in this article was constructed by the author for classroom demonstration purposes. Although no originality is claimed for the design it was felt that a description of the instrument would be of interest to other constructors, particularly those engaged in teaching.

BASIC CIRCUIT

The computer is based on the familiar Wheatstone bridge network shown in Fig. 1. Such a network is commonly employed in the determination of an unknown resistance. When the bridge is balanced, for example, when the current through the galvanometer is zero, the following well known relationship holds,

$$R1 \times R4 = R2 \times R3$$

or transposing,

$$\frac{R1}{R2} = \frac{R3}{R4}$$

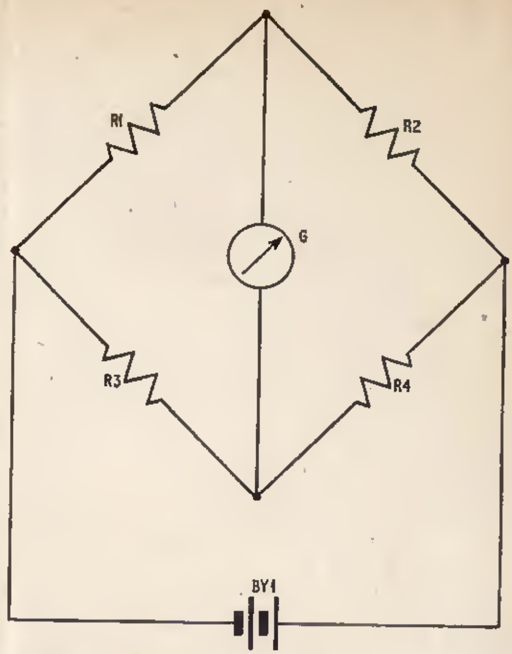
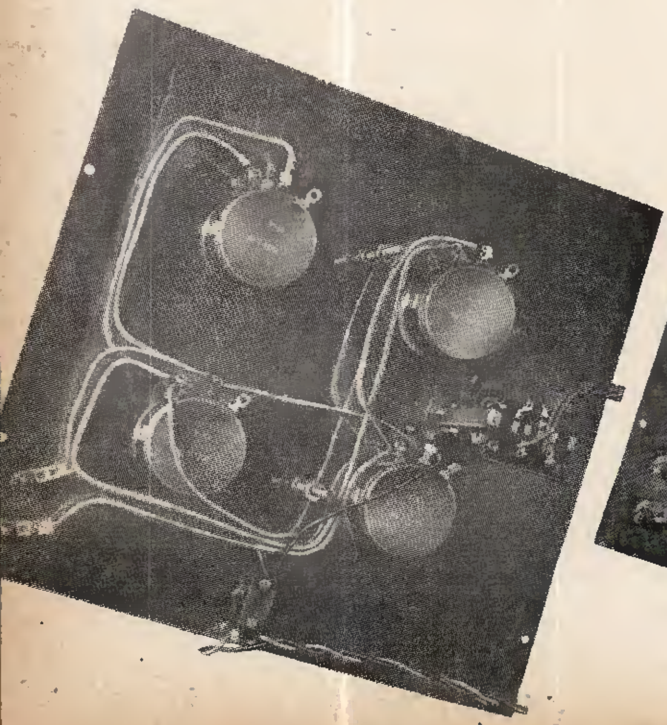


Fig. 1. Basic Wheatstone bridge network on which the computer is based

Generally, R1 and R2 form a calibrated resistance wire system, while R3 is a resistor of known value. R4 is the unknown resistor. When the system is balanced, the ratio R1:R2 is determined, and hence R4 can be calculated. By a reversal of this procedure, the operations of multiplication and division can be carried out.



If the resistors constituting the arms of the bridge are made variable and are accurately calibrated, the two arithmetical operations are easily performed. To multiply two numbers, R4 is set to some power of ten, the multiplicand set on R2 and the multiplier on R3. The bridge is balanced with R1 and the answer automatically read off on the R1 scale. To perform the operation of division, R4 is again set to a power of ten, while the numerator and denominator are set on R1 and R2 respectively. The bridge is balanced with R3 and the answer taken from this scale. For both arithmetical operations it is of course necessary to find the decimal point by inspection.

The scope of the bridge can be further extended by providing logarithmic scales for R3 and R4. Powers and roots may then be evaluated. This application will be discussed at a later stage.

PRACTICAL CONSIDERATIONS

In common with all other analogue computers the accuracy is limited by the precision of the components employed in the circuit. The author found that ordinary wire wound variable resistors of the type normally employed in radio work were of sufficient precision to enable quite a high degree of accuracy to be achieved.

In the original design the bridge was energised by a battery, the balance point being indicated by a sensitive galvanometer. However, since it was highly likely that the instrument would be subjected to somewhat indelicate handling, the fragile galvanometer was replaced by headphones and a simple but robust transistor audio oscillator used to energise the bridge.

CONSTRUCTIONAL DETAILS

The computer is mounted on an aluminium panel, the relevant drilling and mounting details being given in Fig. 3. Four 3¼in diameter discs cut from stiff white cardboard, and on which are described 2¼in diameter circles, are used as dials.

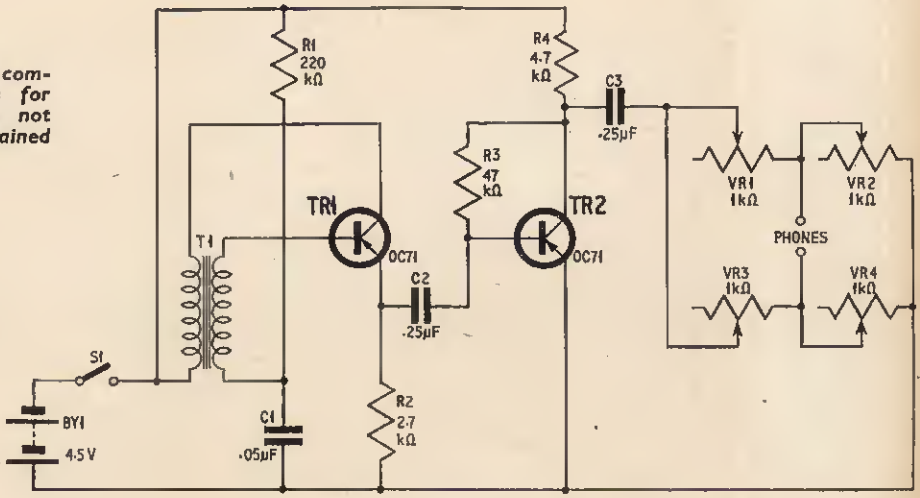
The audio oscillator is mounted on a 6in × 4in etched wiring board as shown in Figs. 4 and 5. An alternative method using Veroboard may also be used by those constructors who wish to avoid the use of chemicals. For comprehensive examples of this method the reader is referred to the April 1965 issue of PRACTICAL ELECTRONICS.

ETCHED WIRING BOARD

The copper laminate is polished with metal polish and then washed in warm soapy water. After rinsing and drying, the circuit pattern shown in Fig. 4 is drawn out with cellulose paint of the car "touch up" type. The paint is allowed to dry for approximately 30 minutes and the laminate immersed in a 30 per cent w.v. solution of ferric chloride. This solution is prepared either by dissolving 75gm of the anhydrous salt or 92gm of the hydrated salt in 200ml of water containing 3ml of concentrated hydrochloric acid. The resulting solution is made up to 250ml. For complete dissolution of the unwanted copper a reaction time of roughly 30 minutes at 40 degrees C is required. The etching is done by gentle agitation of the solution.

The prepared board is washed with water to remove all traces of the iron salt and the cellulose paint removed by swabbing with cotton wool soaked in acetone or other suitable solvents.

Fig. 2. Circuit of the simple computer. Additional resistors for calibration (R5-R10) are not shown here but are explained later in Figs. 6, 7, and 10



CIRCUIT DESCRIPTION

The circuit diagram of the computer is given in Fig. 2. Four 1,000 ohm wire wound potentiometers (VR1–4) form the arms of the bridge. The transistor oscillator is of the Hartley type. Oscillation is maintained by feedback in the correct sense through the primary of the audio transformer T1. Although the output of the oscillator may be taken via C2 from the emitter of TR1, an additional stage of amplification may be found advantageous, particularly where noisy background levels are encountered.

Holes are drilled at the points shown in Fig. 5. Wiring of the board is straightforward and the customary heat shunt precautions are observed when the transistors and other closely clipped components are soldered in position.

The audio frequency transformer is temporarily connected to the appropriate points on the board and a check made on the correct functioning of the oscillator. It may be found that the leads to the primary of the transformer require reversal to ensure feedback in the correct sense.

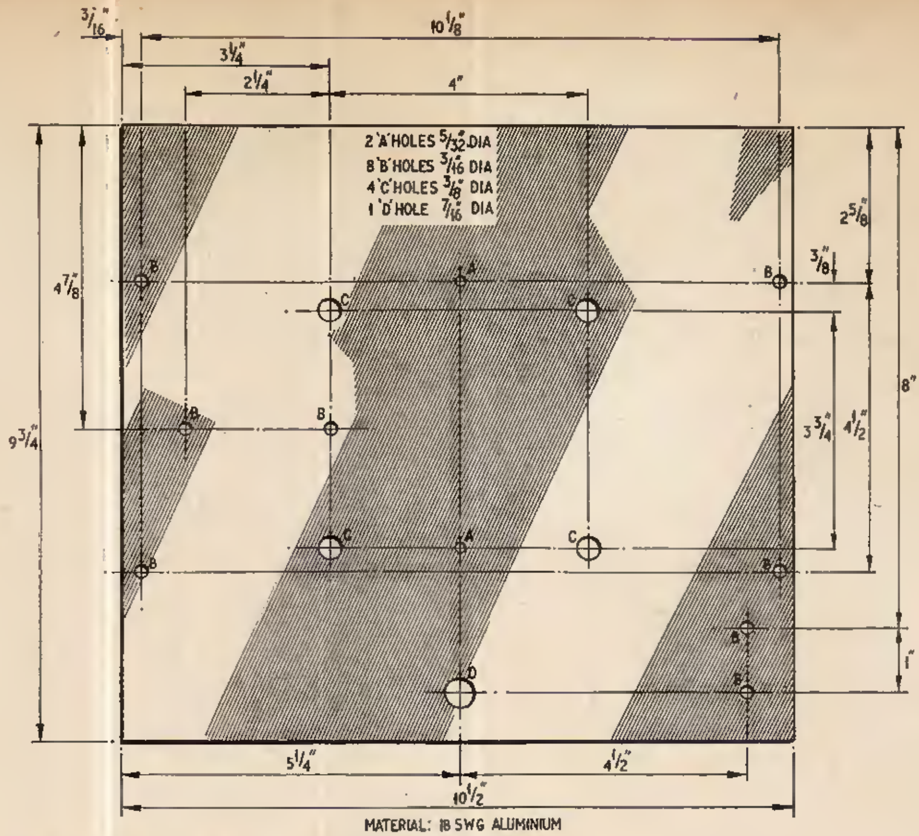


Fig. 3 (above). Drilling details of the aluminium panel to hold the potentiometers

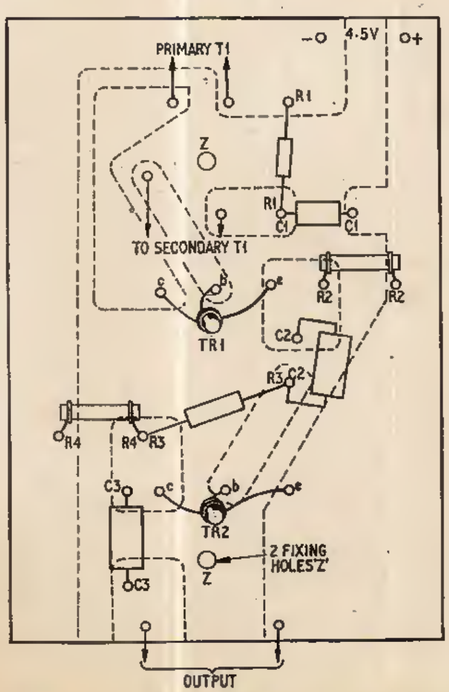


Fig. 4. Component layout on the printed circuit board

Fig. 5. Plan of the printed circuit board shown half scale

Before the completed audio oscillator is mounted on the main potentiometer panel, the potentiometers are calibrated by the following procedure.

CALIBRATION OF BRIDGE

A careful calibration of the four potentiometers is essential if accurate results are to be obtained. Although calibration is simplified if a resistance box calibrated in 10 ohm and 100 ohm steps is available, it is possible to use close tolerance fixed resistors as calibration standards. The construction of such a standard is shown later in Fig. 10.

Both calibration methods will be described, the resistance box method being dealt with first.

VR1 CALIBRATION

Two close tolerance resistors, R9 and R10, each of 1,000 ohms, are wired with VR1 and the decade resistance box as shown in Fig. 6. The audio oscillator and headphones are connected to the appropriate points. With the decade box set at 100 ohms, VR1 is adjusted until the null point is observed. The dial of VR1 is carefully marked with pencil at this point. Repetition of the process with the decade box set at 200, 300, 400 ohm etc., followed by balancing with VR1 gives a series of points separated by 100 ohm intervals up to 1,000 ohms. If the decade box is calibrated in 10 ohm steps intermediate points may be filled in.

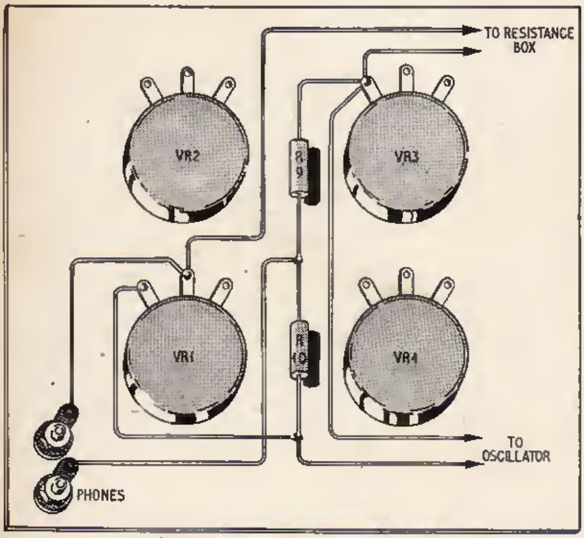


Fig. 6. VR1 calibration

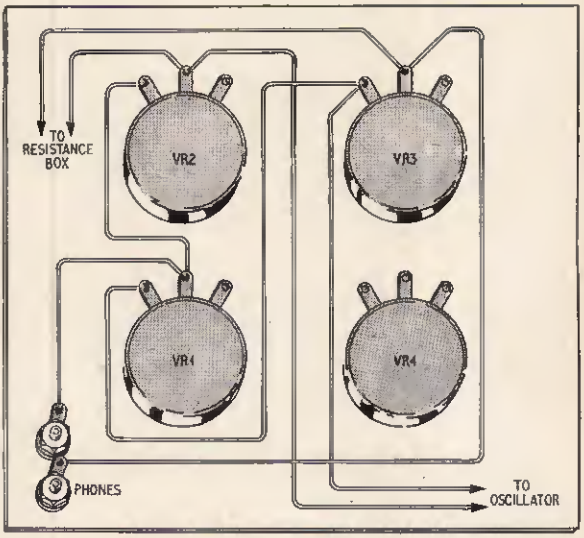


Fig. 8. VR3 calibration

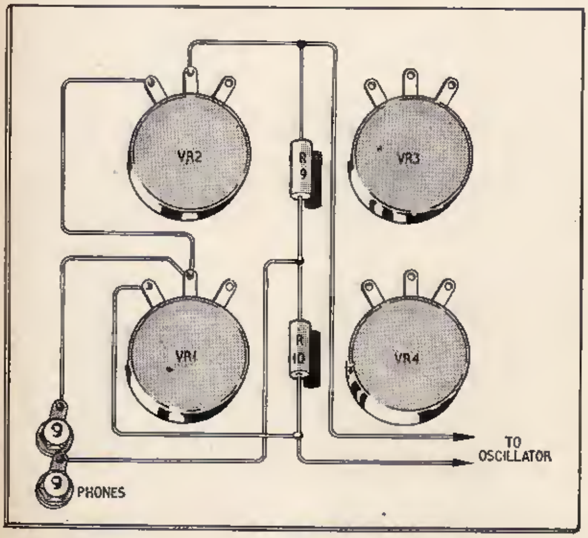


Fig. 7. VR2 calibration

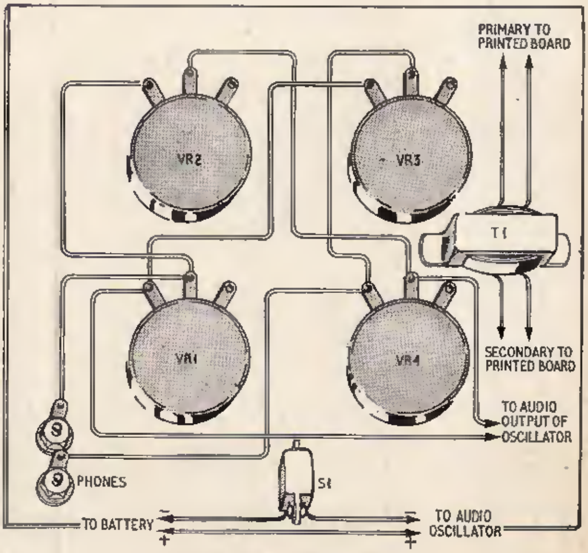


Fig. 9. VR4 calibration

Figs. 6-8. Temporary wiring of the potentiometer panel for calibration. Fig. 9. The final wiring

VR2 CALIBRATION

The decade box is disconnected and VR2 wired into circuit as shown in Fig. 7.

VR1 is successively set at each of the previously determined points and VR2 balanced against each point. In this way VR2 can be accurately calibrated in terms of VR1.

VR3 CALIBRATION

The decade box is reintroduced and R9 and R10 deleted. VR1 and VR2 are each set at 500 ohms and VR3 calibrated in 10 or 100 ohm steps against the decade box. Wiring details are shown in Fig. 8.

VR4 CALIBRATION

Prior to this final calibration the complete panel is wired as shown in Fig. 9. The audio oscillator and transformer may also be permanently attached. Two 3in 4 B.A. bolts serve as stand-off supports for the oscillator panel.

After completing the wiring VR4 is calibrated against VR3 with VR1 and VR2 each set at 500 ohms.

CALIBRATION WITH FIXED RESISTORS

A simple calibration standard is shown in Fig. 10. Four close tolerance resistors of 100, 200, 300 and 400 ohms respectively, are wired together as shown. By shorting out the appropriate sections a selection of resistance values from 100 to 1,000 ohms may be made. Two leads which terminate in crocodile clips are conveniently used as shorting links. Resistance values obtained when the appropriate sections are shorted are given in Table 1.

TABLE 1

Resistance Ω	Short Out
100	3 & 8
200	1 & 2, 6 & 8
300	6 & 8
400	1 & 5
500	3 & 5
600	7 & 8
700	1 & 4
800	3 & 4
900	1 & 2
1,000	none

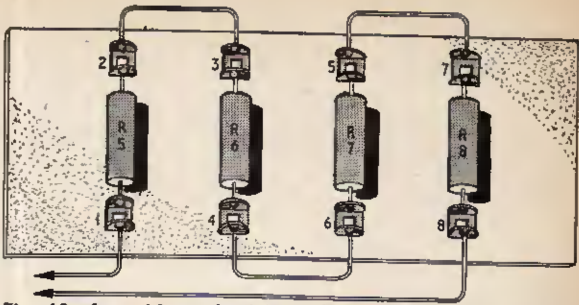


Fig. 10. Assembly and wiring of the calibration resistors. Due to the accuracy required for these resistors, it may be necessary to select and measure to within 1 per cent tolerance of the quoted values from resistors of the nearest "preferred" value available

Calibration of the bridge using this standard is carried out exactly as before, the standard taking the place of the decade box.

When calibration is complete the dials may be numbered from 0 to 10 and permanently marked with indian ink. If the calibration has been made in 100 ohm steps the intervals may be divided into ten equal parts. No great loss of accuracy will occur since it was found that over small portions of the potentiometer tracks the resistance per unit length was constant enough to warrant this procedure.

OPERATION OF COMPUTER

A discussion of the operations of multiplication and division was given in the introduction to this article. These operations are summarised at this point.

MULTIPLICATION

Set VR4 to 1 or 10. The multiplicand is set on VR2 and the multiplier on VR3. The bridge is balanced with VR1 and the answer taken from this scale.

DIVISION

Set VR4 to 1 or 10. The numerator is set on VR1 and the denominator on VR2. The bridge is balanced with VR3 and the answer taken from this scale.

COMPONENTS . . .

Resistors

R1	220kΩ 10%	see Fig. 2
R2	2·7kΩ 10%	see Fig. 2
R3	47kΩ 10%	see Fig. 2
R4	4·7kΩ 10%	see Fig. 2
R5	100Ω 1%	see Fig. 10
R6	200Ω 1%	see Fig. 10
R7	300Ω 1%	see Fig. 10
R8	400Ω 1%	see Fig. 10
R9	1,000Ω 1%	see Figs. 6 and 7
R10	1,000Ω 1%	see Figs. 6 and 7

Potentiometers
VR1, 2, 3, 4 1kΩ linear, wire wound

Capacitors
C1 0·05μF paper
C2 0·25μF paper
C3 0·25μF paper

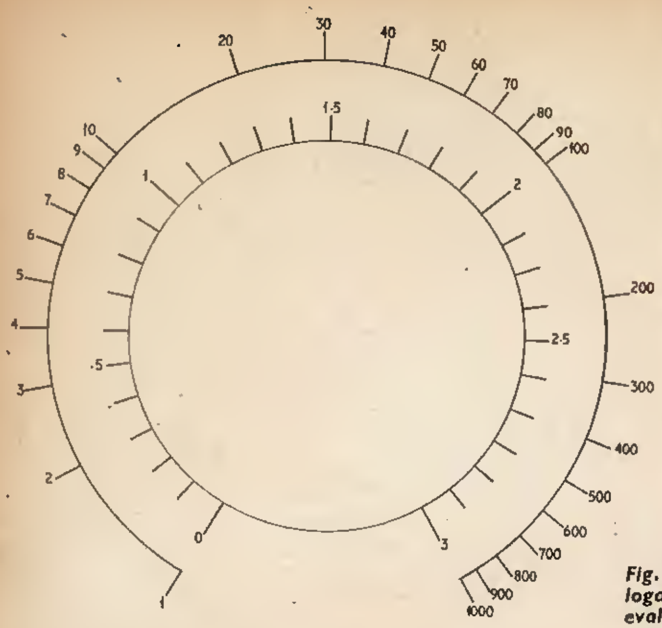
Transformer
Intervalve type, ratio 3:1

Transistors
TR1, TR2 OC71 or NKT272

Switch
S1 Single pole on/off

Battery
BY1 4·5V battery

Miscellaneous
Aluminium panel. Copper laminate board. Four pointer knobs. Headphones. Terminals. P.V.C. insulated connecting wire.



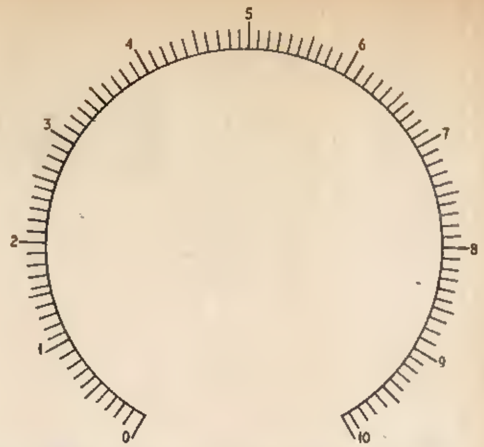


Fig. 12 (above). Example of the linear type of scale that will be produced when the four potentiometers are individually calibrated as described on page 694. This linear scale is used for multiplication and division

Fig. 11 (left). Calibration scale for VR4 drawn on a logarithmic basis to full size. This scale is used for the evaluation of powers and roots

EVALUATION OF POWERS AND ROOTS

In addition to the operations of multiplication and division, further interesting evaluations may be made if the scales of VR3 and VR4 are calibrated logarithmically.

If we let r_3 be the reading of VR3 such that $\log r_3 =$ VR3 and similarly r_4 the reading of VR4 so that $\log r_4 =$ VR4, then at the balance point, and recalling that in the basic bridge of Fig. 1, R1 × R4 = R2 × R3, it follows that

$$\mathrm{VR1}\log r_4 = \mathrm{VR2}\log r_3$$

or

$$r_4^{\mathrm{VR1}} = r_3^{\mathrm{VR2}}$$

or

$$r_4 = r_3^{\mathrm{VR2/VR1}}$$

In other words we can determine the value of r_3 to the power VR2/VR1.

As a simple example consider the evaluation of 3^4. The required power VR2/VR1, is conveniently obtained by setting VR2 to 8 and VR1 to 2. VR3 is set to 3 and the bridge balanced with VR4. The answer is taken from this scale.

Roots may be evaluated using a similar procedure. For example, suppose we wish to find $\sqrt[3]{27}$ or, what is the same thing, $27^{\frac{1}{3}}$. VR2 is set to 1 and VR1 to 3. After setting VR3 to 27 the answer is read off the VR4 scale.

LOGARITHMIC SCALES

The logarithmic scales are prepared as follows. A 2¼in diameter circle is inscribed on a disc. Two points are marked with pencil on the circumference of the circle such that the length of the arc is the same as that of the linear scales. The arc is then divided into three equal portions which in turn are subdivided into tenths. This calibration represents the logarithms of numbers between 1 and 1,000. The resistance scale may now be calibrated by inserting the values whose logarithms correspond to the inner scale. An illustrative example is given in Fig. 11. This scale can conveniently be used for VR4.

The second logarithmic scale is prepared by calibrating VR3 in terms of VR4. To do this VR1 and VR2 are each set at a dial reading of 5 and VR3 then balanced against each point of VR4 by the usual method. Fig. 12 shows an example of this scale.

Doubtless other evaluations will suggest themselves to the mathematically-minded constructor. Circuit variations are also possible, for example, the audio oscillator may be replaced by a buzzer with a cheapening in the overall cost. As a point of interest the cost of the instrument excluding battery and phones was ust over £2. ★

Contributed Articles

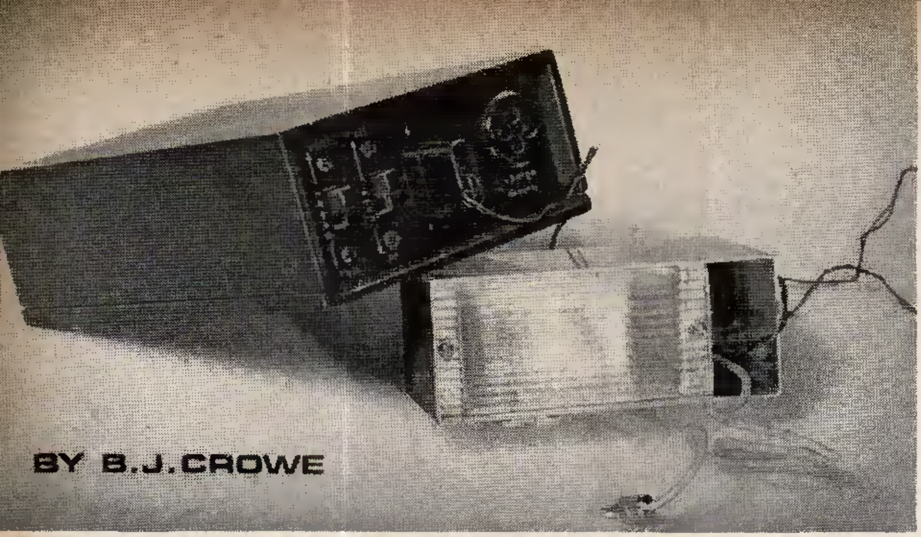
The Editor will be pleased to consider for publication articles of a theoretical or practical nature. Constructional articles are particularly welcome, and the projects described should be of proven design, feasible for amateur constructors and use currently available components.

Intending contributors are requested to observe the style in our published articles with regard to component references on circuit diagrams and the arrangement of components list.

The text should be written on one side of the paper only with double spacing between lines. If the manuscript is handwritten, ruled paper should be used, and care taken to ensure clarity, especially where figures and signs are concerned.

Diagrams should be drawn on separate sheets and not incorporated in the text. Photographic prints should be of high quality suitable for reproduction; but wherever possible, negatives should be forwarded.

The Editor cannot hold himself responsible for manuscripts, but every effort will be made to return them if a stamped and addressed envelope is enclosed.



PART TWO

FLASH HEAD

BY B.J.CROWE

ELECTRONIC FLASH GUN

WARNING: High voltages are encountered in this flash gun. Care should be exercised in handling and it is essential that the components and wiring should not be touched until the capacitors are completely discharged (see text later). To avoid any risk of damage or shocks the whole units should be kept dry and carried in a waterproof carrying case.

THE DESIGN of the flash head posed a rather different problem from that of the power pack. In the latter the innovation was in the circuit design rather than in the hardware; in the flash head, the circuit is well known, but as far as the author is aware a compact mechanical design is not available.

The greatest contribution to miniaturisation in electronic flash has been the introduction of a compact reflector. The author decided, therefore, to attempt the design of a compact flash head incorporating the trigger circuit and cable storage compartment. The construction of the flash head necessarily involves some metal work, but this is kept to a minimum, and alternative designs will be suggested later for those who do not wish to attempt the compact head.

