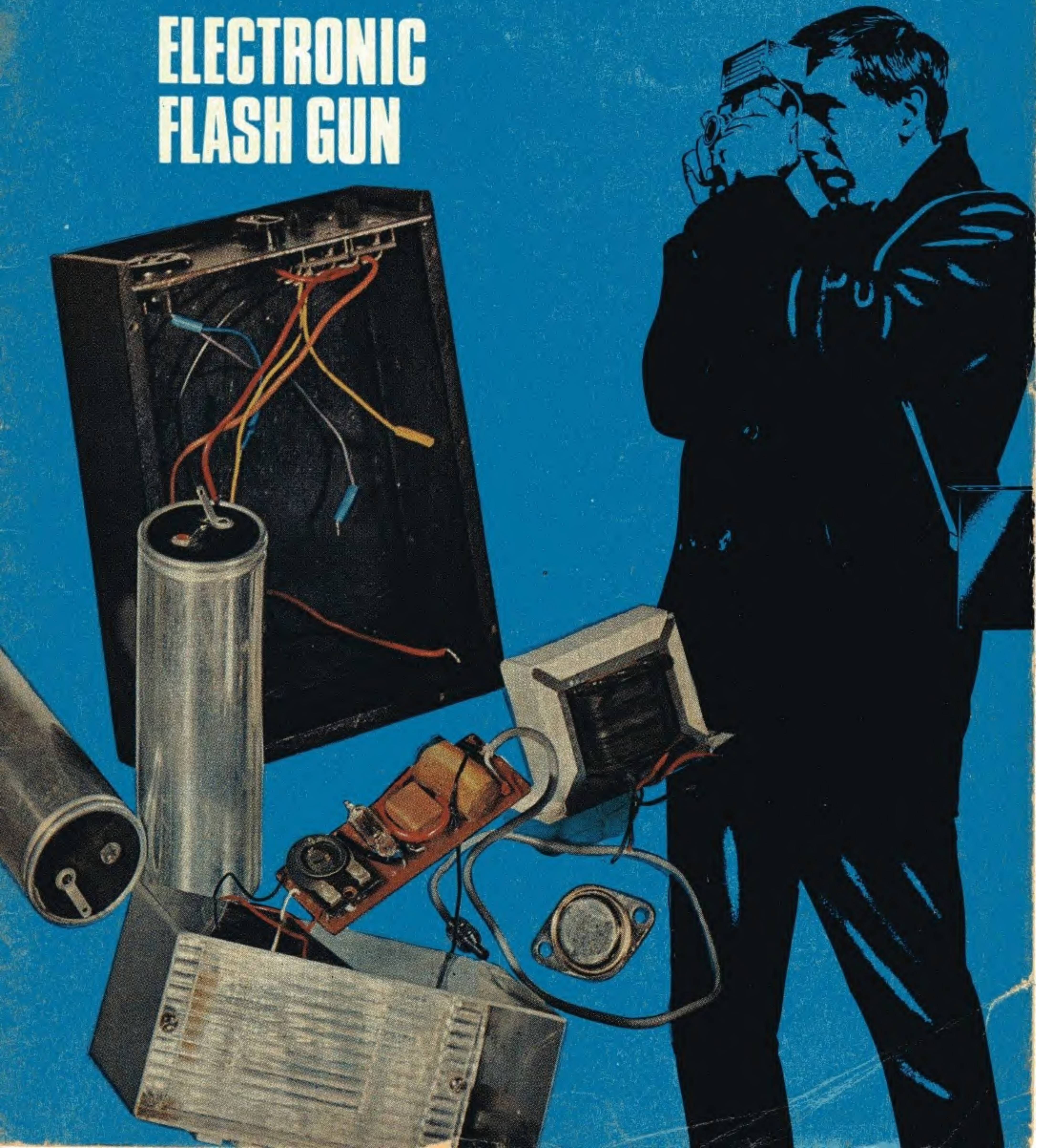
Practical Electronics

JULY 1965

PRICE 2'6

ELECTRONIC FLASH GUN



VOL. 1 No. 9
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COMPONENT NOMENCLATURE

THE value of electronic components exported in 1964 reached a new record figure of £70 million—a 20 per cent increase over the previous year.