CIRCUIT

The circuit diagram for the flash head is shown in Fig. 2.1. The output voltage of the power pack is applied across the xenon tube (V2) and a proportion of this voltage appears at the junction of R1 and R2 to charge the capacitor C1 to approximately 250 volts. When the camera shutter is operated C1 is effectively placed in parallel with the primary of the trigger coil (T1) producing a "ringing" circuit, the first spike of which, at about 6 kilovolts, triggers the xenon tube into its conducting state. A smaller portion of the supply voltage (about 70 volts) is tapped off from VR1 to ignite the wire-ended neon indicator V1 when the main capacitors have reached about 90 per cent of their charge voltage. Resistors R2 and R3 are not strictly necessary and may be dispensed with if VR1 is replaced with a 2·5MΩ preset, but some sensitivity will be lost in setting the ignition point of the neon.

HOUSING DESIGN

The size of the flash head was dictated primarily by the size of the FA10 xenon tube, and secondly by the requirement that it should fit on top of the power pack and form a compact unit for transportation. The size of the trigger circuit board and the space required for cable storage were also influencing fac-

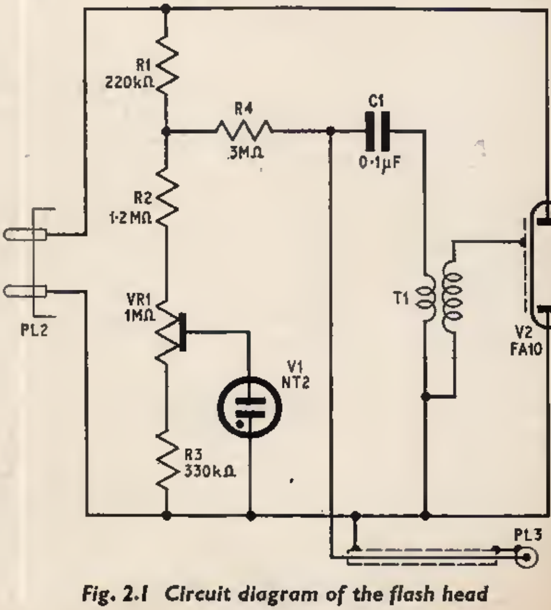


Fig. 2.1 Circuit diagram of the flash head

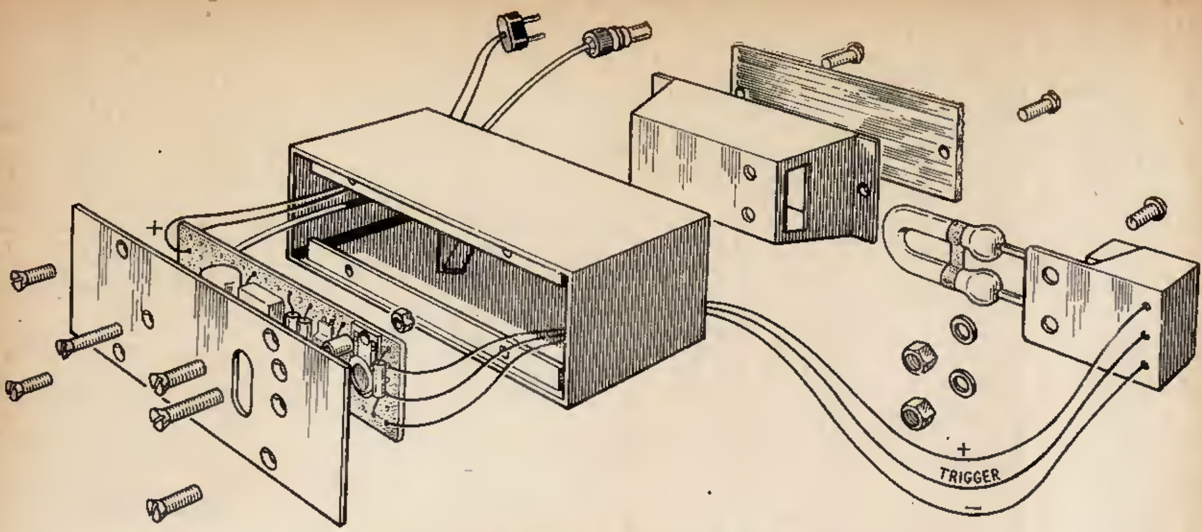


Fig. 2.2 Exploded view of the complete flash head

tors. A pleasing appearance and relatively simple construction is achieved by keeping the mechanical fastening to a minimum by the use of "Araldite" epoxy resin adhesive.

An exploded view of the flash head is shown in Fig. 2.2. The main component is a simple shallow rectangular box of 20 s.w.g. sheet aluminium, open at each end, and carrying two horizontal rails at the back and two short vertical rails at the front.

The front rails carry the lens and reflector, on which is mounted the xenon tube socket. The rear rails carry the backplate which in turn carries the trigger and charge indicating circuit.

The right-hand front rail is set in approximately ¾in from the edge of the box, forming a space alongside the lens in which the synchronisation and power supply leads may be stored. Only six screws are used as fasteners on the main assembly; all other joints are glued.

CASE CONSTRUCTION

Since the finished appearance of the flash head is directly dependent upon the accuracy and neatness with which the box is folded, as much care as possible should be exercised at this stage. The box is folded from a sheet of 20 s.w.g. aluminium measuring 11·56in × 2·10in (Fig. 2.3a) and should be obtained ready cut, or cut by a friend with access to a guillotine, if possible, as this produces neat straight edges. If it is possible to gain access to a folding machine, the task of folding the box is greatly simplified. The box may, however, be folded quite successfully in an ordinary bench vice using the block shown in Fig. 2.3b and protecting the aluminium from the vice jaws with soft jaws or suitable packing, such as wood, on both sides of the sheet.

When the box has been squared up the chamfered edges are cleaned thoroughly with acetone, carbon tetrachloride or trichlorethylene and a small quantity of Araldite applied to each edge. The edges are then brought together and held in position with elastic bands or adhesive tape. A liberal fillet of Araldite is run into the corner as in Fig. 2.4 to ensure a sound joint. The box should now be left for 24 hours to set, preferably in a warm, dry atmosphere.

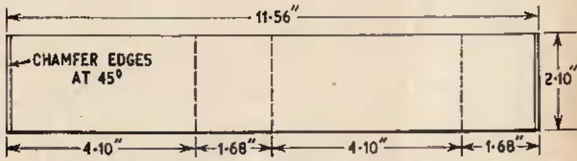


Fig. 2.3a. The main case of the flash head is made from aluminium alloy sheet 20 s.w.g. and folded . . .

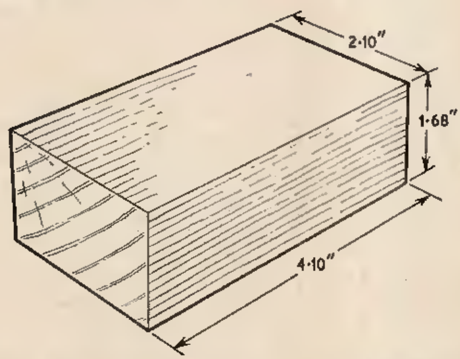


Fig. 2.3b. . . . round this block to form an open ended box

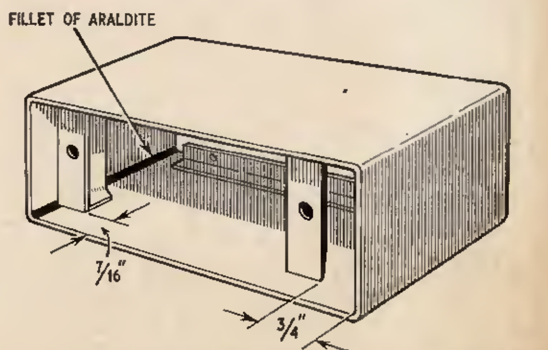


Fig. 2.4. Front view of the completed box with the rails fitted in position

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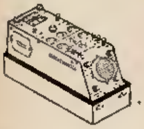

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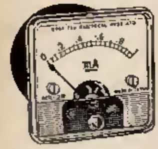

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100mA	22/6	10V D.C.	22/6	50V A.C.	22/6
150mA	22/6	20V D.C.	22/6	150V A.C.	22/6
200mA	22/6	50V D.C.	22/6	300V A.C.	22/6
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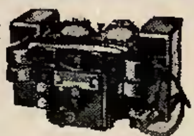

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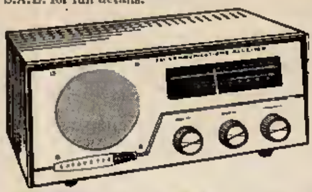

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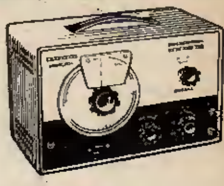

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Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

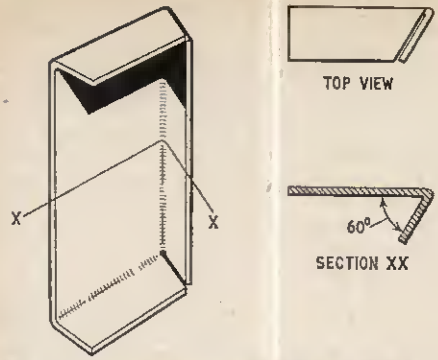


Fig. 2.5. Construction and bending details of the right-hand front rail

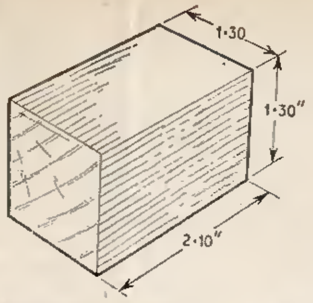


Fig. 2.7. This block is used to form the reflector shape shown in Fig. 2

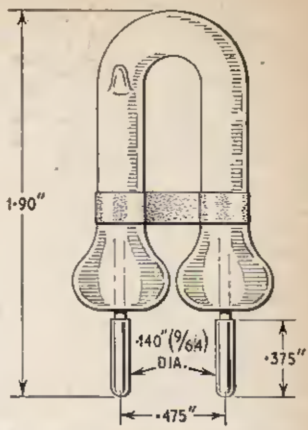


Fig. 2.8. Dimensions of the xenon tube

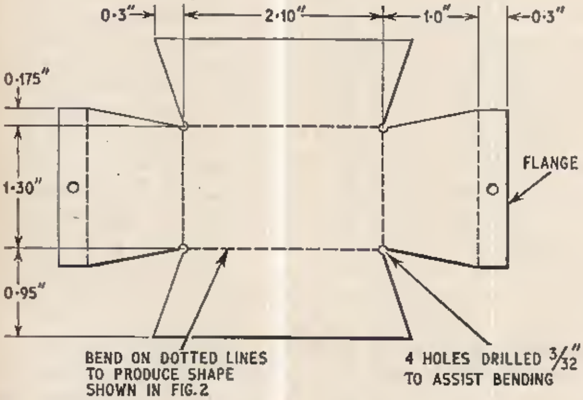


Fig. 2.6. The reflector base is cut from aluminium alloy sheet 20 s.w.g. and folded

The rails may now be constructed while the joint is hardening. The two rear rails and the front left-hand rail are ¼in × ¼in angle sections bent in the vice from ½in strips of 20 s.w.g. aluminium and cut to the appropriate lengths to fit inside the case as shown in Figs. 2.2 and 2.4. The right-hand front rail is ¼in × ½in and is bent to form an acute angle of 60 degrees (see Fig. 2.5) in order to prevent the cables chafing when being withdrawn from the storage compartment. Since it cannot be bonded along the edge like the other rails, the ends are turned over as shown to provide the anchorages. It should be made slightly longer than required and then, when the box is set hard, the ends may be filed until it is a sliding fit in the box.

The surface to be bonded on each rail and the mating surfaces in the box are scored with a sharp point (such as a scriber or hacksaw blade) in a fine criss-cross pattern until the whole surface to be bonded is rough. The surfaces are then cleaned with one of the fluids previously mentioned, smeared lightly with Araldite and each rail offered up to its mating surface. It is better to tackle the rails in pairs and allow one pair to set before fixing the next.

The rear rails may be spaced from the back using a scrap of 20 s.w.g. material to simulate the backplate.

The front rails are set back 7/16in from the front of the box, and the right-hand rail set ¾in in from the inside of the box (Fig. 2.4). A small card template facilitates the setting of these components.

REFLECTOR

The reflector base is made from 20 s.w.g. sheet and covered with reflecting material (see later), so that the surface need not be protected during the bending operation. Cut the blank to the template shown in Fig. 2.6, and make the block from a scrap of wood (Fig. 2.7). Bend the flanges down at approximately 60 degrees, and then clamp the blank in the vice with the block, the holes in the blank lying at the corners of the block. The sides are then bent forward until the edges all line up. Square up the flanges, bond the edge joints with Araldite and put on one side for 24 hours to harden.

The backplate is cut from 20 s.w.g. sheet and fitted into the back of the box on the rear rails. The lens is cut from a piece of acrylic sheet to 3·375in × 1·65in. It may be plain or fluted (as in the author's gun) in which case the curves are placed so as to give a "condensing" effect to the light beam. Admittedly no tests have been carried out on this lens to assess its performance compared with a clear lens, but the fluted effect undoubtedly provides a more uniform and diffused light.

The lens and reflector assembly may be fixed with self-tapping screws, or, if a more durable fastening system is required, small pieces (¼in × ½in) of 16 s.w.g. mild steel may be glued to the back of the rail and tapped for 6 B.A. screws.

When the necessary preparation has been done, lay the reflector and lens on the rails and drill carefully through all three with a small drill, and then enlarge and tap the holes as required. The backing plate may be glued permanently in position, but in the author's gun it was attached by screws to give greater access to the interior.

XENON TUBE SOCKET

The FA10 xenon tube (Fig. 2.8) has two pins which are spaced so as to fit a standard two-pin 2 amp socket, but the latter is bulky, and no provision is made for a contact to the trigger strap. Amateur

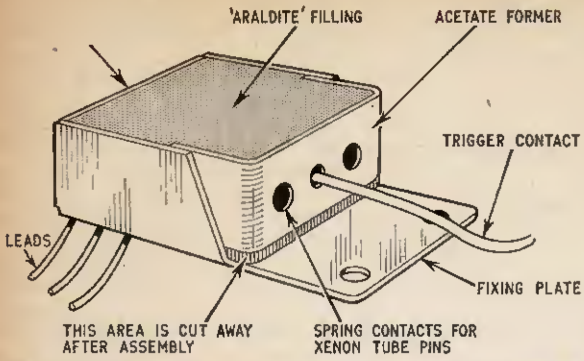


***Fig. 2.9** The socket to hold the xenon tube. Note the trigger contact strip which makes contact with the strap across the tube shown in Fig 8*

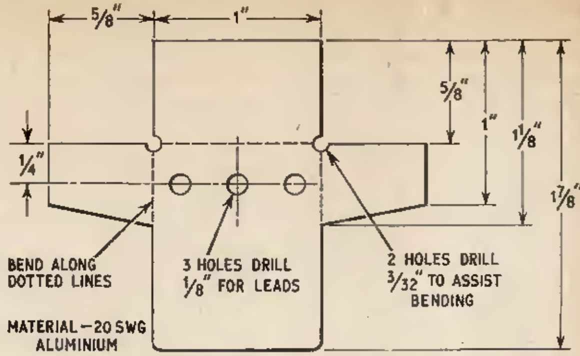


***Fig 2.10.** The casing for the xenon tube socket is cut to shape and bent to form the shape shown in Fig. 9*

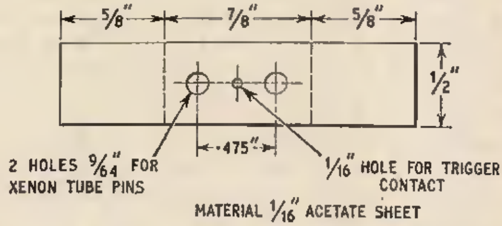


***Fig. 2.11.** The front plate of the xenon tube socket is cut to the size shown, drilled and bent to the shape shown in Fig. 9*

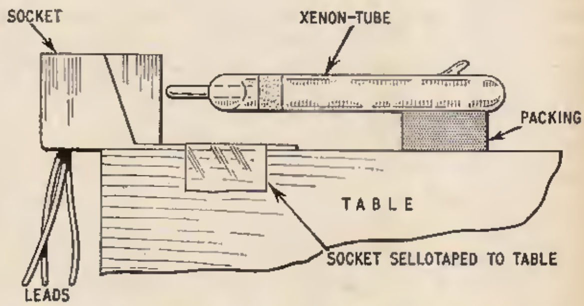


***Fig. 2.12.** Aligning the xenon tube with the socket by using packing and adhesive tape prior to filling the socket with araldite. The pins should be inserted in the socket.*

flash-heads usually use a coil of stiff wire twisted around the pins, and flexible wire twisted round the trigger strap, but with this system the tube is neither rigidly held, nor easily removed. The author has designed a socket in which all three contacts are made and yet the tube may be removed using moderate force.

A word of warning before going into the description—the xenon tube is extremely fragile and should be handled with great care.

The socket (Fig. 2.9) is made from a small piece of celluloid or cellulose acetate and some thin (22 s.w.g. or 24 s.w.g.) beryllium copper or phosphor-bronze sheet (obtainable from any good engineers' suppliers and many model shops).

Cut a piece of phosphor-bronze (or beryllium copper) about ⅜in wide and 3in long, and wrap it round a nail or drill about ⅛in diameter so that it looks like a clock-spring. When 2½ turns have been wound, cut off the surplus and solder the coil so that it is held closed. This can be removed from the nail and fitted over one of the pins of the tube. Repeat for the other pins and solder a 6in length of plastics-covered wire (7/·0048) to each one, red and black. Cut a thin strip (about 1/16in wide) of phosphor-bronze about ½in long and solder a 6in length of white covered wire to this. (Phosphor-bronze sheet of this thickness may be cut with ordinary household scissors or tinsman's shears.)

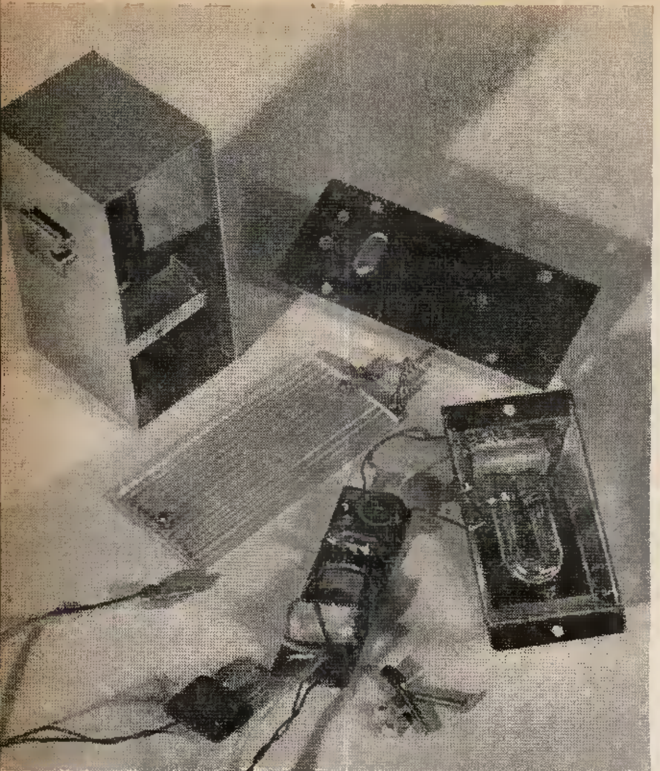
Cut the socket box from 20 s.w.g. aluminium alloy sheet to the shape shown in Fig. 2.10 and fold up the edges. (This may be done by hand with the aid of a pair of pliers or in a small vice.) Cut a piece of celluloid or acetate sheet 1/16in thick (obtainable from model shops) about 2⅛in × ½in and drill and bend as shown in Fig. 2.11. Cement it to the box as shown in Fig. 2.9.

Thread the wires of the three contacts through the appropriate holes in the box, and push the long thin bronze strip (which forms the trigger contact) through the centre hole in the acetate sheet. The spring contacts are held in position while the Araldite sets by the pins of the xenon tube (Fig. 2.12) so these must be lightly smeared with grease to prevent unwanted adhesion.

Insert the tube pins through the outer holes in the acetate sheet and push the spring contacts gently on to them (observe polarity!). The box is then laid on a flat surface with the end overhanging to allow the three wires to clear it, and the xenon tube packed up until it lies parallel to the surface (Fig. 2.12). Mix a good quantity of Araldite (about a third of each tube) on a piece of clean scrap metal or glass and warm it in front of the fire until it runs easily. The Araldite may now be poured round the contacts into the mould formed by the box and the acetate sheet until it is level with the top, and then allowed to set.

After 24 hours, the xenon tube may gently be removed from the socket (the importance of ensuring that no Araldite comes into contact with the pins is obvious) and the shaded portion (Fig. 2.9) cut away with a junior hacksaw and sharp knife. The socket may then be cleaned up with a file and the trigger contact bent to shape as shown in Fig. 2.9, so that it bears on the trigger strap when the tube is inserted.

A hole must now be cut in the reflector base to accept the socket (see Fig. 2.2), either by drilling a series of small holes or using an "Abrafile" saw blade which fits a standard hacksaw frame. The hole is



The component parts of the flash head before assembly

carefully enlarged with a file until the socket sits snugly against the back and side of the reflector base. Two holes are then drilled through the reflector base and socket plate to take 6 B.A. countersunk head nickel plated screws.

The reflector base must now have its reflective coating applied. In the author's gun this was a piece of 0·00025in thick aluminised transparent plastic film (Melinex) fixed to the reflector base with clear adhesive, the aluminium side being glued down to leave the plastic film as a protective coating on the outside. Alternatively, the reflector base may be covered with kitchen foil, or simply polished as it stands, although neither of these surfaces will have as high a reflectivity or durability as the former method provides.

CIRCUIT BOARD

The circuit is built up on a piece of Veroboard 3in × 1in (matrix of 19 × 6 holes). The component layout is shown in Fig. 2.13, and the component wiring points on the reverse of the board are shown in Fig. 2.14. Cut the board to size and make the breaks in the strips at A7, A9, and E11. Drill ⅛in clearance holes at A3 and C18 and cut the strip well back from the holes.

The author used a preset (skeleton type) potentiometer for VR1, which was modified for use in the horizontal position by bending down the tags and cutting short the centre one. The holes in the Veroboard must be enlarged slightly to take this component,

TABLE 1: COMPONENT CONNECTION POINTS

Component	Wiring Board Location
R1	D8, A8 & B8
R2	A5, E5
R3	A1, F2
R4	A10, E9
VR1	A2, A4, wiper to C3
C1	A13, E13
T1	Common F15 L.T. winding E16 H.T. winding D13
V1	C7, F6
PL2	B19 (Power in +)
PL2	F19 (Power in −)
V2 positive	B1
V2 negative	F1
V2 trigger	D1
PL3	A18 (Sync inner)
PL3	F18 (Sync screen)

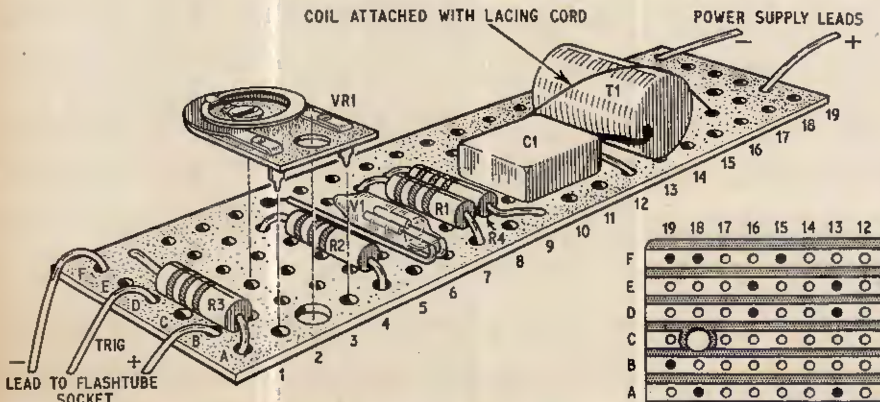


Fig. 2.13. Component layout of the wiring board. VR1 is shown removed from its position to indicate its connections

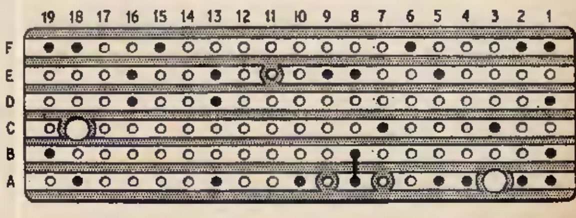


Fig. 2.14. Underside view of the wiring board showing the component connections and cut-outs

but miniature components intended for use on 0·15in matrix board are available and would be preferable here.

The connection points of each component are shown in Table 1. The trigger coil should be strapped to the board using lacing card or p.v.c. covered wire passed through spare holes. Note that the lead of R1 is fed through position A8 and bent up and soldered to strip B at B8. (A miniature resistor could be connected direct to B8 and so avoid this strap.) If the preset potentiometer is used a hole must be drilled through it between the tags to take the mounting screw.

The board is now fitted, components downward, on the inside of the backplate, and holes drilled in the backplate to correspond to holes A3 and C18 in the Veroboard (see Fig. 2.2). A piece of p.v.c. sleeving from coaxial cable serves as a spacer under the circuit board at position A3. Two 6 B.A. screws are pushed through the backplate and board, and secured with nuts. Nylon screws and nuts are obtainable from some component shops and are best used here to prevent shorting adjacent circuit strips.

Mark the position of the neon and potentiometer, remove the circuit board, and cut the holes which allow the neon to be viewed and the preset to be adjusted from the back (see Fig. 2.2). Attach the socket leads, power supply lead (4ft red and black 7/·0048in twisted together) and the synchronisation cable (4mm coaxial plug and coaxial cable, obtainable from photographic dealers) to the appropriate points on the board, and fit the board to the backplate. The copper strip side of the wiring board should be thoroughly cleaned and lightly smeared with a coat of silicon grease. *This is very important to avoid the possibility of shorts if any damp is present.*

Pass the leads through the flash head box from the front, followed by the backplate and circuit board, until the reflector is in position. Place the lens in position and insert the screws. Feed the cables back through the box, through the cable storage compartment until the backplate is in position, and screw down. After fitting the Radiospares flex-connector plug PL2 to the power lead the cables can be coiled and inserted in the storage space. To complete the flash head, make a T-piece from a scrap of aluminium to fit the camera accessory shoe and fix in place with Araldite or screws to the underside of the flash head case (see photograph on page 703).

CALIBRATION

Plug the power supply lead from the flash head into the power pack and connect the synchronisation cable to a camera or suitable shorting switch. Turn the preset potentiometer in the flash head completely clockwise and switch S2 on the power pack to half power.

COMPONENTS . . .

FLASH-HEAD UNIT

Resistors

R1 220kΩ	R3 330kΩ
R2 1·2MΩ	R4 3MΩ

All ½ watt 10 per cent

Potentiometer

VR1 1MΩ skeleton preset (Radiospares)

Capacitor

C1 0·1μF 250V Polyester (Radiospares)

Transformer

T1 Trigger coil (General Electronics, 129 Portobello Road, London, W.11)

Gas-filled tubes

V1 NT2 Neon indicator (or similar)
V2 FA10 Xenon discharge tube (A.E.I.)
(Available from General Electronics, London)

Plugs

PL2 Two-pin plug to fit SK2 on the power unit (see last month's article)
PL3 4mm sync plug and cable for camera (Arrowtabs)

Miscellaneous

Aluminium alloy sheet (half hard grade) 20 s.w.g., 12in × 12in

Perspex acrylic sheet (clear) plain or fluted, 3½in × 1¾in × ⅛in thick from Perspex stockists or Fresnal lens (Proops Bros. Ltd)

Aluminised Melinex plastic film, 6in × 6in × 0·00025in thick (Utilex Ltd., Mill Street, Kingston upon Thames, Surrey)

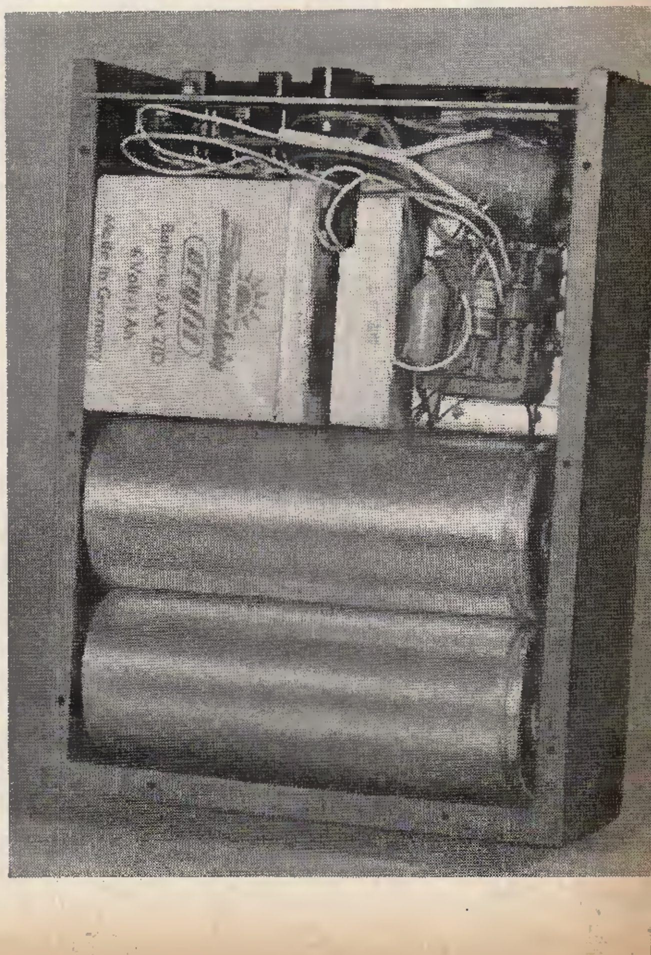
Phosphor bronze or beryllium copper, 3in × 1in × 22 s.w.g.