We are happy to join in the general applause for this outstanding success. However, it seems obvious that the battle for foreign markets is going to become increasingly tough in future, and we would like to offer certain thoughts to our component manufacturers. This we do in full appreciation of the fact that the total sales on the amateur market constitute but a minimal part of the vast output from the factories of RECMF members. But there is no diffidence on our part in making these observations, for it seems to us that the non-professional enthusiast in some respects occupies a unique position and can comment on the component situation from a special standpoint.

★ ★ ★

Sooner or later, every amateur becomes aware of the anomalies and the frequent lack of standardisation in many types of electronic components, and in the terminology and nomenclature used to describe them. To his detached mind it must seem utterly ridiculous that different firms producing virtually identical parts should use entirely different systems of coding and classifying.

The most glaring example of this kind of anarchy is found among the semiconductor devices. It is indeed strange that with 50-odd years experience with valves to guide them, the makers did not decide right at the outset to prevent a similar proliferation of type numbers in the case of semiconductors. After all they had a perfect model to follow in the American numbering system.

* * *

In these days of keen competition in international trade the different coding systems adopted by rival firms are surely as archaic as the hundred and one types of screw threads that were once the nightmare of engineers.

Perhaps it is of no consequence to the maker that some poor individual may spend hours endeavouring to identify another maker's equivalent for a particular type of transistor; but is it not possible that the same frustrating experience may be the lot of some potential overseas buyer? If so, then this is indeed a matter for real concern to us all—whether we be " amateur " or " professional ".

* * *

Standardisation of component specifications and type nomenclature is obligatory for all military purposes. Where then is the logic in " going it alone " on the commercial or consumer front?

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our August issue will be published on Thursday, July 15

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TAPE TALKING BOOKS for the BLIND

BY ADRIAN MORRIS

UNTIL comparatively recently many blind people have been unable to gain pleasure from books apart from reading braille. Some are unable to learn braille through old age, insensitive fingers, or arthritis. Even so a large quantity of publications are reproduced in braille but there are many cases where it is an expensive and bulky proposition.

Novels, biographies and true stories have been read to the blind through the eyes of sighted persons. It is through this latter medium that the principle of providing "talking books" came into existence some years ago.

The earliest talking books developed by the Royal National Institute for the Blind used discs, but since these are now out of use and superseded by tape recordings it is not proposed in this article to describe disc methods. The tape system is entirely different from any commercial tape recorder; the two are not compatible as will be obvious from the article.

The books for recording are selected by a special committee appointed by the R.N.I.B. and read by qualified persons, such as actors and actresses, newsreaders, and other broadcasters, who have to be auditioned for this kind of work.