Wood blocks (see text)

P.v.c. covered wire 7/·0048

Araldite adhesive (packet of two tubes)

Interior view of the power pack described last month



Switch on the power pack, and wait for about one minute, then turn VR1, which controls the neon, gradually clockwise until the neon just strikes. Press the camera shutter release and the gun should fire. If still switched on, the gun will automatically recharge and the neon should strike again after 6 or 7 seconds. Repeat this operation with switch S2 on full power. The gun should now take about 12 to 15 seconds to recharge.

If for any reason the gun fails to fire, **it is imperative that the capacitors should be discharged before the power pack is opened.** This may be done with a short length of wire in the output socket, but it is better to short with a low value resistor (say 500Ω) to avoid damaging C4 and C5. Touching the capacitor terminals whilst they are charged up will result in a severe shock and possible local burning of the fingers.

USING THE FLASH GUN

Having ascertained that the gun functions satisfactorily, it is necessary to determine the exact amount of light which the gun provides. This is usually expressed as a pure number called the guide number, and which has the value of the product of the camera aperture and the distance between the camera and the subject, which will give the correct exposure with the film used. A table showing the guide numbers obtained with various film speeds with the author's gun is shown below.

TABLE 2: EXPOSURE GUIDE

Film Speed A.S.A.	Guide Number
50	56
125	88
140	94
200	112
400	158

To determine a guide number, expose several frames at different apertures, and one known camera-to-subject distance. After processing decide from the prints (or transparencies) which aperture gave the best exposure. Multiplying this aperture value by the known distance gives the guide number for the film emulsion in use.

After about 40–50 flashes, it will be found that the recycling time of the gun has increased to 30 seconds or more, and may not even light the neon without resetting the preset potentiometer in the flash head. This indicates that the accumulator needs recharging. If the circuit shown has been incorporated into the power pack, it is only necessary to plug in the mains lead and leave overnight. Alternatively the cell may be charged from any suitable source at 100–150mA for 8–10 hours, *with care.*

References

The author has found the following articles helpful in compiling this article:

1. Wakefield, G. Flash Techniques Nos. 6 and 7. *Amateur Photographer*, October 2 and 9, 1963.
2. Shelton, R. J. Novel Electronic Flash Unit. *Amateur Photographer*, October 24, 1962.

★

Component Developments

IMPROVED washing machines, television sets (including colour TV), research microscopes and hearing aids are foreshadowed by new electronic "bits and pieces" which were shown at the Radio and Electronic Component Show at Olympia, London in May.

Among the new components shown by 300 members of the industry there was a new colour television tube which will enable bigger and brighter pictures to be shown on a *smaller* television set.

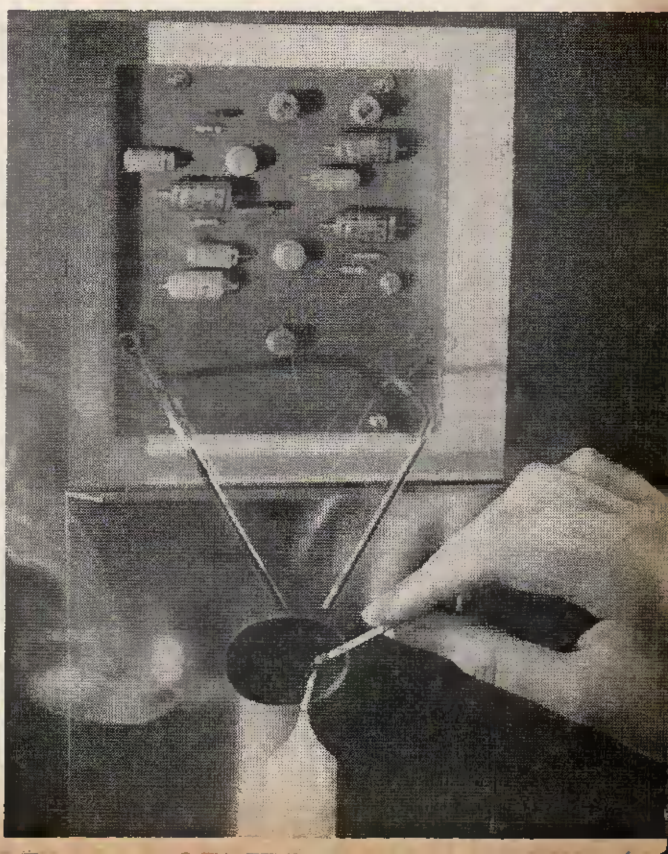
A field ion microscope, the first to be developed commercially in Britain, has a magnification of more than one million times; for the first time it enables individual atoms to be "seen".

One firm foreshadows the use of thyristors, already proving of great value in industrial control, for making domestic washing machines simpler, more reliable and possibly cheaper. By using a thyristor to control a single motor, gearing is eliminated and the "washing" and "spinning" speeds can be optimised.

Try and Light the Candle

THIS working exhibit (shown below) on the Mullard stand at the Components Exhibition effectively demonstrates the very high input impedance (10^{12} ohms) of the recently introduced metal-oxide semiconductor transistor, type 95BFY.

The two bare rods are input connections to a high-gain d.c.-coupled amplifier with an m.o.s. transistor in the first stage. Attempts to light the candle fail because the hot gases produced in the gap by a lighted match are sufficient to reduce the impedance seen by the amplifier. The resulting increase in output current opens a shutter which releases air to extinguish the match before it can light the candle.



UHF RECEPTION

by J. D. Benson

WITH THE rapid expansion of the BBC 2 television service throughout the United Kingdom, television engineers are being faced with an increasing quota of technical problems relating to the reception of these broadcasts in the home. Although this article has been written with service engineers in mind, a large proportion of viewers will probably find many answers to their own problems. To help to explain some of the finer points of u.h.f. reception let us briefly examine some of the fundamentals of radio wave propagation.

TRANSMISSION

Radio waves consist basically of two components: the electrical field and the magnetic field. These two fields are at right angles to one another and when transmitted are either horizontally or vertically polarised according to which field is parallel with the earth's surface. Irrespective of their frequency, the signals travel at the speed of light, i.e. 186,000 miles per second or 300,000,000 metres per second and from this we can derive the wavelength (λ) of any particular transmission:

$$\lambda = \frac{300{,}000{,}000 \text{ (metres per second)}}{\text{frequency (cycles per second)}}$$

Transmissions in the lower frequency bands are usually referred to by wavelength, whilst those in the higher bands are quoted in frequencies.

When transmitted, radio waves produce three types of waves: the ground wave, sky wave, and direct wave. The effectiveness of these waves depends largely on the frequency at which they are transmitted. The ground wave is produced by the electromagnetic component when the transmission is vertically polarised, that is when the electrical component is vertical to the earth's surface.

The power of the ground wave is determined by the frequency of the transmission; this can be better understood if the earth over which the waves travel is considered as a large capacitor. At low frequencies the earth offers a high impedance and little power is lost; as the frequency increases the impedance offered decreases until at very high frequencies the ground wave is practically non-existent. A practical case of ground waves transmitted at low frequencies is the BBC Light Programme on 1,500 metres, which can be received hundreds of miles away from its source.

The sky wave is so called because it is reflected from the Kennelly-Heavyside and Appleton layers which exist from about 40 miles to several hundred miles above the earth's surface. These layers are electrically charged (ionised) by the sun's action and deflect radio waves. Unlike a mirror, the waves are not directly reflected, but according to the frequency and state of ionisation are bent (refracted) before reaching the earth again.

It is due to this natural phenomenon that reception of certain frequencies is possible at great distances. It also explains why any change in these ionised layers (sun spots, etc.) results in a great variation in the results received at various times of the year. Very high frequency waves pass through these layers or are absorbed by them.

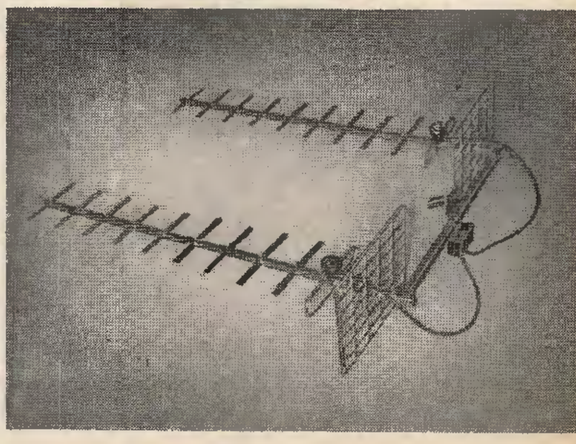


Fig. 1. Twin 'Yagi' array for fringe reception. The beam width is so narrow that very precise positioning must be carried out to obtain best results.

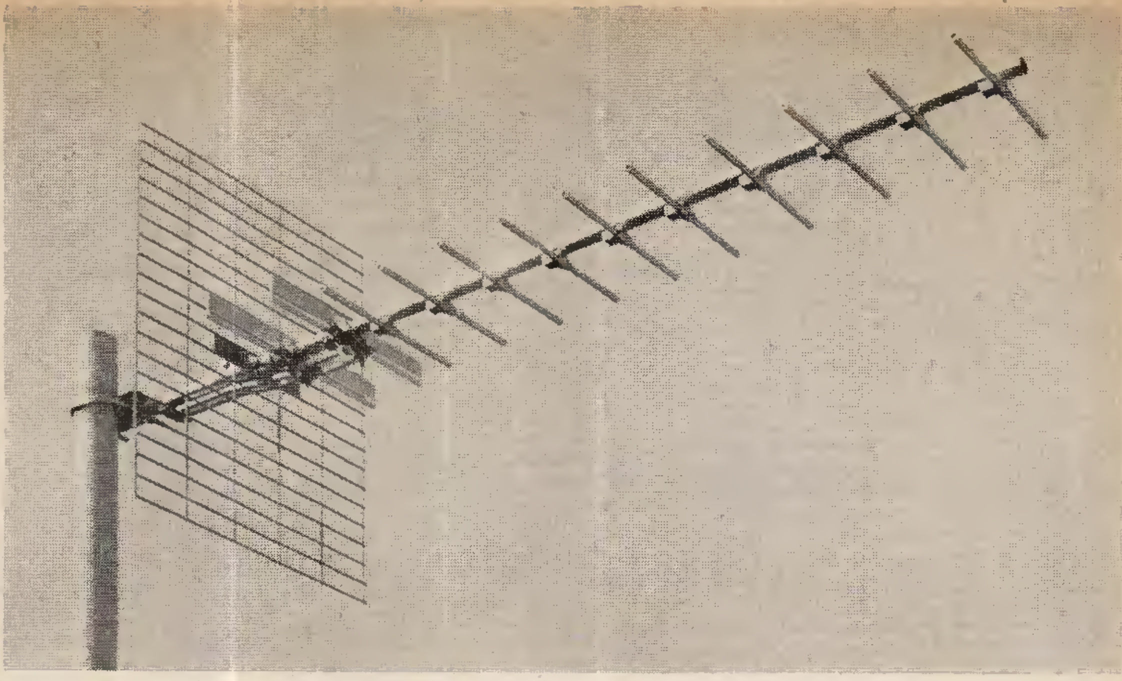


Fig. . A typical commercial 'Yagi' array by Belling & Lee

The long and medium wave stations are therefore very reliable under all climatic conditions because of their powerful ground wave component. The sky wave produced by medium wave stations is greatly reduced in power during the hours of daylight and are very powerful at night, which accounts for the improved reception of the medium wave band Continental stations during the hours of darkness.

SKIP DISTANCE

The high frequency band which covers 100–10 metres depends almost entirely on the sky waves for reception and results, according to climatic conditions can be very erratic. At these frequencies another effect called "skip distance" is present. It is the area between where ground waves are non-existent and where the shortest sky waves begin. In the skip distance area, no reception is possible. By the use of directional aerials and choice of frequency, great distances can be covered, but because of the adverse effect of climatic conditions this band is very prone to interference between stations.

Stations transmitting at v.h.f. rely almost entirely on direct waves for communication, i.e. aerial to aerial or line of sight. There is also a small percentage of reflection from the earth. This band is used for f.m. transmissions, television, radar and many other services. These bands, which extend from I to III, have now become so crowded that any new service had to be allocated a frequency on a new band, hence the choice of u.h.f. (ultra high frequency) for BBC 2 in Band IV (470–582Mc/s).

SITING AN AERIAL

At these ultra high frequencies communication is almost entirely dependent on direct waves, which necessitates the transmitting aerial being very high above ground (1,000ft or more) if a useful service area is to be covered. In spite of the high power (500kW) and high aerials, the BBC 2 transmitter will only cover a service area of about 25–30 miles radius from the transmitter and within that area there will be many locations where the signal strength will be greatly reduced due to the impeding effects of hills and tall buildings.

In areas beyond the service limits the service engineer can estimate his chances of receiving a workable signal by studying the contours of the ground between his receiving site and the transmitter. These contours can be obtained from an Ordnance Survey map. By drawing a straight line on the map from the position of the receiving aerial to that of the transmitter, the various heights can be read off and compared with the height of the transmitting aerial. For example, if the viewer's site is, say, 40 miles from the transmitter and directly behind a hill 1,000ft high, then his chances of receiving a workable signal are very small indeed.

U.H.F. waves follow closely the same rules which apply to light, i.e. they travel in straight lines from the source of origin. They are largely absorbed by buildings, so unless the site is very near the transmitter, the use of indoor aerials may be impracticable. In locations where an indoor aerial will give sufficient signal, it will have to be very carefully sited if interference from nearby moving objects is to be avoided.

Loft aerials are a better answer if the location is near the transmitter, but here the engineer must first ascertain whether the roof is lined with metal or not. In positioning the aerial, he must make sure that no piping, tanks, etc. are near the aerial, as at these extremely short wavelengths, they can produce permanent ghosts and reflections which can ruin reception.

FEEDER LOSS

It is well to remember that the signal strength required for good reception at these frequencies is at least three times more than those required for Band III (ITA). One of the main contributory factors to this is that, as frequency is increased, the noise generated within the receiver itself is greater. To suppress this self-generated noise, a much greater signal strength is required. The feeder to the receiver also adds to the loss, but by using standard low loss feeder it has been proved that very little improvement can be gained by fitting other types of cable if the installation is to be kept within practicable limits.

Whilst dealing with the subject o feeder loss, it must not be forgotten that whilst the aerial is a balanced component, the coaxial feeder is not, since one side, the outer sheath, is normally connected to earth. The danger point is near the aerial where currents can be induced in the outer sheath. This will greatly detract from the performance of the aerial. Since it is imperative to avoid all possible losses it is advisable that the cable be joined to the aerial via a "balun", a fitting well-known to the engineer and needing no description here. The mismatch is much more noticeable with horizontal aerials than with vertical aerials by reason of the position of the feeder in relation to the incoming signal.

ERECTION

Because of the necessity for obtaining as large a signal as possible, the aerials used for u.h.f. reception will be multi-element arrays which will follow the well-known Yagi design. Since the elements of the aerial are physically small, it is possible to increase their number and so effectively boost both the total voltage picked up and their directive qualities. In view of the size of the elements, the aerials are light in weight and can be safely installed in exposed positions where heavier arrays could be unstable. However, it must be borne in mind that u.h.f. arrays must be rigidly constructed, as any inclination to sway in the air when subjected to strong winds can produce variations in the signal strength received.

The erection and positioning of u.h.f. aerials especially in areas of low signal strength, calls for patience. Wherever possible the array should be moved about whilst results are being observed, remembering that at their critical frequencies a matter of inches can mean the difference between a good signal and a poor one. Beyond a certain point there is little to be gained by increasing the size of the array and much better results can be obtained by using a pre-amplifier.

PRE-AMPLIFIER

With the recent advent of a transistor that is capable of handling the Band IV frequencies, it is now possible to build a pre-amplifier which will give an amplification of about 14dB at low cost. This should give sufficient gain in areas where the field strength is below 100mV. The best position to fit such a pre-amplifier is at the mast head; the power to operate it can be fed via the feeder or it can have a self-contained battery. Amplification of a weak signal in the u.h.f. range is more satisfactory than amplification at lower frequencies since these signals are free from man-made forms of impulsive interference. Although Bands IV and V are free from aircraft flutter, they are subject to disturbance by passing vehicles, so wherever possible the installation should be kept as far away from roads bearing heavy traffic as is possible.

For engineers who construct their own pre-amplifiers it should be noted that at Band IV frequencies all connections should be kept to a minimum length, since these wavelengths are measured in inches. A point of warning when using transistors with very short leads, do not forget to use a heat shunt or your transistor may be ruined before it is put into service.

SIGNAL STRENGTH

The following is a list of the signal strengths required to give good results for each of the four television bands from results of research by the BBC.

Band I	0·115–0·170mV/metre
Band III	0·45mV/metre
Band IV	1–2mV/metre
Band V	2–4mV/metre

At a glance it will be seen that a much greater signal is required at u.h.f. to obtain comparable results with the other bands. Added to these requirements is the fact that the signal strength delivered to the receiver is only half the signal strength received by the aerial provided *perfect* matching conditions exist.

From these facts it can be more readily understood why an efficient aerial is required even in areas of comparatively high signal strength. There is one more factor which must be remembered when dealing with u.h.f. signals. For every 5 miles from the transmitter the signal strength decreases more than three times as rapidly as Band I.

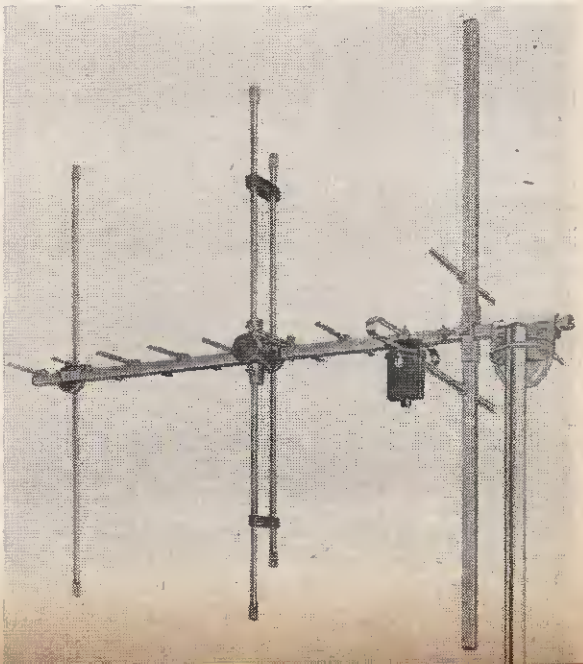
AERIAL ARRAYS

The long wire inverted L aerial is well known to all radio experimenters. As the frequency increases, so the wavelength decreases, until at u.h.f. the wavelengths can be measured in inches. The dipole aerials for v.h.f. and u.h.f. are usually made half a wavelength long, which makes the dipole for the lowest channel in Band IV about 12½ inches and for the highest channel in Band V about 5in.

Elements positioned behind the dipole are known as reflectors; elements in front of the dipole which are pointed towards the transmitter are called directors. The complete array is known as a Yagi (see Fig. 2).

continued on page 713

Fig. 3. Antiference 'Uniray' aerial for the Winter Hill area, comprising 3-element Band III plus 9-element u.h.f. arrays



ELECTRONIC BUILDING BLOCKS

PART FIVE

by R. A. DARLEY

It is not the intention in this series to delve deeply into the theory of transistors; information on this aspect has been published recently. This series is mainly concerned with the *application* of transistors. It is assumed throughout that the reader already has some rough idea of how a transistor works. Where it is essential to the text, *simplified* terms are used to indicate certain characteristics of the transistor.

It should be stressed at this point that it is *not* necessary to know all the finer points of transistor theory in order to be able to design complete, and often complex, circuits.

The essential knowledge of transistors that is needed in order to understand this series can be summed up as follows:

TRANSISTOR CONFIGURATIONS

While it is true that the theory of operation of the valve and transistor are quite different, there are many similarities in their functional operation. In the triode valve, for example, a small grid-to-cathode voltage controls a large anode-to-cathode current flow, while in the transistor a small base-emitter current controls a larger collector-emitter current.

These voltages and currents are illustrated in Fig. 5.1. Note that only the conventional currents are indicated; no reference is made to the flow of electrons.

There are three basic configurations in which the valve can be used: common grid, common cathode, and common anode. Similarly, three configurations are used in transistor circuits: common base, common emitter, and common collector. These last three circuits are shown in Fig. 5.2, together with details of gain and impedance. *Pnp* transistors are depicted in these, as these are the most widely used of the two main types.

The three configurations are easily remembered if the word "grounded" is substituted for "common", i.e., in the common base circuit, the base is connected directly to "ground" (chassis), and is, therefore, common to both the input and output circuits. A point that must be remembered is that, while the negative line and ground are at different d.c. potentials, they are *effectively* common as far as a.c. is concerned, due to the fact that the power supply has a very low internal impedance. Thus, in the common collector circuit, the collector is effectively shorted to ground, and the term "grounded collector" can be applied.

PRACTICAL TRANSISTOR CIRCUITS

The circuits shown in Fig. 5.2 are, of course, very much simplified. A practical example of the most widely used of these configurations, that of the common emitter, is shown in Fig. 5.3. Three additional resistors (R1, R2, and R3) are shown.

The working point of a transistor, relative to its characteristics curve, is determined by the amount of base-bias applied. This "bias" may be referred to either in terms of voltage or current, as the two quantities are interdependent. The working point may be set by a simple voltage divider chain, shown as R1 and R2 in Fig. 5.3.

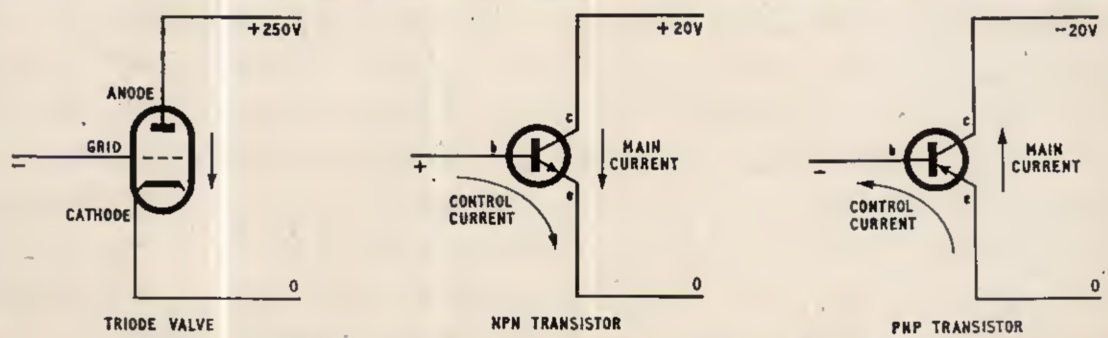


Fig. 5.1. Comparison of current flow in a triode and the two types of transistors

The basic transistor is, unfortunately, notoriously unstable when subjected to termperature changes, and suffers from such ailments as thermal runaway, changing input and output impedances, etc. No complete cure for these troubles exists, as yet, but they can, with careful design, be at least kept under control.

By placing a resistor in series with the emitter (R3 of Fig. 5.3), d.c. negative feedback is obtained; any increase in emitter current results in an increased voltage drop across the emitter resistor. If no corresponding increase in the input voltage to the base has been made, the base-emitter voltage is reduced, thereby tending to reduce the emitter current. To prevent this feedback acting on signals applied to the transistor input, a decoupling capacitor (C2) is connected in parallel with R3, thus preventing a.c. feedback.

The larger the value of R3, the better will be the stability. A limit is set on the maximum value of R3 by the amount of voltage drop that can be afforded across this resistor; this will depend on the current, and hence peak-to-peak output signal, needed at the collector. In practice, it is adequate to allow for a voltage drop of ½ to 1 volt across the emitter resistor.

As mentioned above, the transistor input impedance

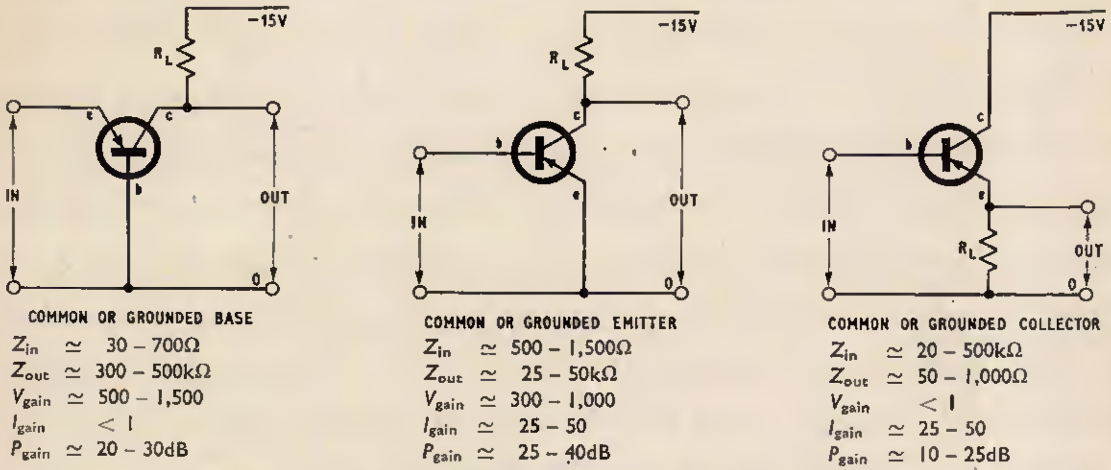


Fig. 5.2. Three basic transistor configurations

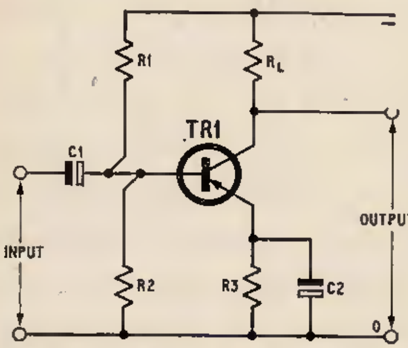


Fig. 5.3. Common emitter single stage transistor amplifier

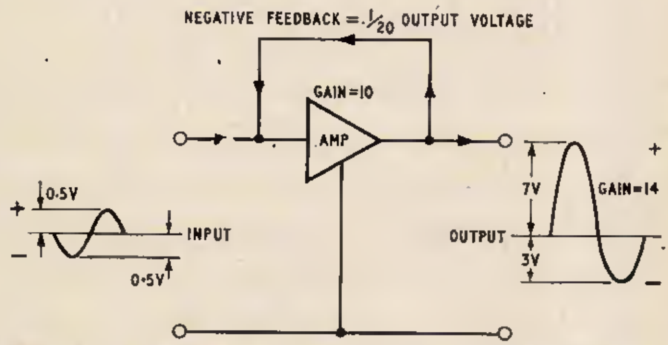


Fig. 5.4a. Block diagram of the circuit shown in Fig. 5.3 and the waveforms of input and output when no negative feedback is applied

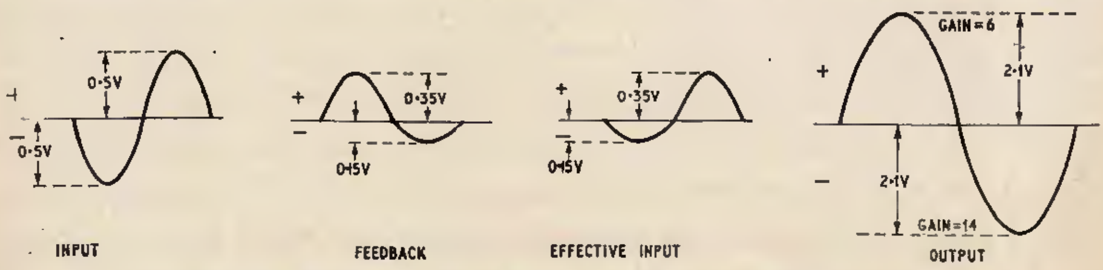


Fig. 5.4b. The effect of applying negative feedback to the circuit shown in Fig. 5.4a

may be subject to change with ambient temperature. The input impedance is effectively in parallel with R2 of the voltage divider chain, and therefore shunts it, so that any changes in input impedance may result in a change in the base-bias voltage, resulting in instability. The current flowing through R1 is shared by R2 and the base and, by ensuring that the current drawn by R2 is about 10 times greater than that of the base, the effect of variations of base current on the bias voltage is considerably reduced and greatly improved stability is obtained. Generally, the lower the values of R1 and R2 for any given voltage divider network, the better the stability will be.

SINGLE COMMON EMITTER STAGE

When designing a single stage common emitter circuit decide from the manufacturer's literature on the transistors working point. For example, an OC71 transistor should be designed to work with an emitter current of about 1mA, in most cases.

Refer to the manufacturer's literature to find the permissible collector current swing without undue distortion, and from this value select R_L to give the required output voltage swing.

Now select the emitter resistor R3. Remembering that the recommended voltage drop across this resistor is between $\frac{1}{2}$ and 1 volt, and that in the case of the OC71, the emitter current is 1mA, R3 will be between 500 and 1,000 ohms. Leakage and base currents have been neglected since they are relatively small and in this calculation are insignificant.

Connect a potentiometer (about 100 kilohms) between the positive and negative supply lines with the wiper connected to the transistor base. Monitor the emitter current and adjust the potentiometer until the emitter current is 1mA. Measure the base voltage between the wiper and chassis and then replace the variable resistor by two fixed value resistors, R1 and R2, with values calculated to give the same base voltage, but with the lower reistor (R2) taking ten times more current than the transistor base. Connect capacitor C2, with a value of about 100μF, in parallel with R3, to eliminate a.c. negative feedback.

This procedure applies ONLY to a single, unloaded stage. When designing the circuit to feed into a specific load, such as the input impedance of a following stage, the value of the collector load, R_L, is chosen to give an impedance match, since R_L is effectively in parallel, and shunted by, the output load.

In some cases R2 may be omitted from the circuit, in which case R1 is regarded as a series base current control resistor. Again, it may be found that R1 is replaced by the collector load of a preceding transistor. Stability may be maintained in this case but it is dependent on the stable functioning of the previous stage.

FREQUENCY RESPONSE

Generally speaking, the frequency response of an RC-coupled transistor a.f. amplifier is limited by two factors. At the low frequency end of the response curve, the limit is set by the time constant of the input coupling capacitor and the base-to-ground impedance of the circuit. For a good low frequency response, a long time constant is required; the input impedance of a common emitter amplifier is generally fairly low, however, and the best way of obtaining a really good low frequency response is to use either a very large value of coupling capacitor, or d.c. coupling between the input and base.

The high frequency response is limited mainly by the characteristics of the transistor. The cut-off frequency of a transistor is usually given in the manufacturer's literature. That of the OC45, for example, is given as about 6Mc/s. It should be noted, however, that this figure applies only to the common base mode of operation, and that in common emitter only a fraction of this figure will be obtained.

NEGATIVE FEEDBACK

The transistor is basically a non-linear device and, although a practical circuit may be designed to work on the most linear part of the characteristic curve, some distortion of the signal at its output must invariably result. By applying negative feedback over the circuit, both the noise and distortion may be kept low. Unfortunately, the gain is reduced also, so no improvement in signal/noise ratio results. The effective cut-off frequency of the circuit is, in the common emitter mode of operation, increased.

If 6dB of negative feedback is applied over a common emitter stage the noise and distortion are halved and the effective cut-off frequency doubled. Negative feedback is feedback in antiphase to the input, and the action may be understood with reference to Fig. 5.4.

To illustrate this let a sine wave of 1 volt peak-to-peak be fed to the input; the transistor has a mean gain of 10, but the distortion due to non-linearity is such that at the output the positive half-cycles rise to 7 volts peak and the negative ones to 3 volts peak. This is the output signal without feedback.

Now suppose that one-twentieth of the output is fed back to the input, in antiphase. When the positive half-cycle, of 0·5 volts peak, is fed to the input, the output will be a negative half-cycle of 3 volts peak, the true gain at this point of the curve being 6. With one-twentieth of the output fed back to the input, the feedback signal will have an amplitude of $3/20 = 0{\cdot}15$ volts, so the actual signal on the base will be $0{\cdot}5 - 0{\cdot}15 = 0{\cdot}35$ volts. With a gain of 6 the output from an input of 0·35 volts will be 2·1 volts.

Now consider what happens when the negative half-cycle of 0·5 volts peak is fed to the input. The output = 7 volts peak at a gain of 14, and the feedback signal $= 7/20 = 0{\cdot}35$. The actual signal on the base is therefore $0{\cdot}5 - 0{\cdot}35$ volts, which gives a base signal of 0·15 volts. The gain is 14, so the output signal = 2·1 volts, exactly the same as was obtained with the other half-cycle. The distortion is thus eliminated.

This explanation of the action of negative feedback is a considerable over-simplification; the gains with feedback would not be the same as those without it. The explanation does, however, serve to indicate the principles involved.

In the case of a single stage common emitter transistor, negative feedback can be obtained by leaving the emitter resistor unbypassed, or by resistive coupling of the base and collector.

PHASE CHANGERS

It is sometimes required that a phase change of 180 degrees be imposed on the signal in some part of a circuit. Such a phase change can be imparted by a conventional common emitter circuit, and it should be noted that, when reading circuit diagrams, what looks like a conventional amplifier may in fact be a mere phase changer, the stage gain of the circuit being of secondary importance, and quite often very low.

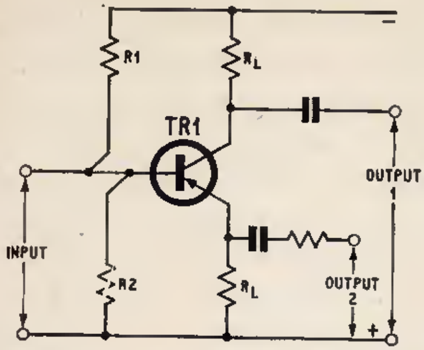


Fig 5.5. Phase splitter or balanced inverter giving two outputs in anti-phase from a single input

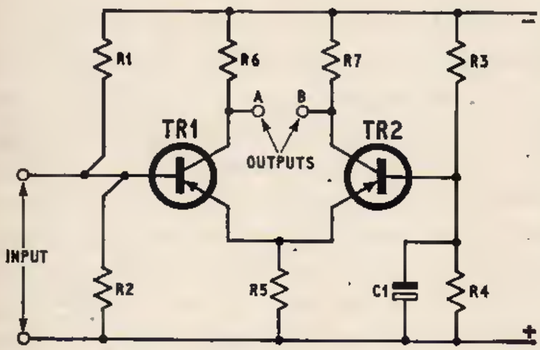


Fig. 5.6a. Another method of phase-splitting by using the long-tailed pair paraphase amplifier

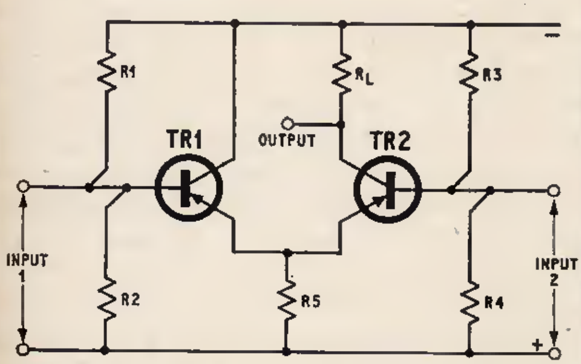


Fig. 5.6b. A variation of the paraphase amplifier known as the differential amplifier in which a single output is obtained from two inputs

PHASE SPLITTERS

It is sometimes required that two outputs, in antiphase to each other, be made available from a single input.

One circuit that fulfils this requirement is shown in Fig. 5.5. This circuit, sometimes known as the "balanced inverter", has equal loads on the emitter and collector outputs. Since the current flowing in the collector circuit is practically the same as that flowing in the emitter, the two outputs across the equal value loads will be, for practical purposes, of equal amplitude, but opposite phase.

The unbypassed emitter load resistor introduces considerable negative feedback, and results in a gain of a little less than one at each output.

A disadvantage of the circuit is that the two output impedances are not equal. The output impedance at the collector is roughly equal to the collector load, and is thus fairly high, while the output impedance at the emitter is low, approximating to the input *source* impedance divided by the transistor current gain. This disadvantage can be overcome by connecting a resistor in series with the emitter output, of a value equal to the difference between the two impedances. When so modified, the circuit gives two outputs of opposite phase, equal magnitude, and with equal output impedances, from a single input signal.

Such a circuit may be used for driving push-pull output stages of an amplifier, or to give symmetrical deflection on the plates of an oscilloscope from a single-ended input.

THE "LONG-TAILED" PAIR

Another circuit that can be used for phase-splitting is shown in Fig. 5.6a. This circuit is a member of the "long-tailed pair" family, this particular version being known as the "paraphase amplifier". The long-tailed pair circuit is distinguished by the use of a common resistor shared by the two emitters of the circuit.

Referring to the circuit diagram, two transistors are connected in the common emitter mode, each with its own base bias chain (R1–R2, and R3–R4), but the input is applied to the base of one transistor only (TR1). The base of the other transistor is shorted to a.c. by C1. With no signal applied, the two base potentials of the circuit are equal.

Let it be assumed that the transistors TR1 and TR2 have similar characteristics, and that the two collector load resistors, R6 and R7, are of equal value. The current flowing through the common emitter resistor (R5) is shared equally by the two transistors, under "no-signal" conditions.

With an input signal applied to the base of TR1, the negative going part of the input waveform results in an increase of current through TR1 and, therefore, through the common emitter resistor R5. The voltage developed across R5 increases and, consequently, the emitters of the two transistors also move in a negative direction; negative feedback is thus obtained over TR1.

Now, the part of the input signal that really controls the emitter current in a transistor amplifier is the effective difference between the emitter and base potentials resulting from the input signals, i.e. if the emitter is at a potential of 1·5 volts and the base potential is at 1·7 volts, the true control voltage is 0·2 volts. Thus, in the circuit under consideration, the effect of the negative-going movement of the emitter potentials on TR2 is to reduce the difference between the emitter and base potentials (remembering that the base of this transistor is held at a fixed potential and is short circuited to a.c.); the emitter current of TR2 is therefore reduced. The output signals at the two collectors of the circuit are therefore in antiphase.

An increase in collector current through one transistor of a long-tailed pair results in a decrease in the collector current of the other transistor; the total current through the common emitter resistor therefore tends to remain constant. The larger the value of this resistor, the more nearly constant will the current be. It therefore follows that, if the ultimate in stability is to be obtained, an increase of *I*mA through TR1 will result in a decrease of *I*mA through TR2, and the two signals at the outputs will be of exactly equal magnitude.

Such a circuit will give two output signals of equal magnitude, equal impedance, but in opposite phase, from a single input.

In any common emitter circuit (using *pnp* transistors), the emitter current can be increased either by applying a negative signal to the base, or a positive signal to the emitter.

THE DIFFERENTIAL AMPLIFIER

A variation of the paraphase amplifier, known as the "differential amplifier", is shown in Fig. 5.6b. The main difference between this and the earlier circuit is that *two* inputs are applied, and only *one* output signal is needed; in view of this last requirement, one of the collector loads can be dispensed with.

The action of the circuit is very similar to that already described; the common emitter resistor results in interaction between the two transistors.

When a negative-going signal is applied to the base of TR1, the emitter current of TR1 increases and that of TR2 decreases. If, simultaneously, a negative-going signal is also applied to the base of TR2, the emitter current of TR2 will increase and that of TR1 will decrease. If the two inputs are of equal amplitude and phase, the increase in emitter current of one transistor due to one input signal will be cancelled by the decrease in emitter current due to the other input; there will be no change in currents and no output signal will result. If the two inputs are not of equal amplitude the currents will not cancel out, and a current that is directly proportional to the difference between the two in-puts will flow in each emitter.

In the circuit shown in Fig. 5.6b, only one collector load has been shown, connected to TR2. If loads are connected to both collectors, the output of TR2 will be in phase with the base of TR1, and the collector of TR1 will be in phase with the base of TR2. The collector loads can be connected to one or both transistors depending on the phase relationship that is required.

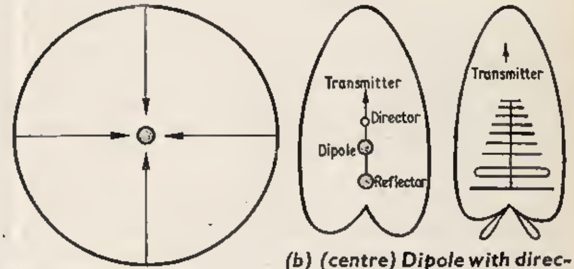
The difference between input signals is dictated not only by amplitude, but also by phase. Thus, if the two inputs are of equal amplitude but opposite phase, the output signal will be proportional to twice the value of either of the inputs.

Next month: Considerations of the effects of impedance in transistor circuits and some practical matching circuits

UHF RECEPTION

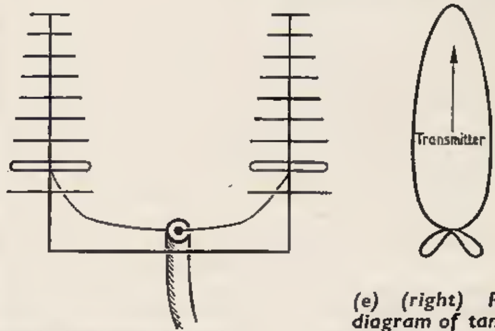
continued from page 708

If a half wave dipole were used on its own, the signal strength would be the same from all directions. If the signal strengths from all directions were plotted on paper, the results would be a circle with the dipole as the centre. This kind of graph is known as a polar diagram (see Fig. 4).



(a) (left) Simple dipole; similar signal strengths from all directions

(b) (centre) Dipole with director and reflector reduces unwanted signals behind dipole and improves directivity
(c) (right) Yagi array giving much greater directivity with greater reduction of unwanted signals behind dipole



(d) (left) Tandem Yagi array

(e) (right) Polar diagram of tandem array

Fig. 4. Polar diagrams of aerial arrays

The addition of reflector and directors has a profound effect on the performance of the aerial as can be seen from the polar diagrams in Figs. 4b and 4c. Broadly speaking, the addition of a reflector greatly reduces the effect of unwanted signals, including man-made interference, from behind the dipole and the addition of reflectors increases the gain of the aerial and also increases the directive qualities of the whole array.

For fringe area reception where two or more arrays may be used to increase the signal strength (Fig. 4d), the directive qualities or beam width is so narrow that very precise positioning of the aerial must be carried out to obtain optimum results. The polar diagram display is shown in Fig. 4e for a twin array. An added characteristic of multi-arrays is excellent selectivity.

Next month: Some practical guidance on constructing aerial arrays for u.h.f.

the 73 page by Jack Hum G5UM

Competitive

Perceptive readers who examined closely the log extracts reproduced here last time will have noticed two details of some significance: that the contacts logged had been coming thick and fast, and that each was accompanied by a code number.

What in fact was being shown was a portion of a log kept during the course of a transmitting contest. This month we reproduce another such log, this time rather more fully, comprising one page from the written record of a radio club station participating in one of the big annual transmitting contests organised by the Radio Society of Great Britain. It is shown here not so much to illustrate how a log should be kept as to underline the intense activity which such contests produce. Here too, as will be seen, contacts were coming thick and fast.

Transmitting contests today occupy such an important part of the amateur radio scene throughout the world that *The 73 Page* would be failing in its duty did it not invite the attention of its readers to them—if indeed they have not become aware of them already, for barely a weekend passes but one contest or another can be heard in progress somewhere or other in the world.

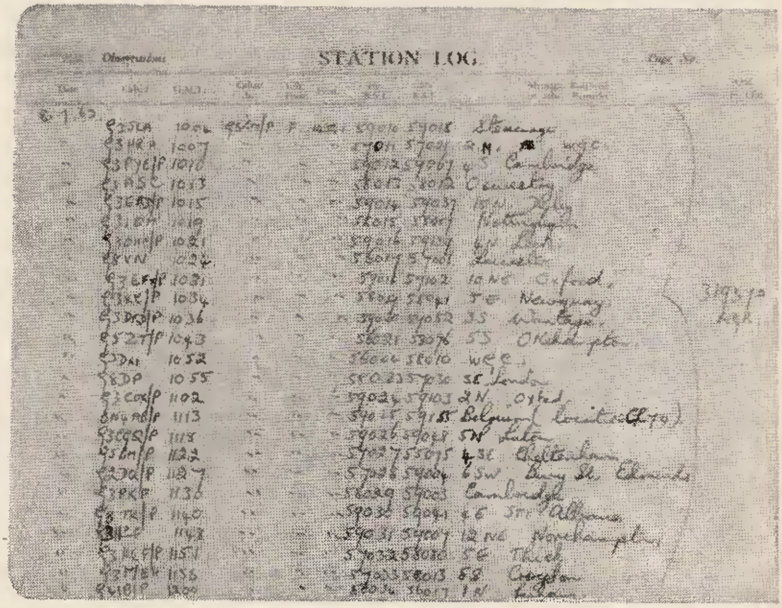
Snappy Operating

The immediate evidence by which the short-wave listener gathers that a contest is on is an aura of urgency that seems to dominate the amateur bands. Operators may be heard calling "CQ Contest", sometimes naming the actual event in which they are participating so that no answers will be sent by people who are not! Leisurely conversation is out during contest time: snappy operating is in. Contacts are disposed of in the quickest possible time.

The operator who collects the largest number of contacts, or winkles out the rarest or most distant countries (according to how the rules are framed), will find his call-sign at the top of the list when the results are eventually published.

The Hard Slog

To achieve this status is the result of sheer hard work. Success in contests calls for nothing less. Nor is a top place simply a brief moment of glory, to be basked in for a month or two before all is forgotten: what is remarkable is how the same call-signs appear time after time in the top positions of the world's competitive transmitting events.



The station log can be either a self-prepared one ruled up to carry the information required by the G.P.O. licence, or it can be one of the several commercially produced varieties which are on the market. The example shown is from a "G6DS logbook". The extract is from a period of contest-operating on the 2 metre amateur band.

There is an obvious reason for this. The operator who is determined to do well in a contest knows he will be wasting his time if either his skill or his technical facilities are less than one hundred per cent efficient.

He knows that if *he* can sort out that elusive signal from beneath a pile-up of perhaps half-a-hundred others which are almost zero-beat with it then he stands a fair chance of a top place in the final table.

He knows that this will be possible only if *his* receiver is better than the next man's—and he knows that "the next man" knows it too!

He knows also that simply to *hear* them is not enough: he must be able to work them as well, with the aid of a transmitter-and-aerial combination of hyper-efficiency and reliability used at the psychological moment—and as a rapier, not as a broadsword.

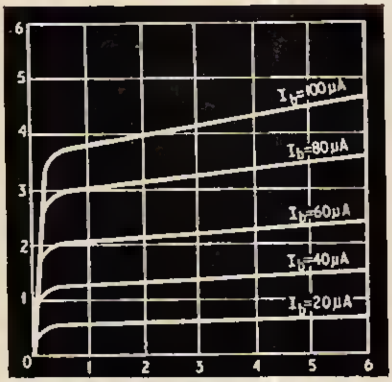
"Is it worth it?"

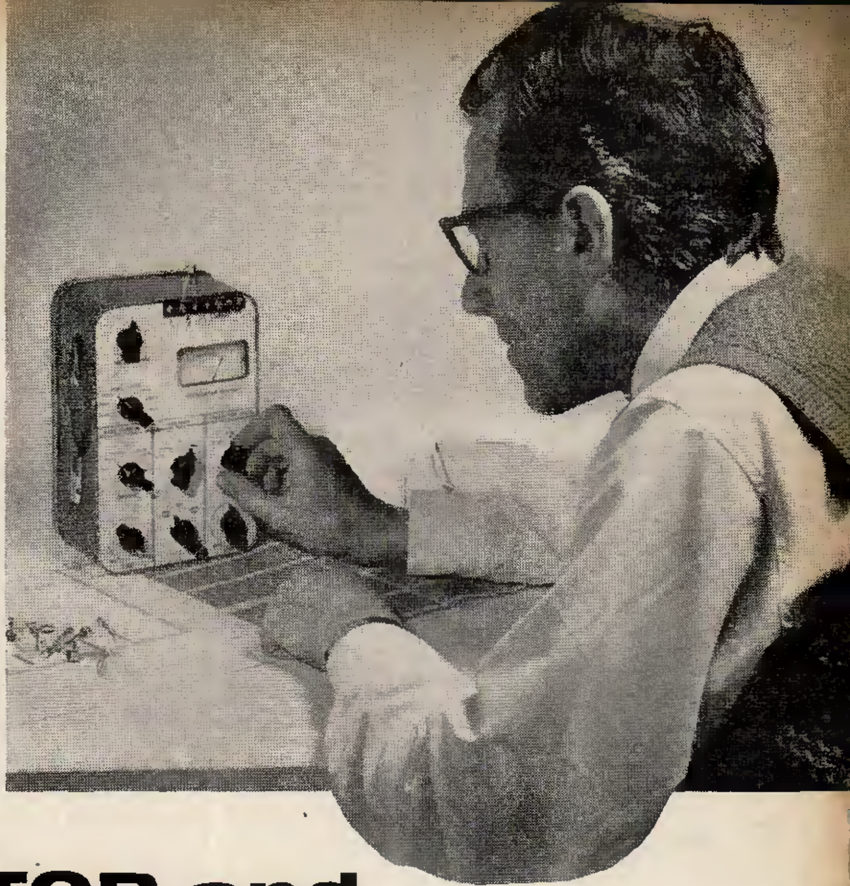
Well may the practical electronician enquire "whether it is all worth it", to which he will be inclined to reply "Yes" if he agrees that the development and exercise of a skill are useful ends in themselves. Most people believe that they are.

This belief counterbalances the oft-heard criticisms that contests "clutter up the bands", that "there is no weekend free of them" and that the collecting of code numbers from a myriad of other stations is a monotonous chore that could be conveniently consigned to a computer—and all of these comments carry some validity.

the 73 page by Ja

Inexpensive
Versatile
Simple to
build





TRANSISTOR and DIODE TESTER

By B. Crank

This instrument was designed to provide an inexpensive unit capable of carrying out a series of d.c. tests on various transistors and diodes. It measures leakage current between collector and emitter (I_{co}) and between collector and base (I_{cbo}). It also enables transfer and collector characteristics to be determined quickly for both *pnp* and *npn* transistors. Forward and reverse currents for diodes at various applied voltages can be measured; Zener voltage can be determined on silicon Zener diodes.

Indication is by an internal 50µA meter which is provided with fourteen ranges between zero and 50mA, and between zero and 25 volts. Collector voltage is available up to 18 volts in three ranges, i.e. zero to 1 volt, zero to 9 volts, and 9 to 18 volts. The circuit employed ensures that any value of collector voltage within the above ranges can be easily and accurately set. Base current is available in six continuously variable ranges from zero to 5mA. Collector currents up to 50mA can be accommodated.

The unit is housed in a small case 8½in × 5½in × 3¾in; the whole unit costs about five pounds to make.

CIRCUIT

This is best started by looking into the power supply arrangements. As can be seen from Fig. 1 two 9 volt batteries are used these being connected in series and centre tapped. S6 is the "*pnp*/off/*npn*" switch and is shown drawn in the *pnp* position. The negative terminal of BY1 is connected via position 1 of S6c to the top end of VR1. The lower end of VR1 is connected via position 1 of S5a, position 1 of S5d and position 1 of S6d to the positive terminal of B2. Thus VR1 has the full 18 volt supply across it. It will also be noticed that in position 1 of S6a and b that the negative side of the meter is connected to S1b and the positive side to S1a. With S6 in position 2 the batteries are disconnected and a short circuit is placed across the meter to damp the movement of the needle due to its own self-generated current during transit. In the third position of S6, i.e. *npn* position, the battery and meter connections are reversed.

For the rest of this description it will be assumed that S6 is in the *pnp* position, i.e. position 1. VR1 as has already been shown has 18 volts across it, as long as the unit is switched on, regardless of other switch positions. VR1 forms a potential divider and is the base current fine control. The potential at the wiper of VR1 is fed, via a limiting resistor, selected by the base current coarse control S4, to the base of the transistor under test via S1e. The resistors selected by S4 (R14 to R19) provide the following ranges of base current: 0–10µA, 0–50µA, 0–100µA, 0–500µA, 0–1mA, 0–5mA.

The action of the collector voltage coarse control (S5) and fine control (VR2) will be discussed next. With S5 in position 1 the negative terminal of BY1, as far as VR2 is concerned, is out of circuit. The negative terminal of BY2 is connected via R20 to VR2; R20 allows about 1 volt to be dropped across VR2, the positive return being S5d and S6d to B1. Therefore a potential of between 0 and 1 volt is available at the wiper of VR2.

With S5 in position 2 the circuit is identical except that R20 is short-circuited. The full nine volts from BY2 is applied across VR2 so that the potential at VR2 wiper can be varied between 0 and 9 volts.

With S5 in position 3 the positive terminal of BY2 is connected via S5a to the earth line of the tester maintaining the 18 volts across VR1. The lower end of VR2 is connected via S5c and S5d to the battery centre-tap and is therefore at 9 volts negative with respect to earth. The upper end of VR2 is connected via S5b to the negative terminal of BY1. Although there is still only 9 volts across VR2 the potential at the wiper is between 9 and 18 volts with respect to battery positive. The extra complication involved in giving VR2 this range of 9–18 volts instead of the much more easily obtained 0–18 volts is well worthwhile as it means that the operator has a much finer control over collector voltage.

The main disadvantage of the system used is that when heavy collector currents are being taken (i.e. over 10mA) and when the switch is in the 9–18 volt position, the collector voltage falls sharply for the first movement of the potentiometer but the voltage soon recovers and still results in finer control being obtained.

S2 and S3 control the meter ranges, provided S1b is at any position except position four, giving eight current ranges with full scale deflections of 50μA, 100μA, 250μA, 500μA, 1mA, 5mA, 10mA and 50mA. With S1 in position four the multiplier resistor selected by S3 is now in the meter circuit to provide up to 0·1V, 0·5V, 1V, 5V, 10V and 25V on each range respectively.

The instrument functions by applying various potentials to the transistor under test and by switching the meter into various parts of the circuit with S1.

S1 IN POSITION 1 I_{c0}

In this position the meter is indicating collector to emitter leakage current; the basic test circuit is shown in Fig. 2a. The meter together with a shunt resistor selected by S2 is in series with the negative supply to the collector; the base is open circuit.

Reference to Fig. 1 will show how this is achieved. The negative supply at the wiper of VR2 is fed via position 1 of S1c through the meter and its shunt (selected by S2) to the collector of the transistor under test, via S1a and the external meter socket. The purpose of this socket is to allow collector currents of greater than 50mA to be measured on a more suitable external meter. It also simplifies the process of plotting performance curves, although this can be done without the external meter. Normally this socket is short-circuited when no external meter is used. The emitter of the transistor is connected to the battery positive line via S5a, S5d and S6d.

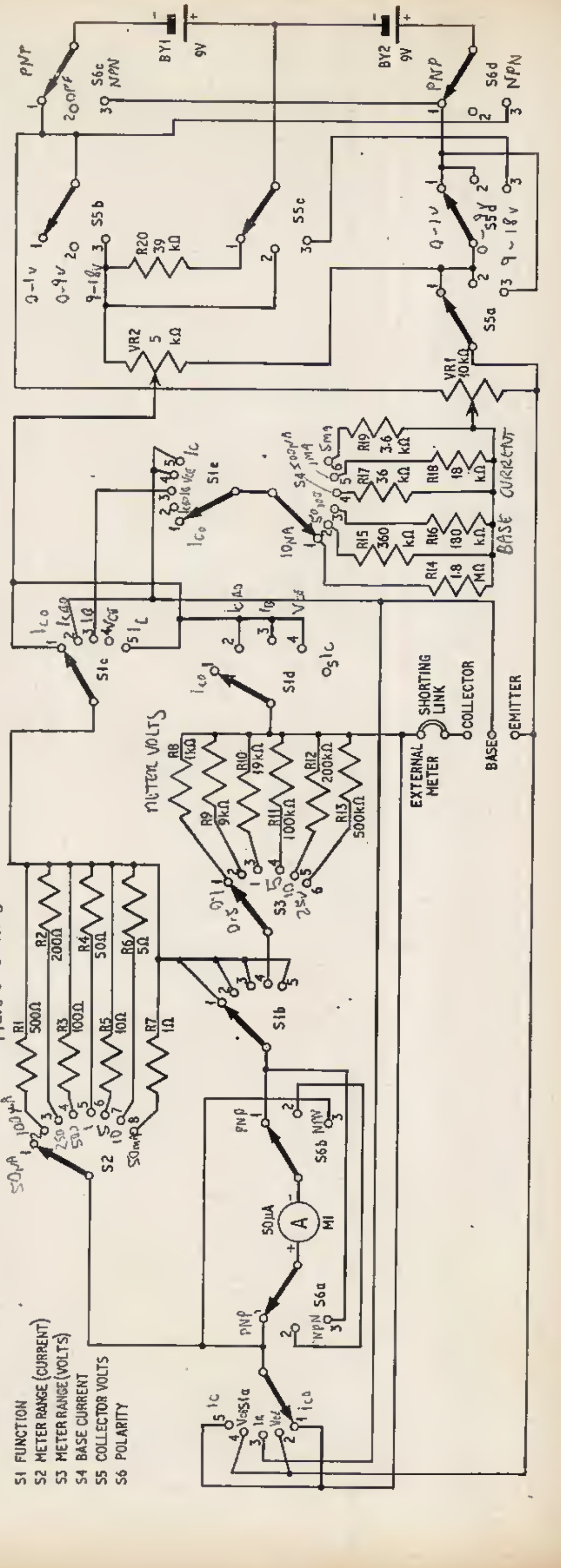


Fig. 1 (right). Circuit diagram of the complete transistor and diode tester. All switch positions are related to the annotations given in Fig. 7. For example: position 1 of S1 is for measuring I_{c0}, and so on

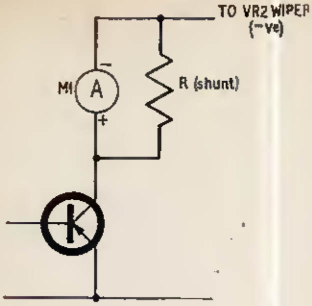
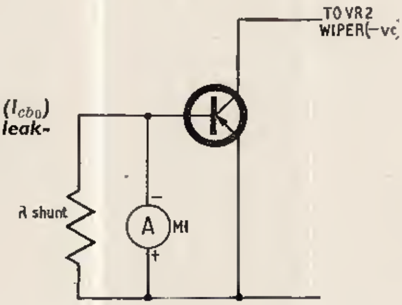


Fig. 2a. Position 1, (I_{co}) collector to emitter leakage current

Fig. 2b. Position 2, (I_{cbo}) collector to base leakage current



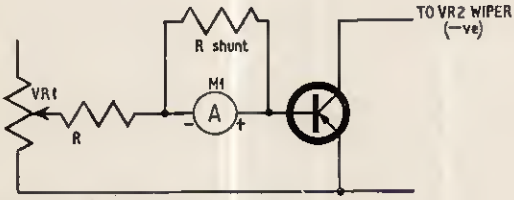


Fig. 2c. Position 3, (I_b) base current

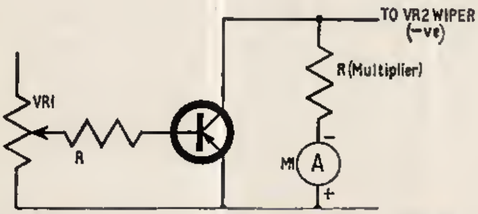


Fig. 2d. Position 4, (V_{ce}) collector to emitter voltage

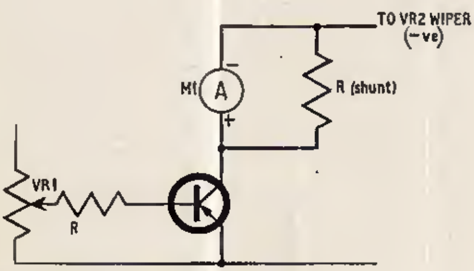


Fig. 2e. Position 5, (I_c) collector current

Fig. 2. Basic circuits for each position of S1

S1 IN POSITION 2 I_{cbo}

The basic circuit is shown in Fig. 2b. Here the negative supply is fed direct to the collector. The meter and its selected shunt is connected between the base and earth to indicate collector to base leakage current.

The negative supply at the wiper of VR2 is fed via position 2 of S1d direct to the collector. The meter complete with shunt is connected via position 2 of S1c and S1a between the base and emitter.

S1 IN POSITION 3 I_b

In this position a measured value of base current is allowed to flow in the transistor. This checks the continuity of the base emitter junction and enables any base current between 0 and 5mA to be preset so that other checks can be carried out. The basic circuit is shown in Fig. 2c. The wiper of VR1 is connected via a limiting resistor selected by S4 to one side of the meter and shunt. The other side of the meter is connected to the base via S6a and S1a. The meter will register base current, the value of that base current being controlled by VR1 and S4. Also the negative supply is still connected to the collector.

The negative supply at the wiper of S4 is fed via position 3 of S1e and S1c to the meter and shunt. The negative supply to the collector is maintained via S1d.

S1 IN POSITION 4 V_{ce}

In this position, the collector voltage being applied is measured and set to any value within the range of the instrument. Also the base current preset in the last operation is maintained. This is because variations in base current alters the collector current flowing through the transistor; changes in collector current cause alteration in collector voltage due to the voltage dropped by VR2. In this instrument the value of collector volts required is set after the base current has been set. The basic circuit may be seen in Fig. 2d. The base current is still allowed to flow and the meter, now a voltmeter, is connected with its multiplier resistor, selected by S3, between the collector and earth.

The base supply is maintained via position 4 of S1e and the collector supply by position 4 of S1d. The multiplier resistor selected by S3 is connected to the meter via position 4 of S1b, then to the emitter via S1a.

S1 IN POSITION 5 I_c

In this position the collector current is measured and hence the gain of the transistor can be calculated. The basic circuit is shown in Fig. 2e. The collector of the transistor is connected to the negative supply through the meter and its selected shunt, through position 5 of S1c and S1a. The previously set base current is still allowed to flow. The base current supply is maintained by position 5 of S1e.

METER SWITCHING

The use of separate range switches for voltage and current reduces the number of switching operations during the test of a transistor to a minimum. The voltage range can be preset to a suitable value before the tests commence. Then it is only necessary to alter the current range switch from a suitable range for base current to one for collector current. If an external meter is employed this need is eliminated. The internal meter range switches can be set to suitable ranges to measure collector voltage and base current, the external meter being switched to a suitable range to measure collector current. If this method is used, collector current can be measured in either the I_b or V_{ce} positions of S1, but not in the I_c position. The alteration of the internal meter to a voltmeter is carried out by the switch S1 to prevent the possibility of too large a voltage being applied across it when on a current range.

Another point worthy of mention is the possible alteration of base current caused by switching the meter in and out of the base current circuit. The actual alteration is very small as the resistance of the meter is very small compared with the series limiting resistance switched in by S4. Once again this possibility is eliminated by using an external meter, as the collector current can be measured in the I_b position.

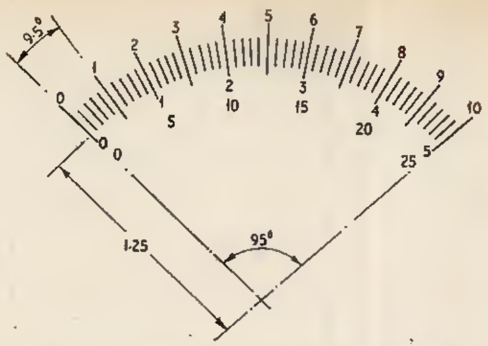


Fig. 4. New scale to suit the ranges of the instrument. This is reproduced full size for the original meter. If a different size or shape of meter is used check that the new scale suitably fits for angle of deflection and length

CONSTRUCTION AND COMPONENTS

The instrument was built in a metal case of the type used for sandwiches as shown in Fig. 3. The meter was a surplus item with a full-scale deflection of 50μA and internal resistance of about 1,000 ohms. It is obtainable on the surplus market for about 25s. although any similar meter would be suitable. A new scale has to be fitted, this is reproduced in Fig. 4. To do this it is necessary to remove the four screws at the rear of the instrument and remove the case. The scale can then be drawn on paper and glued over the original scale, care being taken to ensure that it is correctly aligned. It is a good plan to smear a little vaseline round the flanges of the case when refitting to prevent the ingress of dust.

Due to the number of different contact arrangements used on the wafer switches it is impracticable to show a point to point wiring diagram, therefore the following constructional procedure is recommended.

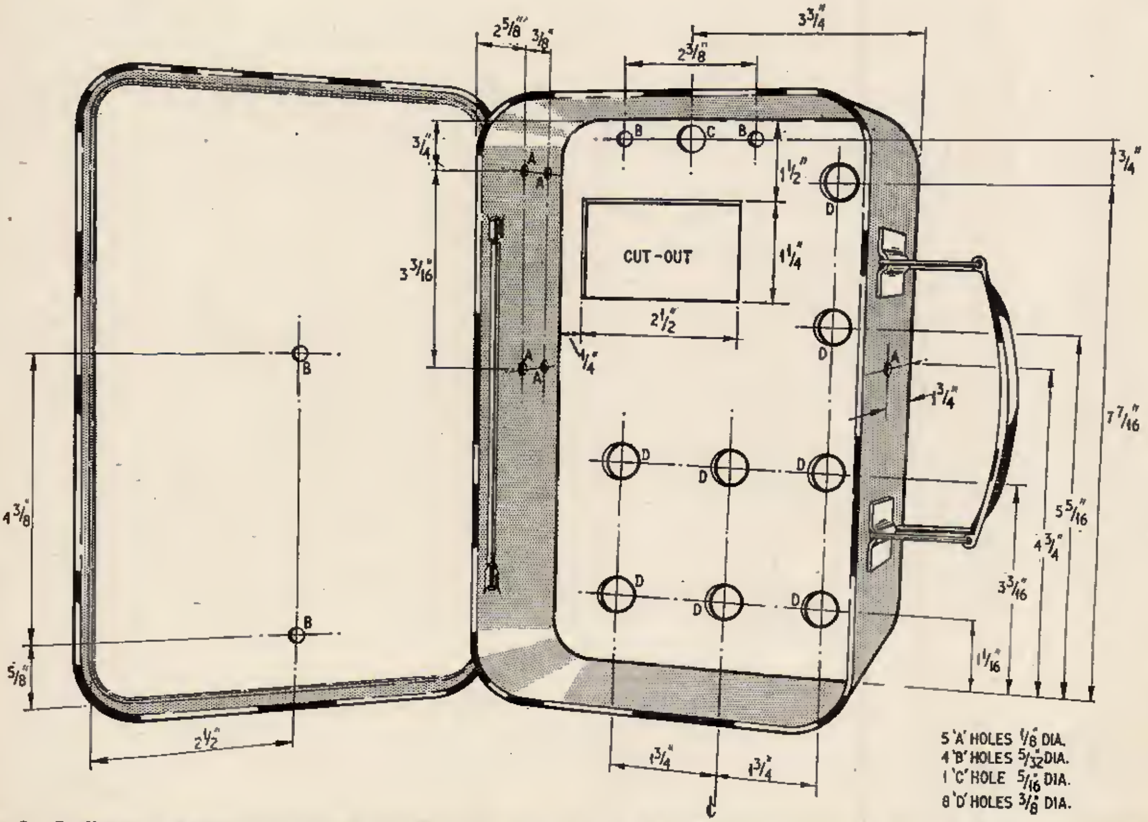


Fig. 3. Drilling details of the metal case used in the prototype. Some adjustments may be necessary if a different shaped meter is used

Sketch each wafer switch used numbering the poles and tags as in Fig. 1. Redraw Fig. 1 in pencil on a separate piece of paper. Mount all switches as shown in Fig. 5 with the exception of S1. S1 is now wired up; as each wire is soldered on it is inked in on the previously made pencil drawing. This method ensures that no wires are omitted. All leads that come from S1 to other parts of the circuit are left about eight inches long and are labelled. When completely satisfied that S1 is correctly wired it can be mounted into the case. The rest of the wiring can now be completed by connecting S1 wires to their appropriate terminations and adding additional wires and components as necessary; mark the circuit diagram as before.

The values of R14 to R20 are not critical and any near values can be used. R11, R12 and R13 should be 1 per cent high stability types. The values given for the meter shunt resistors (R1 to R7) are for guidance only. These are adjusted to their exact value during the setting up procedure. They should be wound on a small piece of s.r.b.p. using suitable resistance wire to a value slightly higher than that specified. R8, R9 and R10 should be high stability types chosen to be slightly lower in value than specified.

The transistor terminals and external meter connections are made up from 4B.A. brass screws and mounted on a paxolin or s.r.b.p. strip about ⅛in thick as shown in Fig. 6. The front panel can be reproduced from that shown in Fig. 7.

ADJUSTING THE METER MULTIPLIERS

After the wiring has been completed and throughly checked set the switches to the following positions:

S1	V_{ce}	S5	0–9 volts
S2	50mA	S6	off
S3	25 volts	VR1	minimum
S4	10μA	VR2	minimum

Connect an external voltmeter to the emitter and collector terminals with the negative meter lead to the collector. Ensure that there is a shorting link fitted across the external meter terminals. Set S6 to *pnp*. Slowly rotate VR2 to maximum when both meters should read 9 volts. Return VR2 to minimum when both meters should indicate zero. Set S5 to "9–18 volts". Both meters should indicate 9 volts. Rotate VR2 to maximum; both meters should indicate 18 volts. Return VR2 to minimum and S5 to the "0–9 volts" position.

The 10 and 5 volt ranges of S3 can be checked in the same manner, the only difference in this case being that the "9–18 volt" position of S5 is not used. The 1·0, 0·5 and 0·1 volt ranges can now be checked for function only, because the internal meter should read high on these ranges. The appropriate multi-

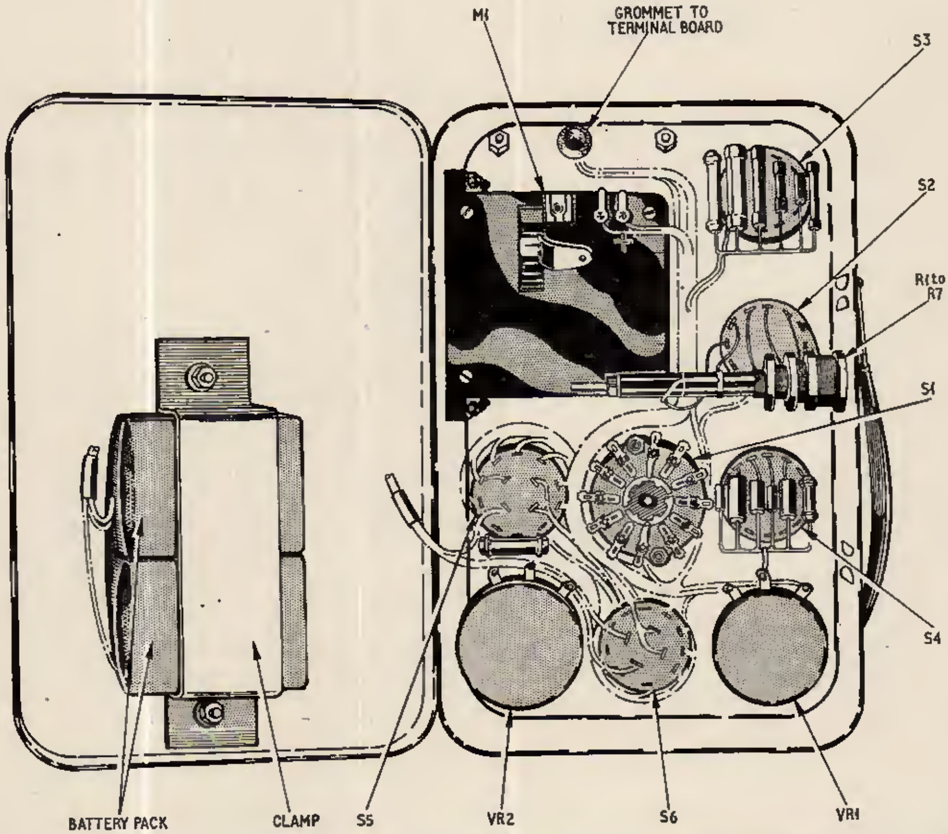


Fig. 5. Interior view of the case with the components assembled. Complete detailed wiring has been omitted for clarity. It is recommended that the system of wiring described in the text is adopted. The wires should be laced into a cable form if possible as shown above

plier resistor is increased in value by careful scraping with a razor blade to reduce its diameter. When the meter is reading accurately on these ranges, the resistors are protected by giving them a coat of clear varnish.

ADJUSTING THE METER SHUNTS

Set switches to the following positions:

S1	I_{co}	S5	0–9 volts
S2	50mA	S6	off
S3	25 volts	VR1	minimum
S4	10μA	VR2	minimum

Connect an external milliammeter to the external meter sockets, the negative test lead going to the supply terminal and the positive to the terminal connected to the collector. Connect a 150 ohm resistor between the collector and emitter terminals. Set S6 to "*pnp*". Rotate VR2 slowly clockwise; both meters should indicate a current, the internal meter should read higher than the external meter. This error is corrected by reducing the value of the selected shunt resistor.

COMPONENTS . . .

Resistors

R1	500Ω	Wirewound (see text)
R2	200Ω	
R3	100Ω	
R4	50Ω	
R5	10Ω	
R6	5Ω	
R7	1Ω	
R8	1kΩ	High stab. ¼ watt carbon (see text)
R9	9kΩ	
R10	19kΩ	
R11	100kΩ	High stab. ¼ watt 1% carbon
R12	200kΩ	
R13	500kΩ	
R14	1·8MΩ	¼ watt 10% carbon
R15	360kΩ	
R16	180kΩ	
R17	36kΩ	
R18	18kΩ	
R19	3·6kΩ	
R20	39kΩ	

Potentiometers
VR1 10kΩ linear wirewound
VR2 5kΩ linear wirewound

Switches
S1 6 poles, 5 ways (3 wafers, 2 poles on each; one pole not used)
S2 1 pole, 12 ways (1 wafer; 4 ways not used)
S3 1 pole, 6 ways (or 2 poles, 6 ways; 1 pole not used)
S4 1 pole, 6 ways (or 2 poles, 6 ways; 1 pole not used)
S5 4 poles, 3 ways
S6 4 poles, 3 ways
All switches are rotary wafer types.

Batteries
BY1 and BY2 9 volts each (type PP7 or similar)

Meters
M1 50μA 1,000Ω Moving coil

Miscellaneous
Metal lunch box (Woolworth), eight pointer knobs, s.r.b.p. strip (see text), 4B.A. nuts and bolts

This must not be done while the instrument is switched on. To reduce the resistance of the shunt shorten the length of wire with which it is wound. This should be done a little at a time. This process is repeated for all the other current ranges. For the lower ranges it is advisable to fit a larger resistor

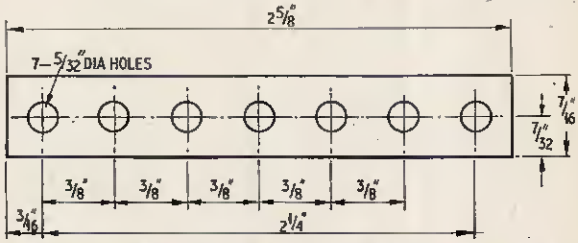


Fig. 6a. Drilling details of the s.r.b.p. strip for mounting the screw terminals

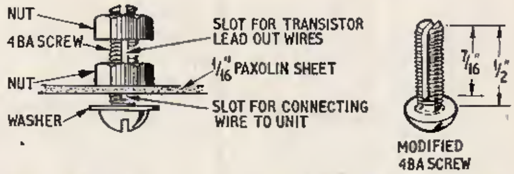


Fig. 6b. The 4 B.A. screw is slotted and mounted as shown above. The transistor wires can be clamped between the two nuts when testing

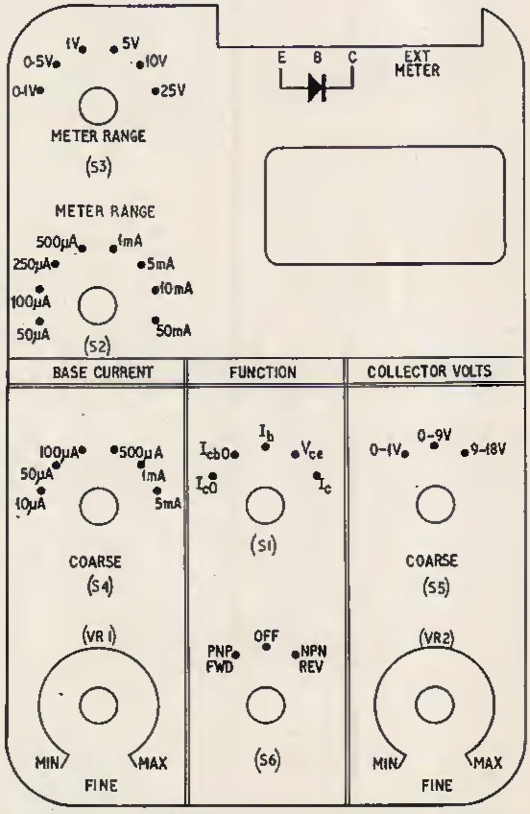


Fig. 7. Suggested design for a front panel made from stiff card and lettered with transfers. This one is reproduced approximately half scale

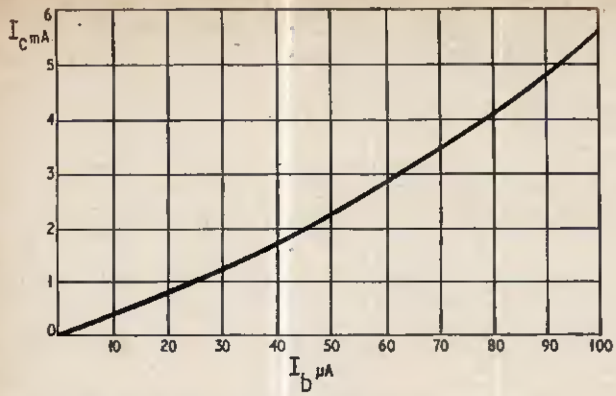


Fig. 8. A typical graph of the transfer characteristic of a medium gain transistor

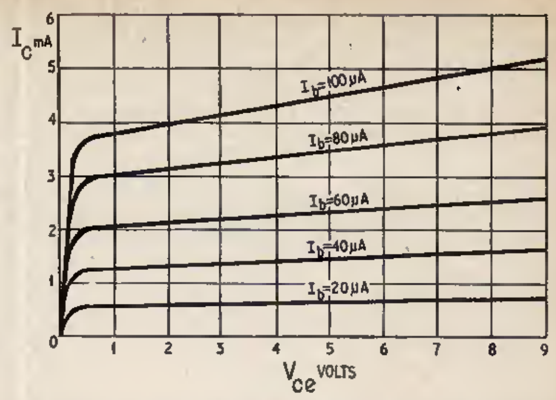


Fig. 9. A typical graph of collector current against collector voltage for given base currents of a medium gain a.f. transistor

between the collector and emitter terminals. This is a tedious job but care and patience will be rewarded in the end. Disconnect this resistor and set VR2 to minimum when finished.

OTHER TESTS

Check that with S5 in the *npn* position the internal meter reads in the correct direction but now the collector terminal is positive with respect to the emitter. Connect a milliammeter between the base and emitter terminals, the negative test lead going to the base. Set S5 to *pnp* and S4 to 1mA. Rotate VR1 towards maximum; both meters should show a reading until 1mA is indicated on both meters at maximum. Set S1 to V_{ce} and I_c in turn; the internal meter should not read but the external should still read 1mA.

With a 150 ohm resistor in circuit between the base and collector terminals select I_{cb0} and ensure that the meter indicates a reading. If the resistor is disconnected the meter reading should fall to zero.

USING THE INSTRUMENT

IMPORTANT NOTE: Care should be taken to ensure that during the following checks the maximum ratings for the transistor under test are not exceeded. The supply voltage should not be switched on until all switches and potentiometers are correctly set.

Set the controls as before when setting up the meter shunts. Connect the transistor to be tested to the test terminals. If an external meter is not being used ensure that the link is in place across the external meter test terminals. Set *pnp* or *npn* as appropriate and switch on. Slowly increase the setting of VR2; if the meter reading climbs rapidly the transistor is short-circuited and the instrument should be switched off. If the meter does not indicate, or indicates very little, all is well. Reduce the meter range until the collector to emitter leakage current can be accurately measured. Increase the meter range. Set VR2 to minimum. Select I_{cb0} on S1. Proceed as before only this time collector to base leakage current is being measured.

Return VR2 to minimum. Set the meter to a high range. Set S1 to I_b and with S4 and VR1 set for a 200μA base current. Select V_{ce} on S1 and set the collector to 9 volts. Switch to I_c and the collector current can be measured. The d.c. gain is given by

$$\frac{\text{collector current}}{\text{base current}} \text{ or } I_c/I_b.$$

This represents the β or α' of the transistor.

TRANSFER CHARACTERISTIC

The transfer characteristic is plotted easily using the instrument. This is done by drawing a graph as typified by Fig. 8, i.e., base current against collector current.

COLLECTOR CHARACTERISTIC

Plot the collector current against collector voltage for various preset values of base current as typified in Fig. 9.

TESTING DIODES

Diodes are tested by connecting them across the collector and emitter test terminals. They can then be checked at various forward and reverse potentials using the *pnp/npn* switch. Voltages and currents flowing are measured in the V_{ce} and I_c switch positions.

OTHER USES

From experience the user may find this instrument invaluable in many other ways. Electrolytic capacitors of low voltage rating may be checked to determine leakage currents by connecting across the collector and emitter terminals and applying voltages and currents as with diodes. The rated working voltage of the capacitor should not be exceeded.

Resistance can be measured by connecting the "unknown" across the collector and emitter terminals, applying a low voltage and measuring as for the colllector current condition. The resistance is then calculated by dividing the applied voltage by the measured current.

Once the instrument has been calibrated against a known reliable meter, other meters can be calibrated by connecting to the collector and emitter terminals and following a procedure similar to that described previously.

The tester also becomes an excellent tool in experimental work, for example, when it is required to design a transistor amplifying stage. Various voltages and currents can be applied to find the most suitable working conditions of a transistor.

Care should be exercised in all operations of this tester to avoid undue damage to transistors. One cannot over stress the necessity to watch for rapidly rising currents indicated on the meter. Switch off the instrument *before* such a current rises too high. ★

ELECTRONORAMA

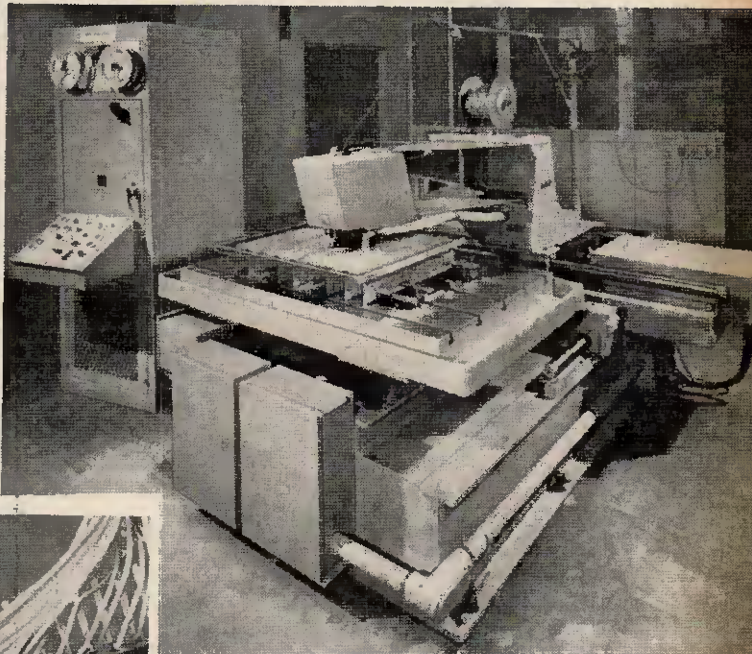
HIGHLIGHTS FROM THE CONTEMPORARY SCENE

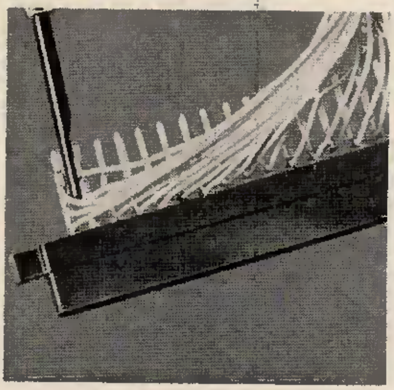
Automatic Wiring

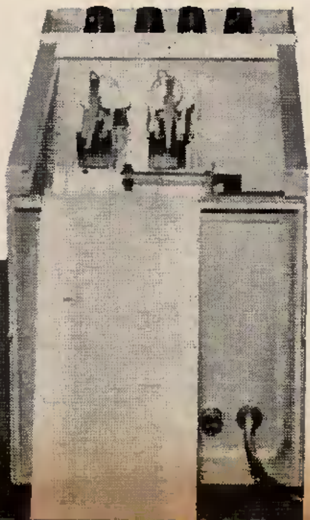
ONE OF the many interesting features at the Components Show held at Olympia in May was this completely automatic wiring machine developed by Aircraft-Marine Products.

The rack of equipment on the left is a punched paper tape programme console, which provides the wiring machine with information to operate the moving head. Insulated wire is fed into the head from a manufacturer's reel. The insulation is stripped at the end; a gold plated phosphor bronze spring clip (like those shown inset below) is crimped to the wire. The head then locates the required tag post on a large matrix and forces the clip on to it.

The head then finds the corresponding post elsewhere on the matrix to which the other end has to be attached. The wire is threaded between the posts on its way. At its destination the wire is cut, stripped, and again fitted with a clip which is forced on to the next tag post.







Painless Activity Recorder

A NEW IDEA in the measurement of body movement is announced by Faraday Electronic Instruments, a company of the Pye Group. Called the "Animal Activity Recorder", it measures and records accurately and electronically many important movements of animals (including humans) under observation. It does this without the use of tilting cages, photoelectric beams or wires attached to the subject.

The sort of things which can now be measured electronically without the "patient" being aware of it include breath-rate and the precise movements of it in its enclosure; even a hiccup is registered. How often a baby moves in its cot and the twitching of the whisker of a rat undergoing drug tests, can all be picked up.

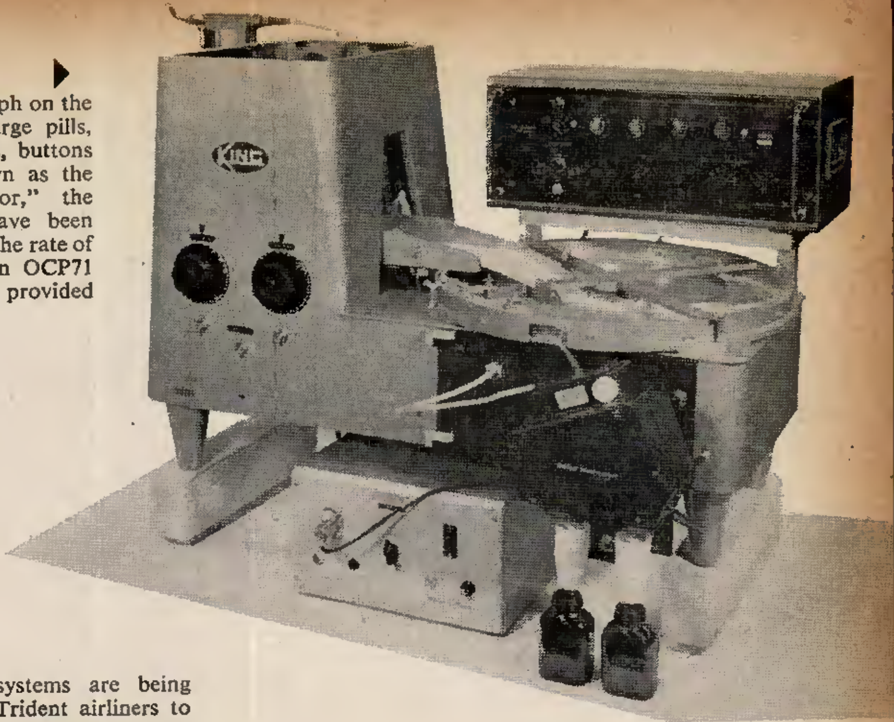
A high frequency low amplitude signal is generated and fed on to the bottom wire grille of the cage containing the animal or to the metal frame of a hospital cot or bed. There is absolutely no danger in this tiny signal and no fear of electric shock. The animal or baby then acts as a "transmitting aerial" within the radiated field deflecting the signals to receiving aerials fastened to the cage or cot.

As the subject moves around, it causes fluctuations in field strength relative to its position.

Count Down

THIS machine (shown in the photograph on the right) counts pills; small pills, large pills, even chocolates, nuts and bolts, seeds, buttons and many other small items. Known as the "Mastercount random path detector," the electronics attached to the front have been developed by Decca Radar to count at the rate of 1,500 to 6,000 per minute by using an OCP71 photo transistor and a beam of light provided by a torch bulb.

The equipment employs an aperture many times larger than the object to be detected, hence the need for a *narrow* light beam is eliminated.



Automatic Descent

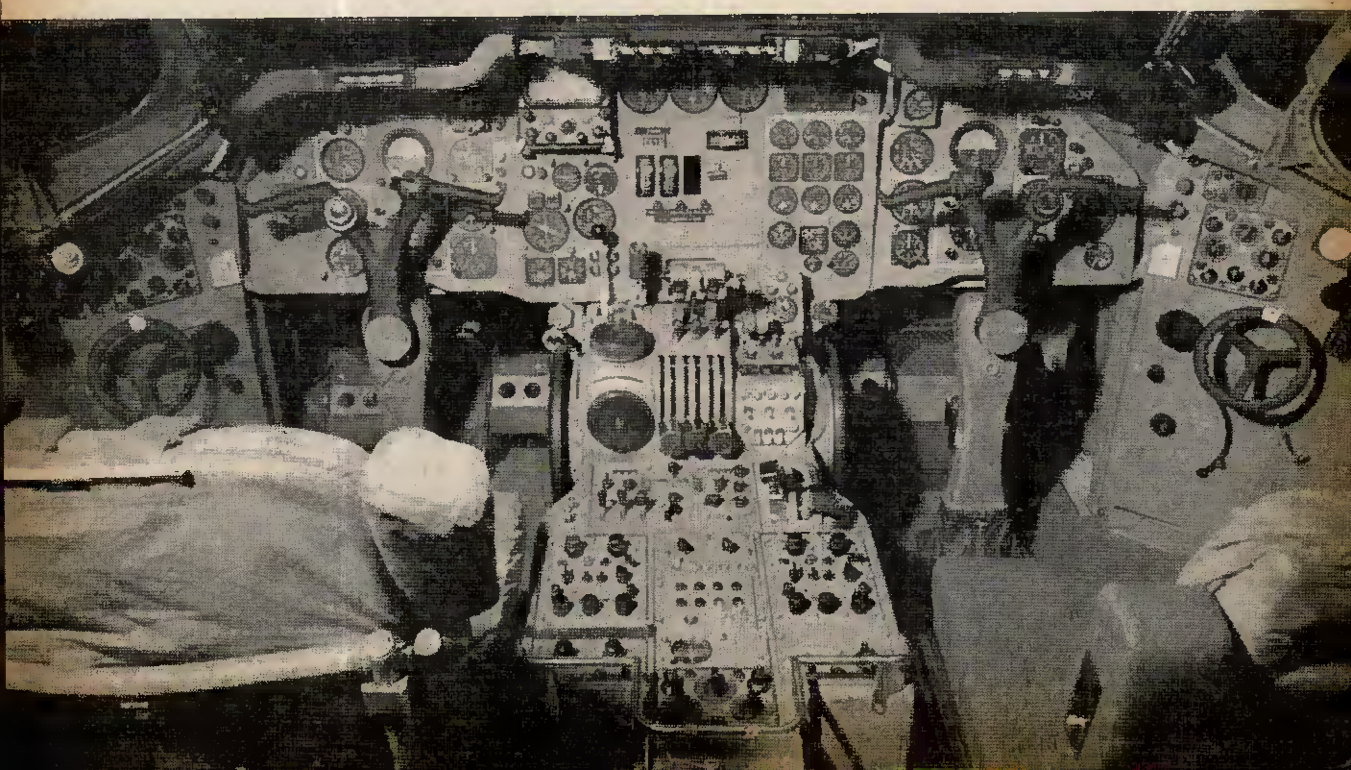
DUPLEX automatic flight control systems are being fitted to B.E.A. Hawker Siddeley Trident airliners to provide "autoflare" or automatic touchdown. The execution of the difficult landing phase is shared between the pilot and the electronic equipment developed by Smiths Aviation Division. The equipment is capable of guiding the Trident to a more precise position than can be achieved by a pilot on his own.

At a height of about 150 feet the autoflare equipment is brought into action until touchdown. Aircraft pitch movements and throttle adjustments are controlled automatically while the pilot keeps the aircraft in line with the runway.

An S.T.C. altimeter, emitting a constant sweep frequency within the 4,200 and 4,400 Mc/s band, measures the height of the aircraft during descent.

The picture below shows the flight deck with duplicated instruments including attitude directors, flight compass, airspeed indicators, altimeter, and vertical speed indicator. The automatic flight control panel is mounted at the front of the pedestal between the pilots' seats.

The system has been approved by the Air Registration Board for use on normal passenger services.



BEGINNERS start here... 10

An Instructional Series for the Newcomer to Electronics

THIS month we complete our present look at inductors and transformers by considering two different aspects of energy. First we note how energy can be *conserved* or *stored* in a coil, and afterwards we examine the energy *losses* incurred in iron-cored components.

STORED ENERGY

One further interpretation of inductor action which is very interesting is the notion that energy is stored in the surrounding magnetic field (see Fig. 10.1). This energy is built up during the current growth: when the current is switched off, this energy is given back to the circuit, and tends to keep the current flowing.

If, in fact, the coil is switched completely off, no current can flow, and the collapsing magnetic field gives rise to a giant voltage peak across the coil. This "inductive surge" is put to good use in high voltage generation for television cathode ray tubes, and in electronic circuits known as "ringing oscillators", "pulse generators" and "blocking oscillators". But, in some circuits, notably transistor designs, these inductive surges are destructive, and must be guarded against. Later on we shall discuss methods of doing this. The storage of energy mentioned above is very similar to a capacitor—except that in the capacitor the energy is stored in the *electric* field between the plates.

LOSSES IN TRANSFORMERS

There are *some* losses in a transformer. For instance, if an output power of 100 watts was being taken from the secondary of a certain specimen, it could easily be the case that 110 watts was being supplied to the primary. Where are the additional 10 watts going? After some little while, the transformer would feel slightly warm, and this heat produced represents the loss.

Some energy is lost in overcoming the resistance of the windings—this is known as the *copper loss*. Some is lost in eddy current heating of the iron core, even though this is reduced to a minimum by laminating the core.

But, this is not the whole story. It takes energy to continually magnetise and demagnetise the iron in the core. In fact, the *magnetic flux* in the core is a different value while increasing with the growth of current in the windings, compared with that while the current is decreasing.

MAGNETIC HYSTERESIS

This lag, or "backlash" effect is called *magnetic hysteresis*, and the characteristic "S" shaped loop is often seen in connection with discussions on this topic. Actually, the iron is magnetised by the field produced by the current. The magnetic flux density, set up by a magnetising force, we can call B to follow convention. The magnetising force is denoted by the letter H. These quantities are connected by a small equation:

$$B = \mu H$$

This "μ" is called the *permeability* of the material being magnetised. For iron μ can be a very large number, meaning that B can be considerable even though H is small. Ferrite rods have a large μ, for instance. For iron, B is not proportional to H—we say the relation between them is non-linear, hence the distortion that can arise when using cored transformers in amplifiers.

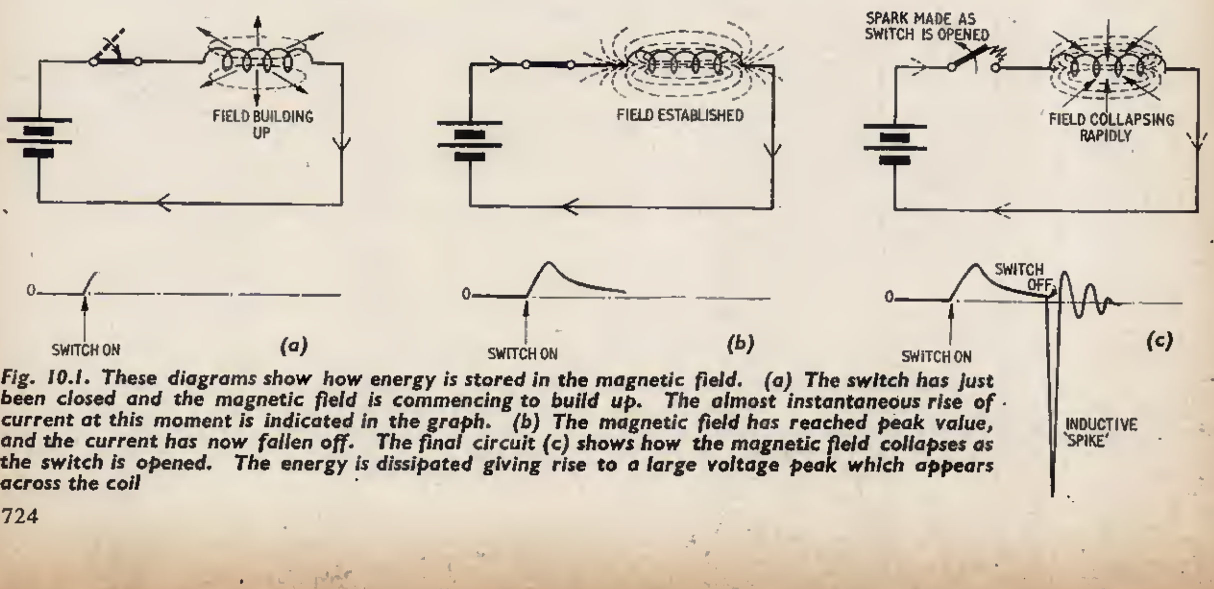
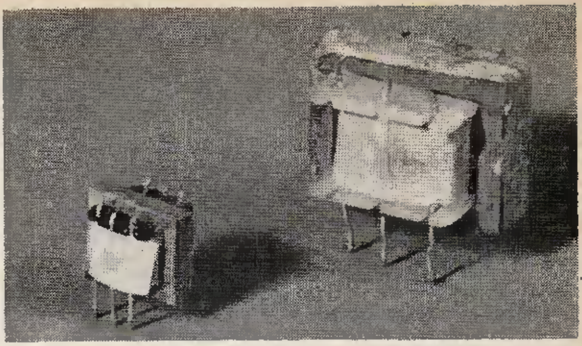


Fig. 10.1. These diagrams show how energy is stored in the magnetic field. (a) The switch has just been closed and the magnetic field is commencing to build up. The almost instantaneous rise of current at this moment is indicated in the graph. (b) The magnetic field has reached peak value, and the current has now fallen off. The final circuit (c) shows how the magnetic field collapses as the switch is opened. The energy is dissipated giving rise to a large voltage peak which appears across the coil

Fig. 10.2a. shows how B might grow with H. Notice how the curve flattens off at the top. This means that the iron has the maximum B, i.e. flux density, that it can take. We say it is saturated. This means that sufficient core area must be used in transformers so that this saturation is not reached while in operation.

Back to hysteresis again. If we reduce the value of H, B will fall, but not so fast as expected. In fact the value of B will still be something, when H has been reduced to zero (no current). This means there is some residual magnetism in the core, or *permanent magnetism* as it is commonly known. In order to reduce the value of B to zero, H would have to be reversed. If a.c. flows in a winding, the core goes through a complete cycle as above, in step with the changing H produced by the a.c.



Two iron cored audio frequency transformers. These are reproduced approximately life size and indicate the kind of miniature components now in common use

HYSTERESIS LOOPS

A typical hysteresis loop is shown in Fig. 10.2b, complete with saturation in the two directions. Permanent magnets have a high residual magnetism, as part of their design. The hysteresis loop for the steel in these

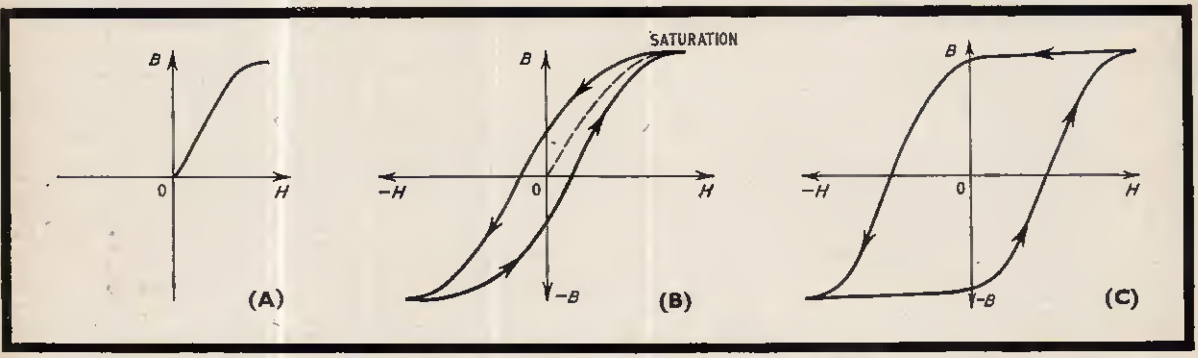


Fig. 10.2a. This shows how the magnetic flux density B grows as the magnetising force H increases

Fig. 10.2b. The initial growth of magnetisation goes from '0' to saturation, thereafter the rise and fall "cycles" in the direction shown

Fig. 10.2c. Materials which tend to retain their magnetisation (permanent magnets) have a "flat" hysteresis loop as depicted here

devices resembles Fig. 10.2c. The ferrite ring material, already mentioned in connection with computers in part 7, usually has a very square loop (it is called *square loop* material)—so that the switching over in direction is well defined and sudden.

Now we finish up this discussion with a final point about transformer cores.

Energy is required to go round and round the hysteresis loop, as it were, and this comprises some of the loss in transformers. It can be shown that the energy lost is proportional to the area of the loop, so iron for a.c. cores is chosen to keep the loop narrow and of small area. Thus the *iron losses* in a transformer consist of two parts, the eddy current loss, and that produced by hysteresis. Transformers designed for use on the 50 cycles per second mains must have at least 1 square inch of core for every 50 watts input when operating at the correct load. A good rule is to assume 8 turns per volt for a core area of 1 square inch; 2 square inches would require 4 turns per volt, and so on.

The gauge of the wire is chosen to carry the resultant current. The last point to check is whether the amount of wire needed will go into the space available around the core (called the "window"). So, an amateur can fairly easily design and make his own transformers—but the last point above usually makes itself apparent *after* most of the turns have been put on!

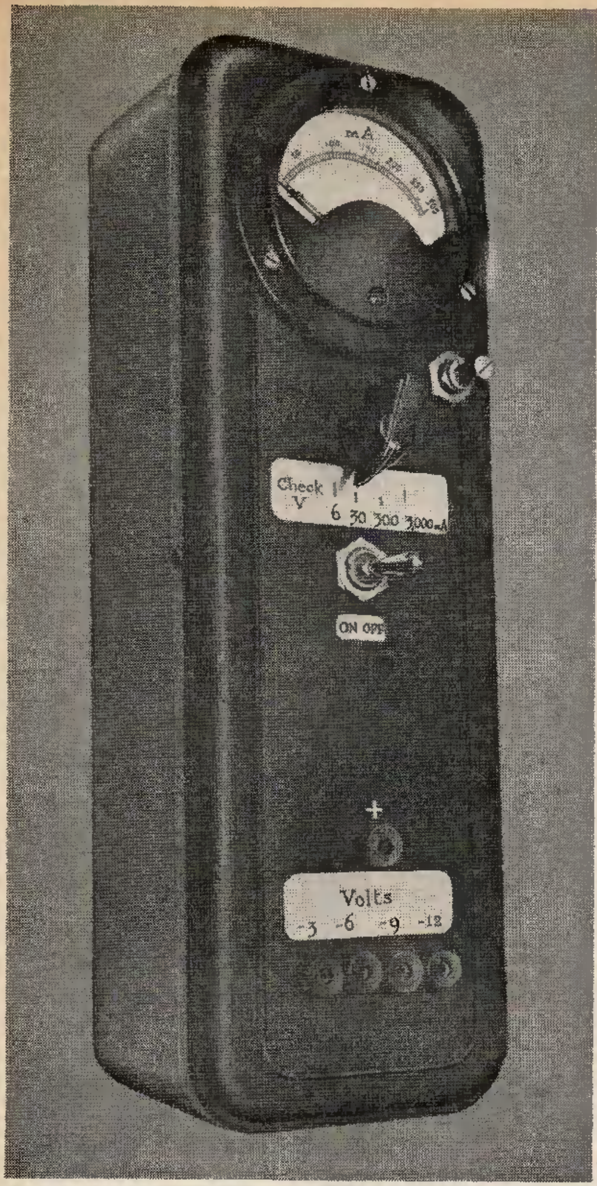
A USE FOR INDUCTIVE KICKS

We end this month with an example of the use of the voltage pulse produced when the current through a coil is changed rapidly.

In order to set up the discharge in the gas contained inside a photographic flash tube, a very high voltage is required across the starting electrodes to ionise the gas. The main store of energy (contained in a large capacitor) then pours through the ionised gas causing a tremendous burst of light output.

The way to get a pulse of a few thousands of volts for this job is simple, if you remember the theory of inductors. A small charge is passed through the primary winding of a transformer by operating the camera shutter switch contacts. This burst of current produces a rapidly changing magnetic field which links with the large number of turns on the secondary winding, and by Faraday's Law a large voltage (many thousands perhaps) is induced across this winding. Thus the tube is triggered in synchronism with the operation of the camera shutter.

You should now be able to follow Mr. B. J. Crowe's article, using your theoretical knowledge to explain the circuit action.



THIS pack provides a convenient and portable source of power for experimental circuits using transistors, small motors, lamps, and other low voltage devices. It incorporates a fast acting current operated trip, which can be set to any value from 0·5 milliamp to 3 amp. This trip circuit protects the meter, power supply, and any connected load. The actual power source comprises four inexpensive cycle lamp batteries, and these are tapped to provide 3, 6, 9, and 12 volts.

If a moving coil meter is shunted to give a range of current readings, the voltage across the meter terminals will remain constant for any given deflection on any range. The prototype battery pack incorporates a 5 milliamp f.s.d. meter movement with an internal resistance of 15 ohms which, by calculation, shows a terminal voltage of 75 millivolts at full-scale deflection. When this meter is shunted to read 3 amp, for instance, the voltage across shunt and terminals will still be 75 millivolts.

CIRCUIT DETAILS

By reference to the circuit diagram (Fig. 1) it can be seen that the transistor TR1 is arranged to "read" the voltage developed across the meter, via R7, and pulls in the relay RLA when this voltage exceeds a level predetermined by the setting of VR1.

Under normal circumstances this trip circuit is set to operate at the full scale deflection of the meter, and will therefore cut out at the values set by the range switch S2, namely 6mA, 30mA, 300mA, and 3A. At the most sensitive setting of VR1, the trip functions at lower than 10 per cent of these values.

The circuit is sufficiently flexible to admit other meter movements and the ranges can be altered to suit the existing meter calibration and power supply characteristics. The formula for calculating alternative shunt values is

$$R = \frac{R_m}{n-1}$$

where R_m is the resistance of the meter and n is the desired multiple of its basic current reading. Shunts may, alternatively, be manufactured by the "cut and try" method using a wide range test meter for comparison. Generally speaking, a very sensitive low internal resistance meter would not be suitable for this circuit.

Almost any a.f. transistor could be used for TR1 provided its maximum rated collector-emitter voltage is greater than 12. Variations in gain can be catered

LOW VOLTAGE BATTERY PACK

BY B. DOUGLAS

for by adjustment of the relay. R9 allows the relay to hold on after the trip operates by permitting a small residual current to pass through the connected load. The trip is automatically reset when the load is disconnected. Capacitor C1 serves to "hold up" the voltage across TR1 and the relay long enough for the trip to function under severe short circuit conditions. The fifth position of S2 checks the battery potential by means of the multiplier resistor R8.

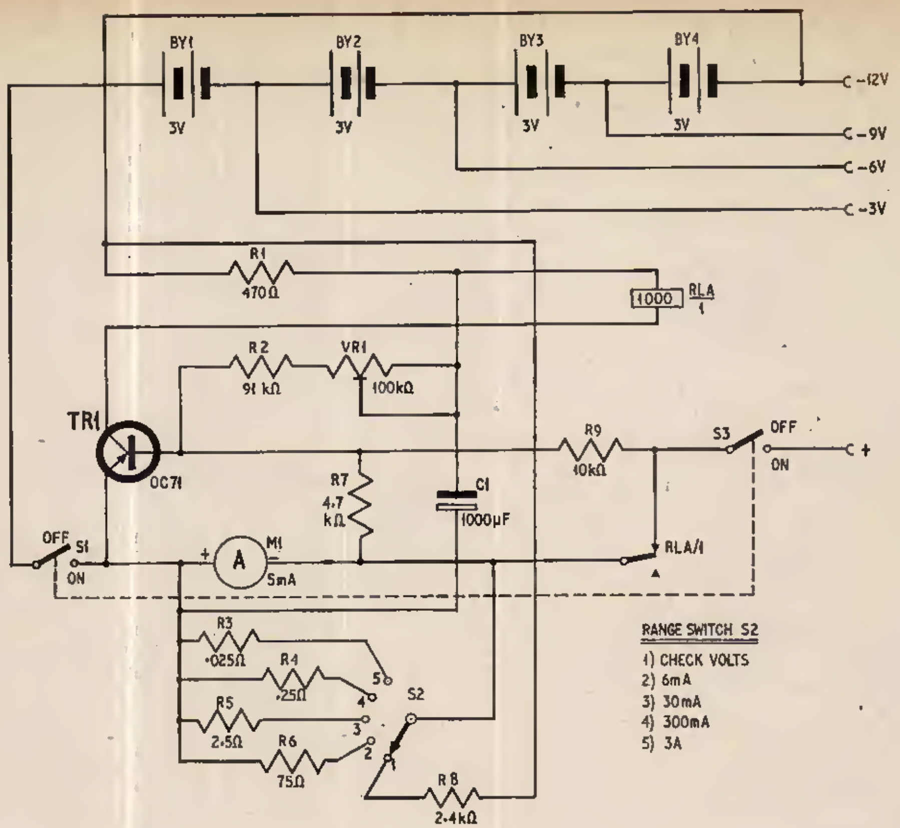


Fig. 1. Complete circuit of the battery pack

Using the relay specified, the cut out operates within $\frac{1}{250}$ of a second, thus giving, for most applications, virtually instantaneous protection. If, for example, a 1·5V 0·3A lamp is connected across the 12V terminals, with the trip set at 300 mA, there will be no glow whatsoever before the supply is cut off, and the meter pointer barely kicks.

CONSTRUCTION

A generally available polystyrene lunch box measuring 12in × 4in × $3\frac{1}{4}$in was found to be ideally suited to contain the batteries and components. It will also stand upright, at a slight angle, thus taking a minimum of bench space. The transparent lid can be painted matt black, or coloured if desired, on the outside. If the lid is painted on the inside minute imperfections in the plastic will tend to look unsightly. To avoid splitting the plastic it is best to make holes with a hot soldering iron, then enlarge them with a round file. Figs. 2, 3 and 4 show the layout of components and wiring inside the box.

Thick wire should be used between batteries, sockets, and the main meter connections, to avoid inaccuracies, particularly on the high current range.

A small tag strip, bolted to the + meter terminal, is used to mount TR1. The relay is fixed on the back of the box, and the batteries "sit" inside it. Because of their large current capacity it is unlikely that the batteries will need replacing frequently so they can be soldered directly into circuit with short lengths of wire.

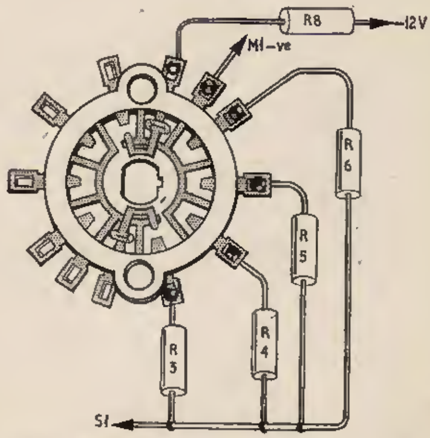


Fig. 2. Details of wiring the switch wafer. This can be a 2 pole 5 way wafer with one pole left unused

The good contact thus made also helps to maintain consistent performance. All resistors can be wired point-to-point directly on to the mounted components. Finally, the lid is secured to the box with small self-tapping screws.

SETTING UP

Check that R8 indicates the actual battery voltage when switched on by S2. Set S2 to one of the lower current ranges and VR1 to maximum resistance.

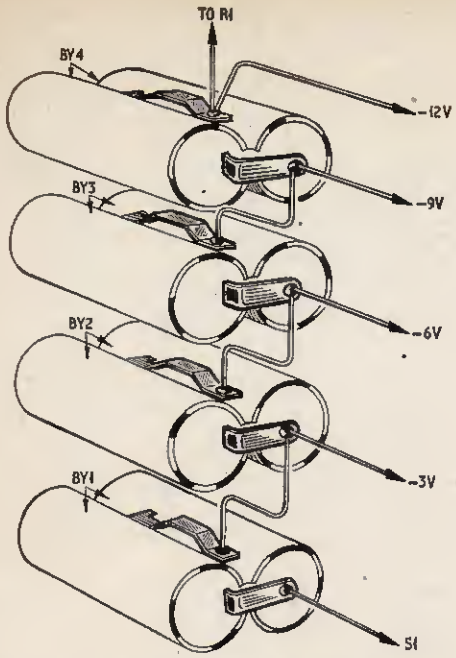


Fig. 3. Wiring details of the batteries to the "negative" sockets

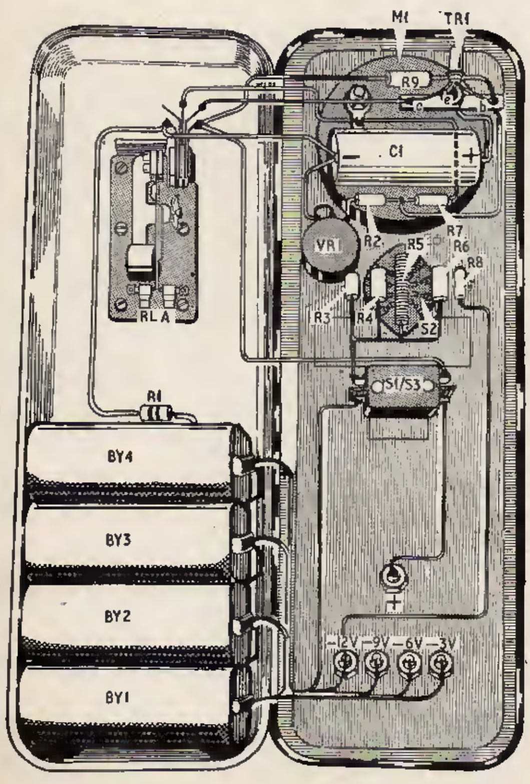


Fig. 4. Internal view of the completed unit

COMPONENTS . . .

Resistors
R1 470Ω
R2 91kΩ
R3 0·025Ω w-w
R4 0·25Ω w-w
R5 2·5Ω w-w
R6 75Ω
R7 4·7kΩ
R8 2·4kΩ
R9 10kΩ
All high stability, cracked carbon except where otherwise indicated.

Potentiometer
VR1 100kΩ carbon preset

Capacitor
C1 1,000 μF 12V electrolytic

Transistor
TR1 OC71 or NKT 272

Meter
M1 5mA f.s.d., 15Ω, moving coil

Relay
RLA 1,000Ω coil, single pole changeover contacts, Siemens high speed

Switches
S1, S3 Double pole on/off
S2 Single pole, 5 way

Batteries
BY1-4 Twin cell cycle lamp batteries 3V type (4 off)

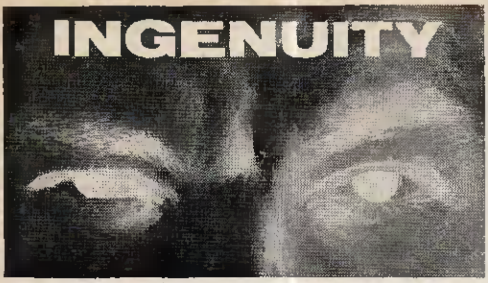
Miscellaneous
Polystyrene lunch box 12in × 4in × 3½in
Five wander plugs and sockets

Connect a suitable variable load resistor across the positive and one of the negative output sockets. The meter should show that a current is passing through the load.

Increase the load until the meter reads full-scale, then advance VR1 until the trip operates. A click will be heard from the relay and the meter pointer will drop to zero. If this does not happen, and there is no wiring fault, the relay should be set for greater sensitivity by adjustment of its armature spring tension screw until it pulls in with VR1 set near maximum resistance. Then disconnect, reduce the value of the load resistor and reconnect. It should be found that the trip operates at full scale on all ranges, or at less than full scale, depending on the setting of VR1.

When, say, a transistor receiver is powered by the pack, two points should be noted. If there are high value electrolytic capacitors in the receiver, the switch-on current surge will cause the trip to cut off the supply. This can be avoided by setting S2 to a higher current range initially, then dropping down again to the range consistent with the normal consumption of the receiver. Also, audio peaks, not indicated by the meter, but many times greater than the mean standing current of the receiver, will tend to operate the trip.

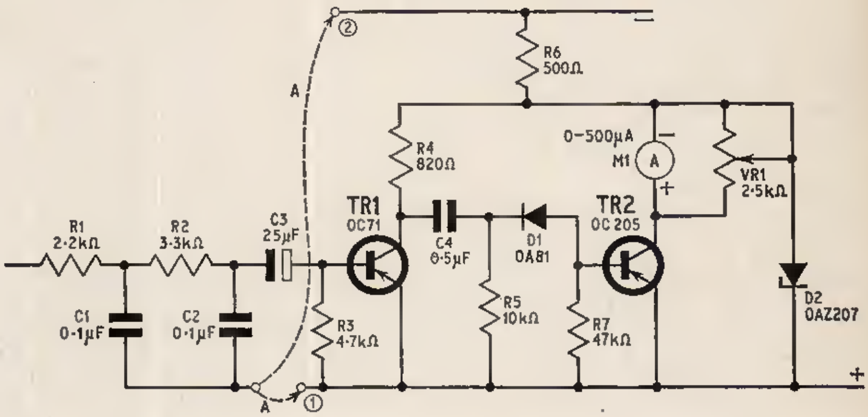
In use, the pack allows minor adjustments to be made to experimental circuits while they are functioning, and protects against slow thermal runaway when transistorised circuits are left on and unattended for long periods. This is especially useful in development work and for extended soak tests. ★



INGENUITY UNLIMITED!

IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par excellence* but could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

PULSE COUNTER



METER AMPLIFIER

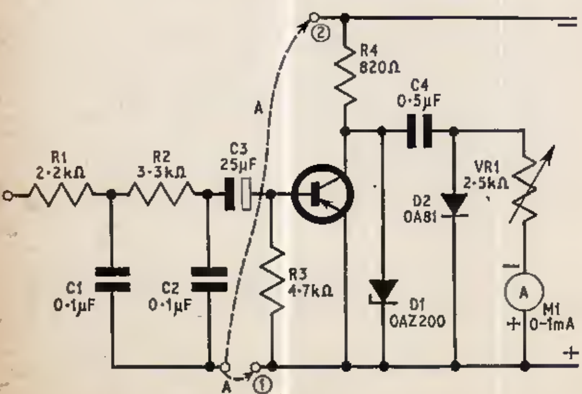
As the output from my version of the pulse counter was only 50μA, I left the Zener diode out and added a meter amplifier. This gives about 500μA enabling a cheaper meter to be used.

To guard against instability through temperature changes, and to obviate non-linearity or zeroing difficulties, a silicon transistor such as an OC205 can be used. If battery variations are troublesome, a simple Zener stabiliser (OAZ207) may be introduced as in the circuit diagram above. This should be effective over the range 11 to 17 volts.

The extra components can be mounted on the sample piece of printed wiring board which was given with the April issue of the magazine. To accommodate them the components to the right of the original Zener diode should be moved to the left by one hole and re-positioned according to the circuit above.

R. L. Mustow,
Ickenham,
Middlesex.

METER ECONOMY



With reference to the "Pulse Counter" in the April issue I would recommend the following modification.

In view of the relatively high cost and fragility of a 100μA meter compared with a 1mA meter I have modified the circuit as shown to give 1mA output for 200c/s input. The performance is very linear but any increase in the value of C4 above 0·5μF leads to non-linearity.

F. M. Gray,
Rugeley,
Staffordshire.

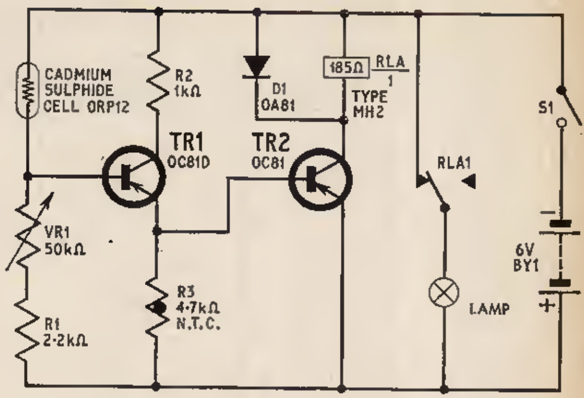
Two good ideas well worth considering. Incidentally a few readers noticed in the article that C4 on the original drawing and in the components list should be 0·47μF, and the polarity of the meter in Fig. 1 should be reversed.—Ed.

SIX VOLT PARKING LIGHT

With reference to the "Automatic Parking Light" the circuit shown in the March issue is not sensitive enough for operation on 6 volt car batteries. It may work with a high gain pair of transistors but not with those of low gain.

This can be remedied by a change in the photo transistors. The OCP71 was originally chosen because of its small size, but its sensitive area is only about 7 square millimetres. Light sensitive resistors (cadmium sulphide cells) such as ORP12 have a considerably larger sensitive area and, therefore, give effectively greater output. I am enclosing an alternative circuit which should operate from a 6 volt battery. The value of VR1 may need to be changed to suit different transistors.

A. K. Stevenson,
Fife,
Scotland.



"MODULE SEVEN"

I used the piece of Veroboard, presented with the April issue, as the circuit board for the construction of the "Automatic Parking Light" described in the March issue.

Specified components were used throughout except for the photo-transistor. Being unable to afford the cost of an OCP71 I used a new OC71 with the metal can removed.

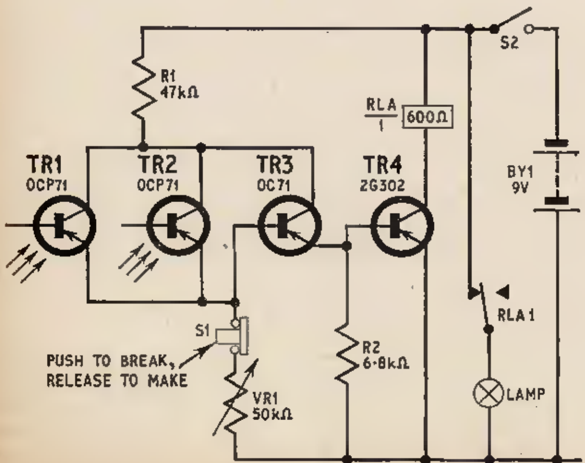
By gently squeezing at the base of the transistor with a pair of long nosed pliers, the glass to metal seal can be broken and the transistor drawn out of the case.

Any glass should be removed (most of it will have powdered when the can was squeezed), and by using a pin the majority of the opaque filling can be cleaned from the transistor junction.

To protect the transistor a small piece of plastic tubing (transparent ink-cartridges are ideal) is placed over the transistor and stuck with a small amount of plastics glue to the transistor lead-out wires. The plastic tubing can be painted black leaving a small area unpainted through which light can pass on to the collector-base junction of the transistor.

An OC71 modified in this manner has been used in the "Parking Light" circuit with complete success. The writer has used the cheap "Red Spot" transistors in place of the OC71, the only difference being that the time delay between the light striking the junction and the operation of the relay is greater.

Nigel Isle,
Stourport-on-Severn,
Worcestershire.



SENSITIVE PARKING LIGHT

I have been experimenting with the circuit from the article "Automatic Parking Light" in the March issue and would like to suggest the following circuit which will operate even a clumsy large relay.

Two OCP71 photo transistors were connected in parallel as shown in the diagram. When VR1 is set to some value between 5 kilohms and 50 kilohms the relay will operate when light falls on the photo transistors. The push button switch (S1) is normally closed and is pressed to reset the required condition between each operation of the circuit.

Battery current consumption is 2mA in the dark and 5 to 15mA in the light depending on its intensity.

R. W. Marshall,
Belmont,
Harrow.

TESTING DIODES

Further to the "Magic Boxes" articles in the March and April issues, the principle of a diode conducting in one direction only can be applied to a practical unit such as a diode tester. I have made an instrument which will indicate whether a given diode is faulty or not, or if it is open-circuit or short-circuit. The polarity of an unmarked diode can also be determined.

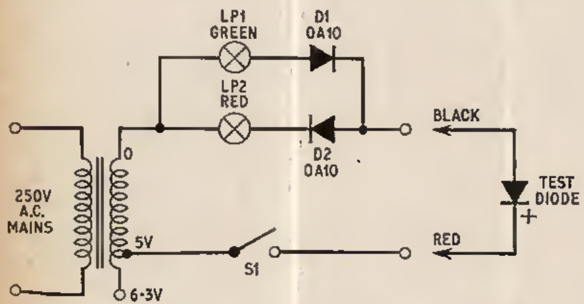
The known diode to be tested is connected across the test terminals—cathode to red and anode to black as shown in the circuit below. Since the test diode and D1 will conduct in the same direction the green lamp LP1 will light. Diode D2 is connected in reverse; no current will flow through it or LP2.

If the test diode is connected in reverse the red lamp (LP2) will light due to the current flowing in the reverse direction through D2.

If the polarity of the test diode is unknown it can be easily determined from the above tests.

If it is found that both lamps light together, this can only be due to a short-circuit in the test diode, which will allow current to flow in both directions. Since the supply is alternating both lamps will be illuminated.

Conversely if both lamps fail to light, this must be due to the diode being open-circuit. Such a diode would not allow current to flow in either direction.



Most types of diodes and rectifiers can be tested with this instrument, e.g., germanium, silicon, selenium, etc., so long as these are above the power rating of this circuit. This is governed by the supply voltage and current rating of the lamps, and should be calculated to ensure low power diodes can be safely tested.

A 6 volt 60mA lamp is most suitable here and gives a calculated power dissipation of 360mW. Clearly any diode rated at about ½ watt or above could safely be tested. Other lamps and power supplies will work equally well providing this power dissipation does not exceed the rated power of the diode.

A 6·3 volt heater transformer will be the one which is usually to hand and this may be readily employed. Mine had tappings at 3, 5 and 8 volts. The 5-volt tapping was used in conjunction with a 6 volt 60mA lamp, slightly under-running the lamp, and actually permitted diodes down to about 300mW rating to be tested.

The internal diodes, D1 and D2 are not critical so long as they are above the rating of the circuit as mentioned before. Two OA10s were used, since they were readily available, but ones with much lower ratings could have been used.

B. J. McNaughton,
Sutton Coldfield,
Warwickshire.

THE DECIBEL

BY J. R. BRADBURY

Outside the communications field the decibel is somewhat unfamiliar, yet its value to the hi-fi enthusiast is of far greater significance than some of the more familiar units.

This article sets out to explain the decibel and its practical applications, ending with an exposition of its subjective use in listening which explains its value in assessing fidelity.

ORIGIN

The decibel (or dB) was originally called the "transmission unit" (itself a development from the "Neper") and was the attenuation of a 886c/s signal in a mile of standard cable such that

$$\frac{\text{input power } P_1}{\text{output power } P_2} = \frac{E_1 I_1}{E_2 I_2} = 10^{0{\cdot}1}$$

This ratio was easily expressed in common logarithms and, as it is easier to add or subtract rather than multiply or divide when calculating gains or losses, it was adopted as standard for all frequencies.

Later the transmission unit became the "decibel" and expressed the change in power over a given network of equipment.

$$\frac{P_1}{P_2} = 10^{0{\cdot}1N}$$

and

$$N = 10 \log_{10} \frac{P_1}{P_2} \text{ decibels}$$

The somewhat large unit of the "bel" equals ten decibels and is the common logarithm of the power ratio; the term honouring the inventor of the telephone, Alexander Graham Bell.

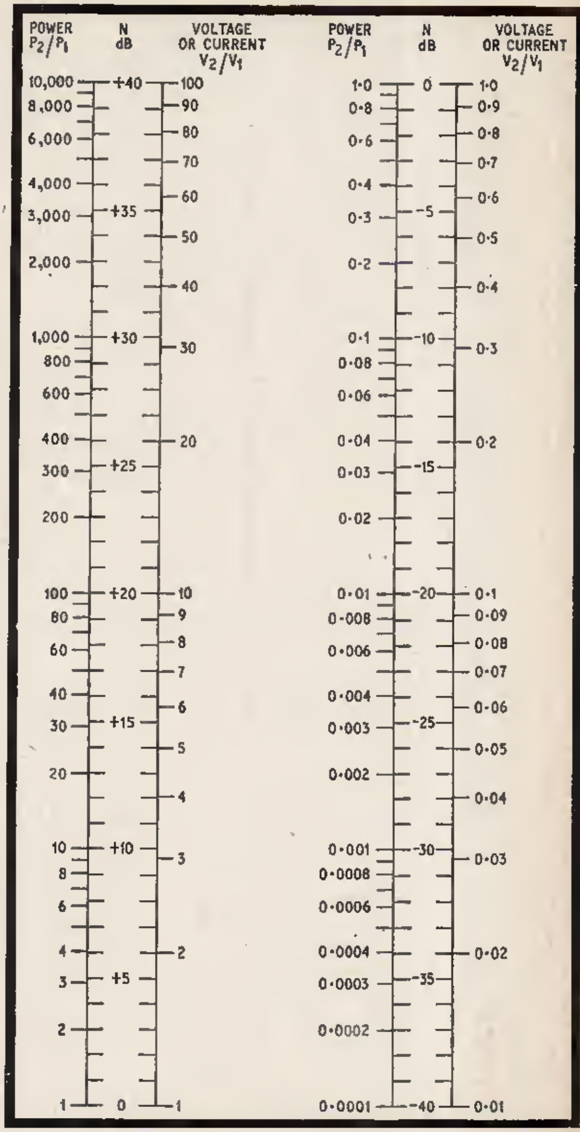
BASIC FORMULAE

The decibel is a comparison ratio between two power levels, one of which is a reference or "zero" level. Zero level is sometimes arbitrary—a value regarded as unity power, of which the other level is either a multiple or sub-multiple, or can be the conventional zero level which, in Europe and the U.K., is a voltage of 0·775 volt r.m.s. across 600 ohms to give a dissipation of 1 milliwatt. In the U.S.A., zero power is regarded as 6 milliwatts.

Amplifier gain, expressed in decibels, is

$$N = 10 \log_{10} \frac{P_2}{P_1} \text{ decibels (power ratio)}$$

P_1 being the input or zero reference level and P_2 the output or compared value.



Conversion scales of decibels to power, voltage and current ratios

In this, and other decibel formulae, if the ratio (i.e. P_2/P_1 in the case above) becomes fractional due to a power *loss* as opposed to a gain, calculations are simplified by inverting the ratio and prefixing the formula with a negative sign:

$$N(\text{loss}) = -10 \log_{10} \frac{P_1}{P_2} \text{ dB}$$

Since the decibel is a power ratio it may be used to express voltage or current ratios. For instance

$P = V^2/R$ and if two voltages are measured across identical impedance values Z, their decibel ratio is

$$N = 10\log_{10}\frac{V_2^2/R}{V_1^2/R}$$
$$= 10\log_{10}\left(\frac{V_2}{V_1}\right)^2$$
$$= (2)10\log_{10}\frac{V_2}{V_1}$$
$$= 20\log_{10}\frac{V_2}{V_1}\ \text{dB (voltage ratio)}$$

V_1 being the zero or reference voltage and V_2 the output or compared value. Phase relationships have been ignored here since they would cancel out in the above equations.

This only applies if the resistances or impedances across which V_1 and V_2 are measured are identical in both magnitude and phase.

Because $P = I^2R$, the formulae may be similarly applied to current ratios across identical resistances or impedances.

DISSIMILAR IMPEDANCES

An allowance has to be made in the case where the two impedances, are not the same. Voltage ratios across pure, but dissimilar, resistances are:

$$N = 20\log_{10}\frac{V_2}{V_1} + 10\log_{10}\frac{R_1}{R_2}\ \text{dB}$$

(Note that resistance ratios are always the inverse of the voltage ratios but are not so for current ratios.)

When impedances differ and cannot be regarded as pure resistances then power $= VI\cos\phi = I^2Z\cos\phi = V^2/Z\cos\phi$. Hence

$$N = 20\log_{10}\frac{V_2}{V_1} + 10\log_{10}\frac{Z_1\cos\phi_1}{Z_2\cos\phi_2}\ \text{dB}$$

where $\cos\phi$ is phase angle between a.c. voltage and current for each respective impedance.

Conversely, the power ratio equivalent to N dB is

$$\frac{P_2}{P_1} = \text{antilog}\,\frac{N}{10}$$

and a voltage ratio

$$\frac{V_2}{V_1} = \text{antilog}\,\frac{N}{20}$$

the decibel equation being transposed and the antilog found, instead of the logarithm, as part of the transposition.

COMMUNICATION NETWORKS

The simplest network always comprises several components providing gains or losses. Fig. 1 shows a simple communication network between a microphone at A whose output is carried to a transmitter at B.

The microphone level is 60dB below (−60dB) "zero" level and raised to "zero" level by an amplifier having a gain of 60dB. This is followed by a power amplifier which increases the level to 4dB above zero (+4dB) to counteract the noise in the transmission line carrying the signal to the transmitter. During its passage the signal level is distorted by the component quantities (inductance, capacitance and resistance) of the line. To restore the signal to its original quality, an equaliser network is inserted in the system to cut down the least attenuated frequencies to the level of those that have suffered maximum attenuation.

In so doing the overall level of the signal is generally lower (up to about −50dB). To overcome this the receiving amplifier (C) is inserted to raise the signal by 50dB to zero level. A power amplifier boosts the signal to the required level of +10dB to feed the transmitter. Adding the gains and losses in the chain:

$$-60 + 60 + 4 - 54 + 50 + 10 = +10\text{dB}.$$

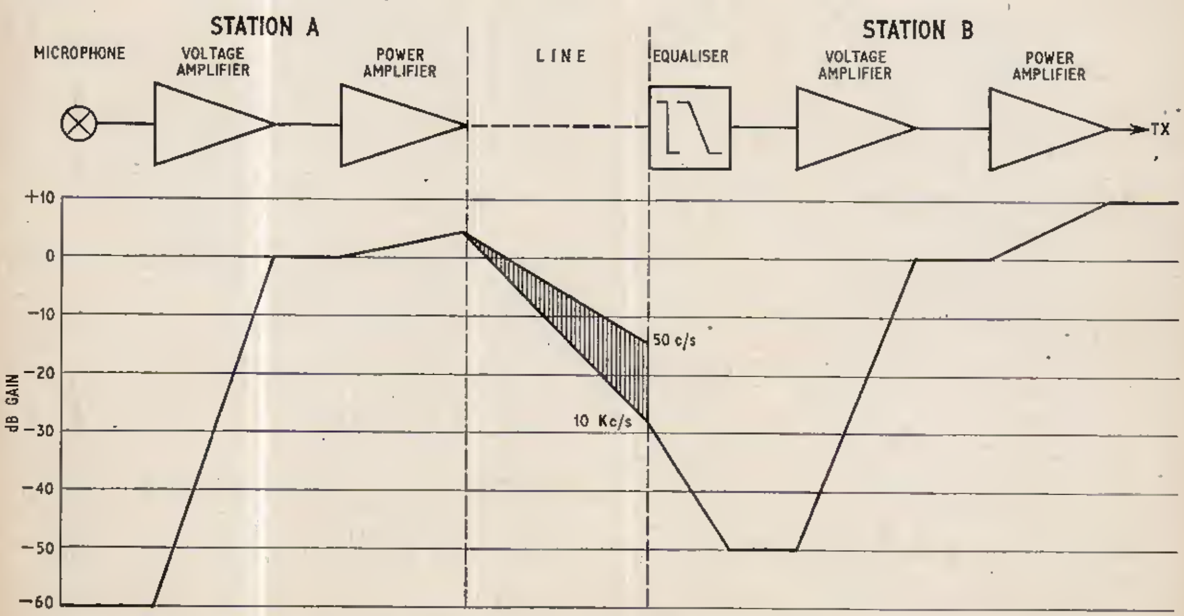


Fig. 1. A simple communications chain. Below it is a graph showing typical levels (in decibels) throughout the chain. The shaded area shows the differences due to line losses between 50c/s and 10kc/s

These levels are used purely to illustrate a typical example but in practice there would be several other items in the circuit whose attenuations and gains would need to be taken into consideration. It is obvious from this example that adding and subtracting decibels is preferable to multiplying and dividing voltages; calculations can be astronomical, even for a simple chain.

Knowing the decibel gains or losses of each item of equipment immensely simplifies the planning of a communications chain, not only to find the gain required in amplifiers but also to assess the power levels and signal/noise ratio anywhere in the chain.

AMPLIFIER FREQUENCY RESPONSE

The frequency response of an amplifier (or other apparatus) is frequently expressed in decibels which are related to a "zero" reference level at a given frequency (often 1,000c/s) at which the amplifier gain has first been found. The relationship between the power at two different frequencies is

$$N = 10 \log_{10}\frac{P_{f1}}{P_{f2}} \text{ dB}$$

where P_{f1} is the power at 1,000c/s and P_{f2} is the power at some other given frequency.

In this case if P_{f1} is greater than P_{f2} the answer would be negative and is prefixed by a minus sign. If P_{f2} is greater than P_{f1} the answer is positive and is prefixed by a plus sign.

In practice it is easier to work in voltages. Hence the relationship would then be

$$N = 20 \log_{10}\frac{V_{f1}}{V_{f2}} \text{ dB}$$

assuming that the input voltage is constant at all relevant frequencies. The signs apply as for power.

Some measuring instruments are calibrated in decibels and read the values of level direct in decibels. In such a case the voltage at the reference frequency (say 1,000c/s) is set so that the meter reads 0dB. Hence the relative levels at other frequencies can be read direct in terms of $\pm N$dB relative to the level at 1,000c/s.

Frequency responses can be plotted with the y-axis on a linear scale for voltage and decibels, and frequency on the three-cycle log x-axis. The decibel curve is broadly similar to the voltage curve but always flatter, as shown in Fig. 2.

MEASURING TECHNIQUE

The decibel has been the cause of the introduction of special measuring techniques—because applying decibel theory to voltage readings for each frequency can be time consuming and tedious.

The substitution method is far quicker and has two variations—both being shown in Fig. 3. The first (Fig. 3a) is used for assessing amplifier gain or response, using a calibrated decibel attenuator connected between a test oscillator and the amplifier under test.

A decibel attenuator is constructed of resistors, has a constant impedance and is normally calibrated to vary the attenuation in ½dB steps from zero to 55, 60 or 70dB. The meter M is connected to a change-over switch S which selects either the attenuator or the amplifier output, the latter being terminated with a resistance equal to the attenuator impedance.

Initially, the attenuator is set to zero attenuation and the meter switched to it, virtually connecting it to the

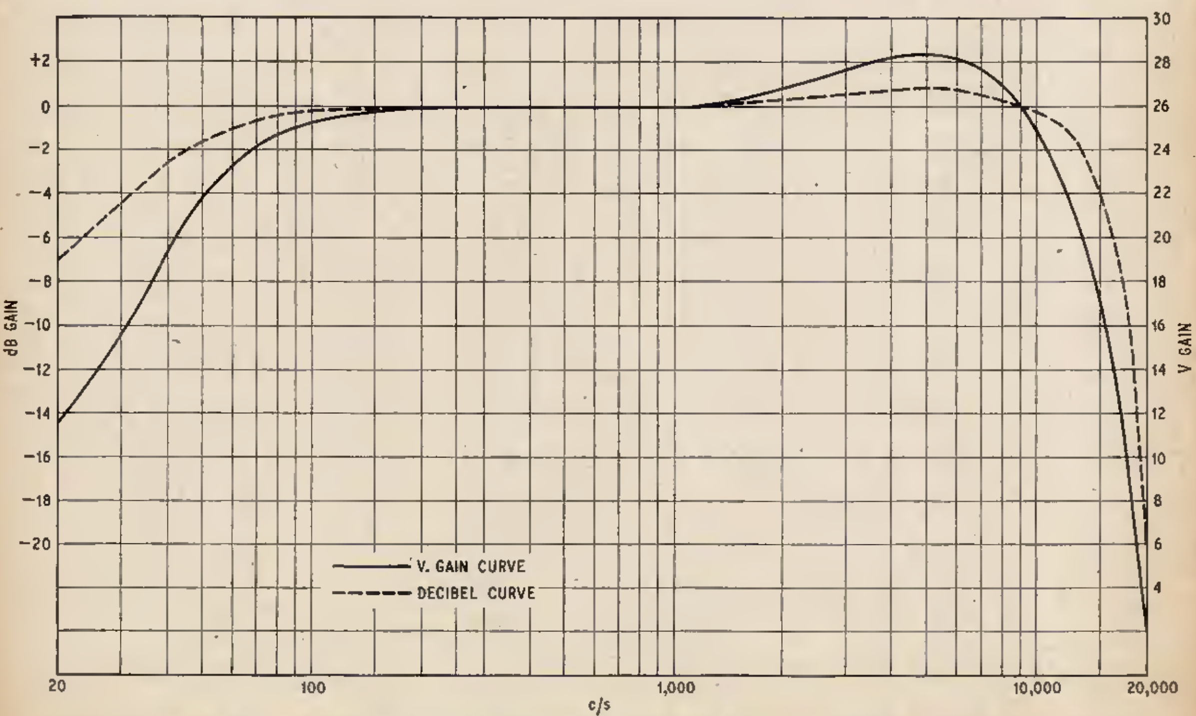


Fig. 2. Frequency response curve for amplifier voltage gain with the equivalent decibel response curve for the same amplifier. The decibels curve shows a characteristically smoother response over the audio frequency range

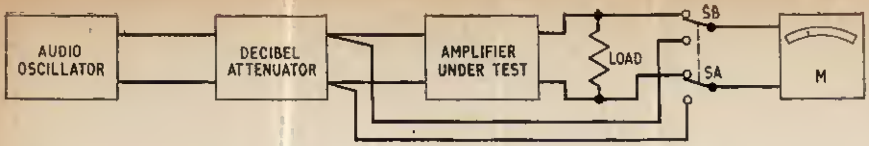


Fig. 3a. Substitution method of measuring the frequency response of an amplifier

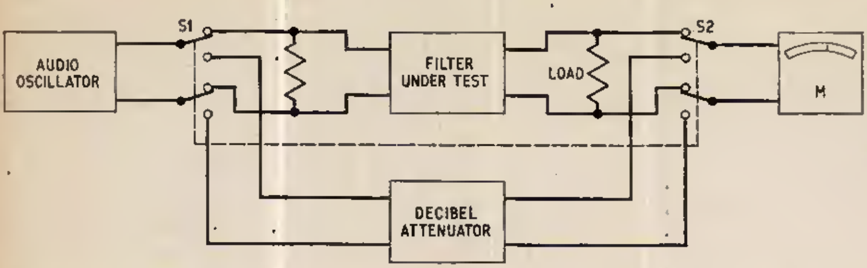


Fig. 3b. Substitution method of measuring frequency response of a filter

oscillator output, the signal from which must be adjusted to give a convenient meter deflection.

The attenuator is then set to maximum attenuation, and the meter is switched to the output of the amplifier under test. The amount of attenuation is gradually reduced until the amplifier gives the same output reading as that obtained in the initial measurement. The amplifier gain then equals the amount of attenuation in use. This is so because the sum of amplifier gain and attenuation must equal unity (the attenuator neutralising the amplifier gain) if the meter deflection is the same for both positions of the switch.

The second application checks the loss in a filter or attenuator which may be just as important as the response of an amplifier. This uses the circuit of Fig. 3b—the decibel attenuator now being connected across the apparatus under test but isolated from it by ganged changeover switches S1 and S2.

The meter is first switched across the filter under test and the oscillator output adjusted for a convenient meter deflection. Changing over S1 and S2, so that the oscillator output passes to the meter through the decibel attenuator, attenuation is then inserted until an identical meter deflection is obtained. The attenuation inserted equals the filter loss at the particular frequency being used.

The input and output impedances of the apparatus under test should be the same as that of the decibel attenuator.

LOUDNESS

Loudness is purely subjective and can be defined as the sound heard by the human ear when the aural senses are stimulated by a given sound intensity, i.e. the amount of sound in terms of power and sound wave pressure.

To produce equal changes in loudness the intensity must increase (or decrease) in proportional steps.

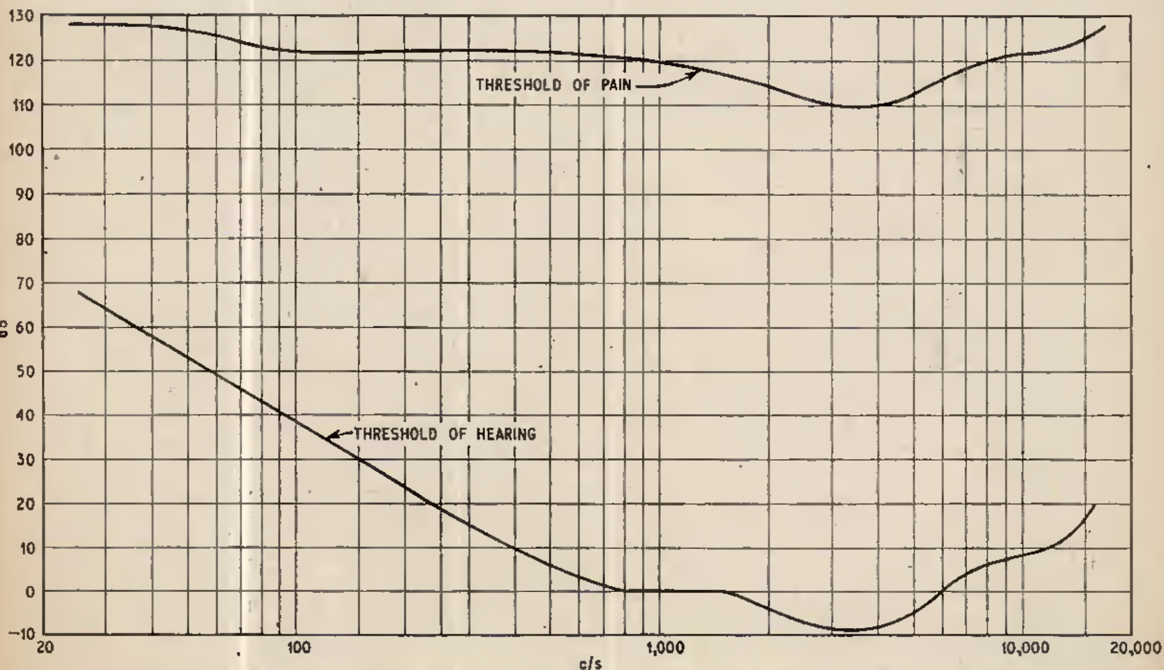


Fig. 4. The upper and lower limit curves of the Fletcher-Munson loudness level responses of the average human ear

Loudness is approximately proportional to the logarithm of the sound intensity.

Because of this relationship, loudness can be measured in decibels related to an acoustic "zero" level. A change in sound intensity of one decibel is the smallest change that can be perceived by the most sensitive human ears, and, in practice, the average person can only detect a change greater than two decibels.

Thus, "electrical" and "acoustical" decibels are linked. For example, an audio system whose response is said to be 3dB down at 5,000c/s will lack treble or "brilliance" to most listeners; if 2dB down this lack of treble might be detected by listeners of average hearing but only the sensitive ear of a musician could detect a change of 1dB.

The decibel therefore offers a useful yardstick for measuring audio "fidelity". The output of an amplifier, record player or other audio system having an overall response within less than 2dB of that of a given reference frequency is considered to be in the range of high fidelity.

ACOUSTIC DECIBEL

Fletcher and Munson published a set of curves of equal loudness and these are outlined in Fig. 4, the intermediate curves falling broadly between the two limits shown. The upper limit was found to be the tolerable limits above which any further increase causes pain. This limit is known as the "threshold of pain". The lower limit indicates what is generally considered to be where the sound is barely perceptible to the human ear. Any further reduction in level is completely inaudible. This limit is known as the "threshold of hearing". The curves reveal that absolute levels for both thresholds vary with frequency.

The curves also reveal that the human ear is most sensitive in the middle frequency range between about 800c/s and 6,000 cycles, becoming relatively insensitive towards 28c/s and 16,000 cycles—with the lower frequencies being "felt" rather than "heard".

The curves are statistically based and so must be accepted with certain reservations; they vary considerably between different individuals, according to health and age. ★

NEWS BRIEFS

Brighter Sharper Pictures

FROM January next year, all Mullard monochrome tubes in the 19in, 23in and 25in sizes will be designed to operate at 20kV instead of the present maximum of 18kV. The increased capability will mean brighter pictures, sharper focusing and a reduction in deflection de-focusing.

If all of the extra brightness of the 20kV tube is not required the tube may run at a reduced beam current to obtain a further reduction in spot size and in deflection de-focusing.

A new e.h.t. rectifier has been designed for use with the 20kV tubes. It incorporates special components to guard against flashover and a 3-rod method of anode construction to improve reliability and life expectancy. Numbered DY802, the new rectifier has identical pinning and dimensions to the widely-used DY87.

The extra scanning power required may be obtained with existing Mullard deflection valves, but to provide a reserve of line-output power a new higher dissipation version of the PL500 will be introduced shortly.

To reduce the size of field-output transformers for the 20kV tubes, the field-output valve PCL85 has been re-designed to give an increased dissipation of 8W.

Young "Hams" Course

ALONGSIDE a week-end course for youth leaders and teachers in Nottinghamshire on "The Hobby of Amateur Radio", at the Residential Youth Centre, Ollerton, Nottinghamshire on 11 and 12 September, there will run a course of lectures for invited established Amateur Radio enthusiasts from the East Midlands and beyond.

The symposium, organised by the Newark and District Amateur Radio Society, is being sponsored by the Radio Society of Great Britain, who are sending speakers of international repute to cover all aspects of amateur radio.

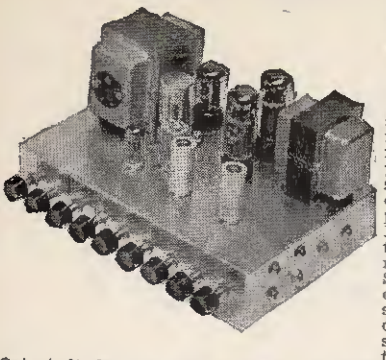
Full details of the course may be obtained from Mr. D. A. Graham, Lower House, South Muskham, Newark, Nottinghamshire.

I.E.E.T.E. Making Rapid Strides

THE Institution of Electrical and Electronics Technician Engineers is making excellent headway and since April 1st, when membership recruitment began, 5,000 have been admitted to the Institution. Large numbers of membership proposals and enquiries are being received daily.

A specialist committee is now working on a programme of technical lectures and meetings to commence in the Autumn and is selecting technical material for the broadsheet which will be going out to members at regular intervals; this is to be the "pilot" for the I.E.E.T.E. Journal now being designed. Another committee is working on plans for the setting up of Regional Centres, from which a nation-wide chain of Centres will radiate. Inquiries regarding membership should be addressed to The Secretary, I.E.E.T.E. Ltd., 26 Bloomsbury Square, London, W.C.1.

GUITAR AMPLIFIERS WITH TREMOLO



Five jack socket inputs, four with separate mixing volume controls, and one input "straight through". All inputs are of very high sensitivity only 10 millivolts input is required for full output, making them suitable for all types of guitars and microphones. Separate Bass and Treble controls, giving a wide range of lift and cut. Separate master gain control. Tremolo speed and depth controls. Jack socket for remote tremolo switching. Outputs for 3 and 15 ohms speakers. Valves used in the 30 watt and 50 watt amplifier ECC83, ECC83, EL34, EL34, GZ34. In the 15 watt amplifier ECC83, ECC83, EL84, EL84, EZ81. An extra valve ECC83 is used in the tremolo circuit. The chassis is complete with baseplate and is solidly made of 18 gauge steel, finished silver grey hammer. Size 12 × 8 × 6½ inches high.

PRICES—

50 watt with tremolo **£20.10.0**
50 watt less tremolo **£19.10.0**
30 watt with tremolo **£15.10.0**
30 watt less tremolo **£14.10.0**
15 watt with tremolo **£12.10.0**
15 watt less tremolo **£11.10.0**

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30F5	8/-	DY87	9/-	EF86	7/6	PCC84	7/-	PY33	10/-		
30FL1	10/-	EABC80	6/6	EF89	6/-	PCC88	10/6	PY80	5/-		
30L15	9/9	EB91	4/-	EF91	4/6	PCC89	9/-	PY81	5/6		
30L17	10/-	EBC41	7/6	EF92	4/-	PCC189	10/6	PY82	5/-		
30P4	12/6	EBC81	7/-	EF183	7/-	PCF80	7/-	PY83	8/-		
30P12	7/6	EBF80	6/-	EF184	7/-	PCF84	6/3	PY88	7/6		
30P19	12/6	EBF89	6/9	EL34	9/-	PCF86	8/-	PY800	6/-		
30PL1	9/6	ECC81	4/6	EL41	8/-	PCF801	10/-	PY801	6/6		
30PL13	9/6	ECC82	5/6	EL42	7/6	PCF805	10/6	U25	10/-		
30PL14	12/-	ECC83	5/6	EL84	6/-	PCL82	7/-	U26	8/-		
DAF91	6/-	ECC84	7/-	EY51	6/6	PCL83	9/6	U191	9/6		
DAF96	8/-	ECC85	6/6	EY86	7/-	PCL84	7/6	U301	11/6		
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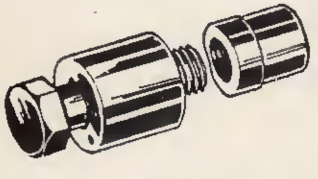

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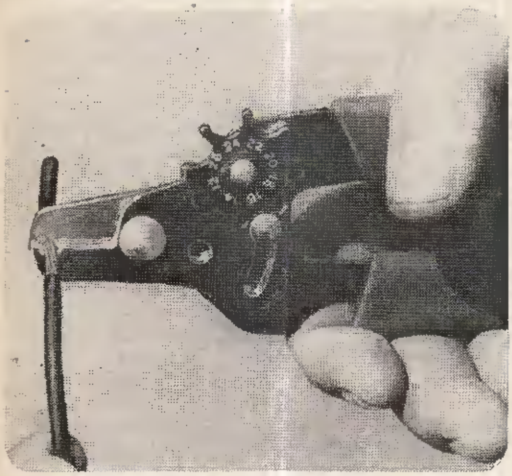


New Model 8 Wire Stripper and Cutter

Multicore Solders Ltd., Multicore Works, Maylands Avenue, Hemel Hempstead, Herts.

The new Bib Model 8 wire stripper is an improved version of the standard stripper marketed by Multicore Solders Ltd. This new stripper is fitted with a pre-set selector gauge (this can be seen in our photograph) for stripping any standard wire between 12 and 26 s.w.g. It not only strips wire or flex but also cuts when required. The model 8 has plastics handles and retails at 7s 6d.

Sub-miniature Indicator Lamps

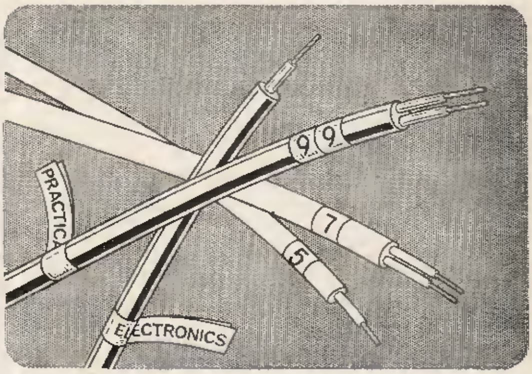
Osram (G.E.C.) Ltd., East Lane, Wembley, Middx.

Our photograph shows one of a range of five new sub-miniature indicator lamps now being manufactured by Osram (G.E.C.) Ltd. The big advantage of these lamps is the ease of fitting, by means of flange clips, and high operating efficiency under conditions of severe vibration and shock. These lamps are obtainable in the following specifications: 28V 0·04A, 12V 0·1A, 6V 0·1A, 6/8V 0·04/0·06A and 12/24V 0·04/0·06A.

New Coded Label Wiremarkers

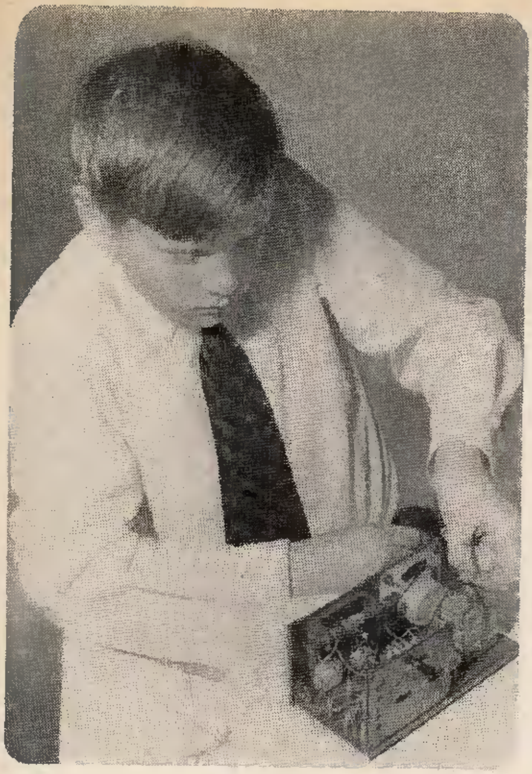
Hird-Brown Ltd., Flash Street, Bolton, Lancs.

Probably the most frustrating tasks the service technician and amateur constructor is confronted with is that of sorting out a multitude of wires in a piece of apparatus. To help improve this tedious problem Hird-Brown Ltd. announce two new types of wiremarkers. The first are sets of colour coded, 0 through to 9, markers in the standard international colour code. The second are sets of alphabet letters A to Z printed black on white.



The markers are self-sticking and comprise twenty markers per card. The number or letter is printed six times on each marker, and is therefore visible at all times irrespective of the diameter of the wire to which it is fixed. Each marker measures 1½in by ¼in wide and is impregnated with plastic to be oil, water and wear resistant.

The markers may be removed at any time without damaging the insulation and a full set of cards with numbers plus letters enables wires to be coded with any combination.



Radio Engineer's Kit

Philips Electrical Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

The demand and response achieved by Philips Electrical Ltd. to their electronic toy kits has prompted them to produce similar kits for the young radio constructor.

Designed specially for the young wouldbe future electronics expert these kits offer a good practical exercise in constructing equipment as well as providing a brief theory of radio, which is contained in an instruction book supplied with every kit.

The basic kit RE1 which costs £5 9s 6d is for earphone listening. Kit RE2 which costs £6 19s 6d is a three transistor radio with loudspeaker output. An add-on kit RE1A which costs £1 17s 6d is available to bring the RE1 kit up to the same standard as the RE2 kit.

The basic kits are constructed by means of screw terminals into battery operated medium-wave radios with on/off, volume and tuning controls. Each kit has an internal ferrite rod aerial, but there is provision for attaching an external aerial and earth if required. Both kits have a two-tone plastics cabinet.

Additional features incorporated in the RE2 kit are loudspeaker output and inputs for gramophone pick-up and microphone amplification. The more adventurous teenager can experiment with a tone control and morse code practice.

Bubble Pack Semiconductors

International Rectifier Co. Ltd., Hurst Green, Oxted, Surrey.

For the first time in this country individual components and semiconductor kits are now being marketed on a self-service bubble pack display board. This form of service, which has been introduced by the International Rectifier Co., is aimed at providing the amateur constructor with a wide range of semiconductor devices, including solar cells, transistors, diodes, Zener diodes, silicon controlled rectifiers and selenium photocells which are easily obtainable. In many cases instruction books giving experiments and practical circuits are attached to the components to encourage the novice, or experienced engineer, to learn to use semiconductors for a variety of functions.

This system of sales promotion, although American in origin, should be of wide appeal especially to the casual purchaser and school science master.

Space is limited in this feature to enable the complete range to be listed, but we recommend anybody interested to call at any of the following retailers where either the full range or a large proportion of it is on display:

D.T.V. Group, 126, Hamilton Road, West Norwood, S.E.27.

Stern-Clyde Ltd., 162, Holloway Road, N.7.

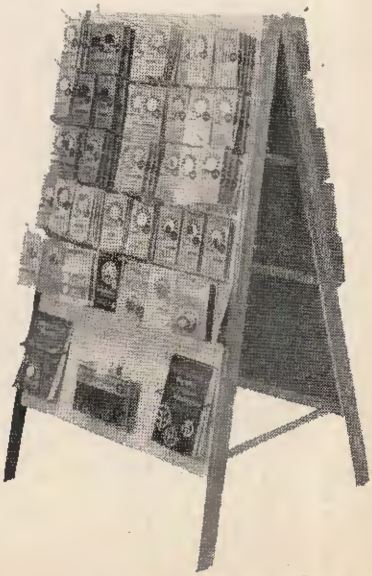
Home Radio (Mitcham) Ltd., 187, London Road, Mitcham, Surrey.

G. W. Smith & Co. Ltd., 3–34, Lisle Street, W.C.2.

A. C. Farnell Ltd., Hereford House, North Court, Vicar Lane, Leeds, 2.

R.S.C. (Manchester) Ltd., 54, Wellington Street, Leeds, 1, and at 326, Argyle Street, Glasgow.

Harmsworth, Townley & Co., 2, Harehill, Todmorden, Lancs.



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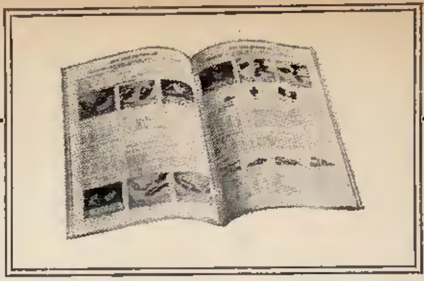

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Due to the greatly increased size of this new edition, plus increased costs of printing and paper, we have regretfully had to raise the price a little. It now costs 7/6, plus 1/- for postage and packing . . . *but we are retaining the popular feature of including 5 Coupons in the catalogue, each worth 1/- when used as directed.* Send off the attached coupon today, enclosing your cheque or P.O. for 8/6.

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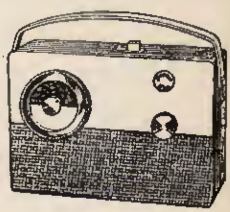

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DETACHED PARTICLES

By John Valence

LOUSY BUSINESS

WHENEVER I browse through the small ads in some of our American contemporaries I am struck by the number of different firms selling electronic surveillance devices. True these announcements are always addressed to professional investigators and detectives, but I don't know whether the firms marketing these ultra miniature devices investigate the bona fides of intending purchasers. They certainly ought to!

The thought of these obnoxious snooping aids becoming readily available to all and sundry frightens me, for one at any rate. This growth industry in snooping devices provides an example of how mixed are the blessings of technical progress. There is something revolting and distasteful about eavesdropping in any shape or form. When this is carried out by reputable authorities for law enforcement purposes, it is a practice we can accept—although with some reluctance; but the opportunities these devices present to unscrupulous characters must cause grave concern to anyone who gives the matter some thought.

It is only just and fair to explain that the electronic industry has also come up with the *antidote* to this menace. One often finds other firms urging the reader to safeguard privacy by buying an instrument that detects electronic bugs, wire tapping and snooping devices. I suppose it would be quite funny if it were not for the sinister complications.

It will indeed be a fine state of affairs should it ever become normal routine to check over a room for electronic "bugs" before it is deemed safe for occupancy.

A SHOCKING TALE

WHEN is a dog a model? This is not a riddle but a legal point the G.P.O. may have to clarify, for I understand that the 27 Mc/s model control band is being used for dog training purposes. Seems a likely story, you say? But perhaps you haven't heard of the electronic dog collar which made its first public appearance at the recent components exhibition?

By operating the remote control transmitter, the trainer can give the dog a mild electric shock whenever he wishes to correct its behaviour. Apparently this gadget has been used with great success in the training of police and sheep dogs. It is to be hoped that the general dog-owning public do not try to jump on the bandwagon, because the electronic collar is not intended as a substitute for the old fashioned local control as administered through the leash. I know the model control fraternity will echo these sentiments for they have enough trouble as it is from unauthorised (two-legged) users of walkie talkie apparatus operating on the model control frequency.

Tail piece. I am unable to confirm or deny the rumour that the canine world is not over enthusiastic about this gadget, but considers it just a pain in the neck!

Switch that confounded thing off and let poor Booboo down at once!

REAL TIME

AROUND about the same time that the World's Fair computer was forging "hands across the sea", as referred to last month, another of its brethren was engaged on rather more sombre business in New York City.

Through evidence compiled by a computer based on betting transactions, eighty-six men were indicted on gambling charges. The significant point of this case is that without the computer the prosecution could not have been made. If left to mere man, the information could not have been compiled within the period of the three year Statute of Limitations. No doubt, as a result of this demonstration of computer against crime, many anti-social types will feel that time is certainly against them now. It only makes the other "time" more certain.

NO JAM TOMORROW?

MANY brains are busily working on schemes to prevent our town and city centres becoming completely stagnant with hordes of motor vehicles. By far the most sophisticated approach suggested so far is the idea of a sort of "electronic licence".

This would be a small article, about the size of a packet of cigarettes, which the motorist would purchase from a tax office and insert into a special receptacle in the car. Pulses radiated from cables buried just below the road surface would be recorded by this electronic box of tricks. When some predetermined "count" had been reached the electronic unit would indicate "licence expired" by switching on a lamp mounted in a conspicuous position on the vehicle.

With an arrangement of special codes, the count rate could be made to vary for given areas. Thus it would be possible to price motorists out of the more central districts; on the other hand the sparsely populated districts would probably be entirely outside the scheme and motoring in such places would be for free! Well that's the theory at any rate.

Readout—
A SELECTION FROM OUR POSTBAG

Who's old hat!

Sir—When I was reading Readout (PRACTICAL ELECTRONICS, June edition) I felt compelled to comment on D. R. Bowman's letter "Transistors cap valves".

I agree with him when he says that printed circuits are better, in many respects, than chassis construction, but I fail to agree with his statement that valves are "old hat".

I have recently constructed a 20 watt amplifier with total distortion only 0·05% at full output. The frequency response at 1 watt is 2c/s to 150kc/s and the power response (20 watt) 10c/s to 30kc/s, each ±0·5dB. Not even P.W.M. type transistor amplifiers, can equal this. Surely the EL34, as I use, cannot be called a special purpose valve?

A. J. Gay,
Bexhill,
Sussex.

All aglow

Sir—When I was sorting out some bits and pieces I found an old night-light bulb. I tried it out and found that it worked, but when I switched it off, I found that if I touched the glass bulb that the filament glowed and as soon as I took my hand off the bulb it stopped glowing.

The slightest touch will make it glow. Could you please tell me the reason for this.

C. D. Cole,
Kingsbridge,
S. Devon.

This is a neon bulb and it seems that when your light is switched off the "live" mains is still present on one contact of the bulb holder (this means that the neutral side of the mains supply is switched, which is incorrect and can be dangerous). By touching the side of the bulb you completed a very high impedance circuit back to earth through your body. This is often sufficient to produce a slight glow in a neon bulb due to gas ionisation.

Slave clock

Sir—I was very interested in the article on the Electronic Timer for Sports Events, in the May issue of P.E.

What I would like to do, is to adapt the circuit to operate a slave clock that gives the time of day. To do this an impulse at intervals of 30 seconds is required. Can this be achieved by increasing the size of the capacitors used in the circuit of the timer?

P. E. Huggett,
Shirley,
Croydon, Surrey.

It will require a little experimenting to get the time exactly right, but I would suggest changing the 2μF capacitors to 50μF (ensure polarity is right when connecting) and increase the multivibrator charging resistors to about 470kΩ. This should give about 30 seconds for each impulse.—J. Hillier.

Can you help?

Sir—As your magazine is now obviously widely read, might I suggest that a column could, with advantage to many subscribers, be devoted to a "Can You Help?" service. To start the ball rolling I would like to insert the following:

"Can anybody help to locate a replacement motor for a 'Nivico' Radio Phonograph model TRE-2, made by Victor Co. of Japan Ltd.?"

R. M. F. Clarke,
Porthcurno,
Penzance,
Cornwall.

Powerless experience

Sir—I had a strange experience recently which you may think worth recording in your columns.

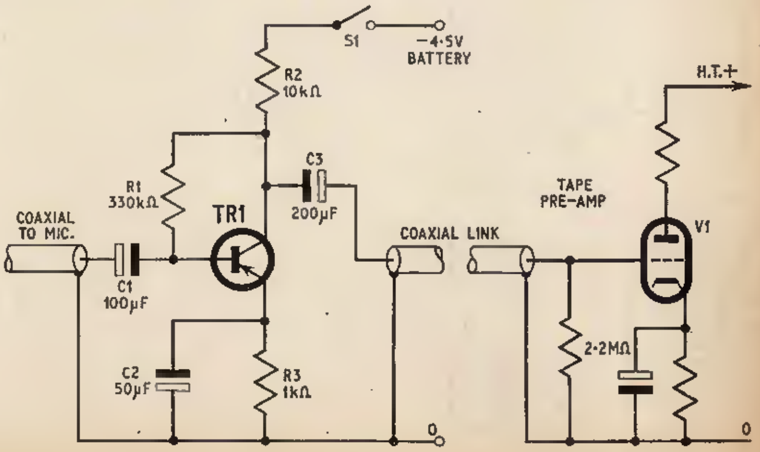
Wishing to match a low impedance microphone into the input of a tape pre-amplifier, I made up a small transistor pre-amplifier as shown in the circuit below.

This did not work very well, and I left it until the next day. To my surprise, it now works perfectly, giving a large increase in volume. On investigating, I found that the 4½V battery had become disconnected! On checking, I find that with no battery, or 10kΩ collector load, I am obtaining at least 100 times amplification!

I have decided in my own mind why this is, and wondered if your readers would care to theorise?

I am incorporating this "powerless" pre-amp as a permanent feature in my recording set up.

S. C. Hooson,
Liverpool, 16.



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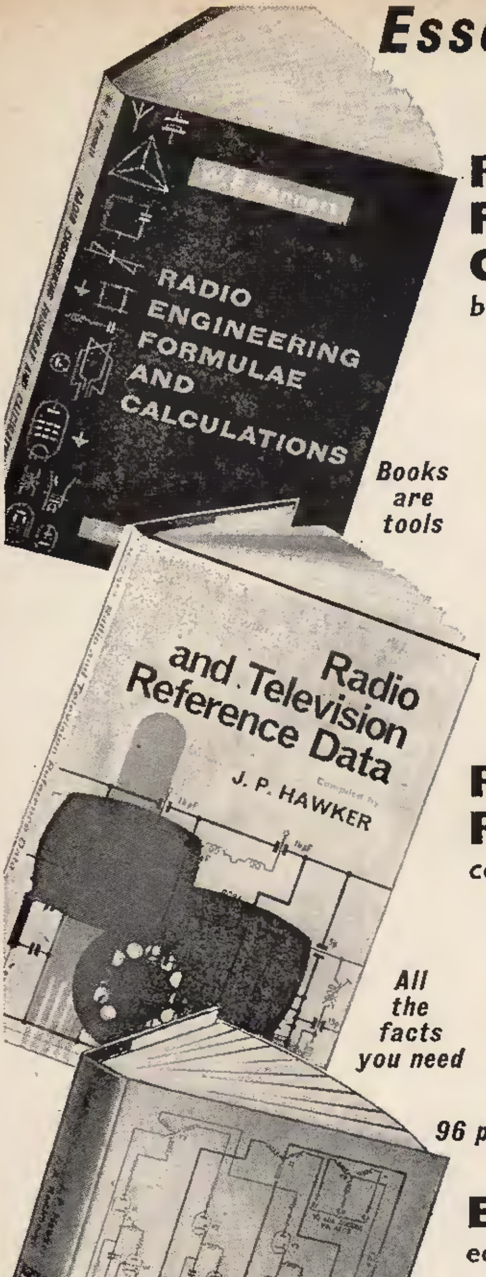

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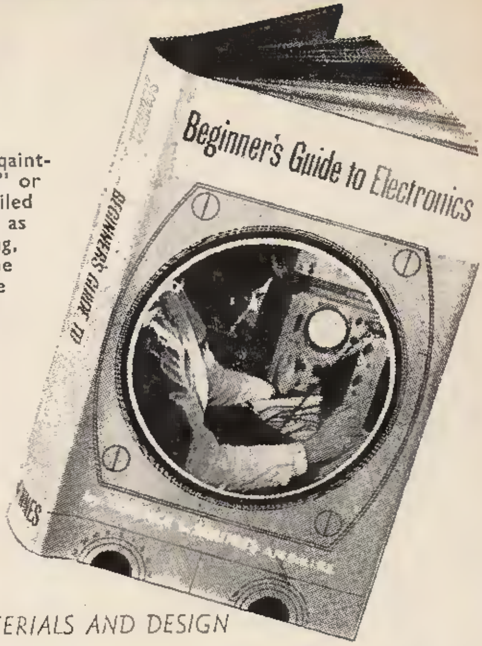

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