Fig. 1a. Mark 1 cassette

Fig. 1b. Mark 2 cassette

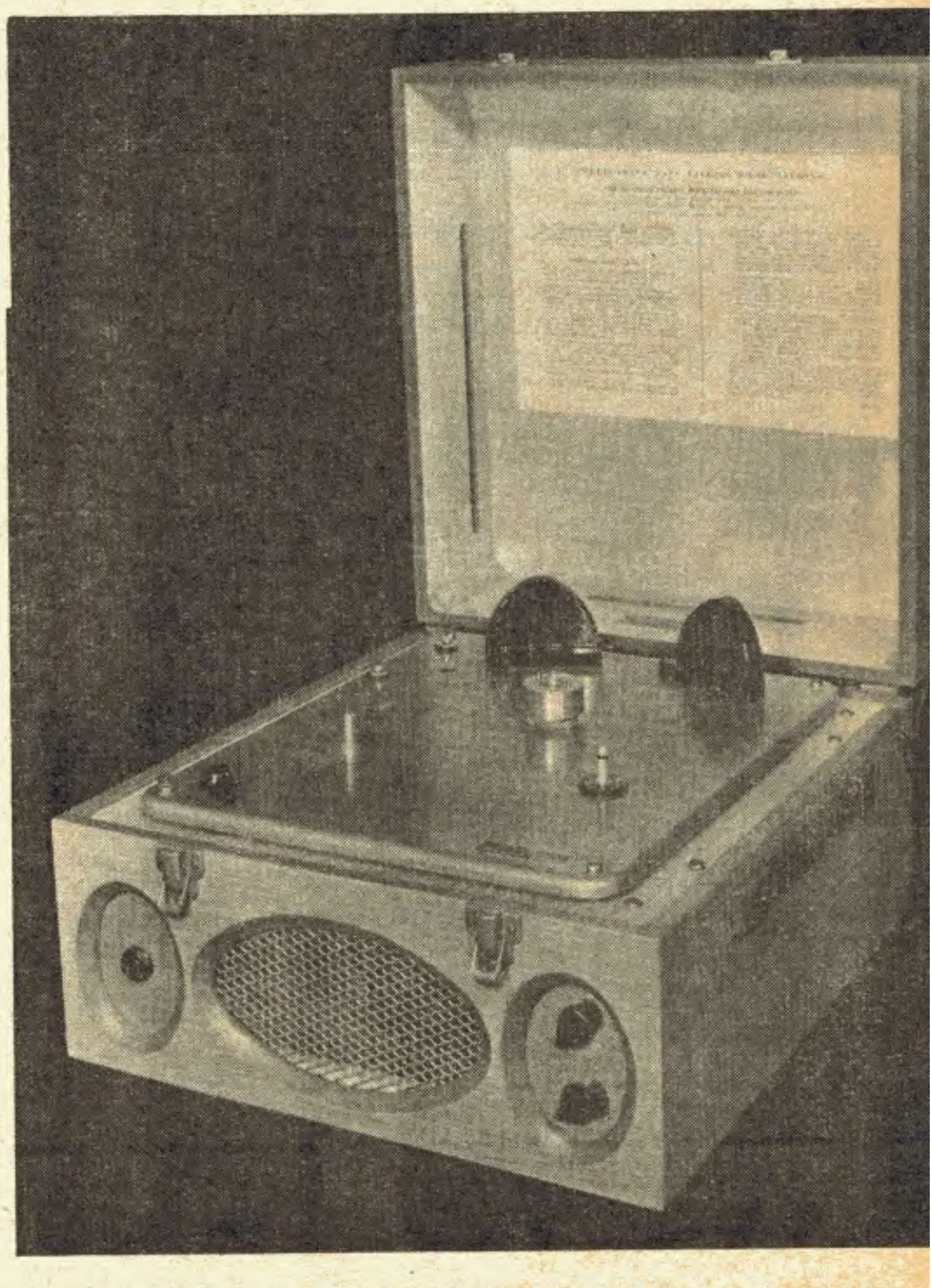

Fig 1c (right). Talking book playback machine

TAPE MACHINE

The advantages of the tape talking book are numerous: simplicity of operation; reduced bulk and weight; the ability to copy master recordings at high speed and hence a greater production output; improved reliability and less likelihood of damage. Perhaps the biggest problem which was overcome was containing the head and tape within the cassette so that the blind reader could not accidentally touch them and possibly damage the tape.

Fig. 1 shows the playback machine with two models of cassette. Operation of the machine is simple and only requires that the cassette be placed on the deck with the locating pillars helping to guide it into position. The lever on the left is operated by the blind person and the cassette drops to engage the centre spigotted spindle in the spool. At the end of each track a pre-recorded announcement is heard instructing the listener to switch the lever to "off", turn the cassette over, push the button on the front of the cassette and switch on again. If the lever is not switched off the machine will switch itself off by detecting a burst of 4kc/s tone at the end of the track. This de-energises a solenoid and releases the driving mechanisms.

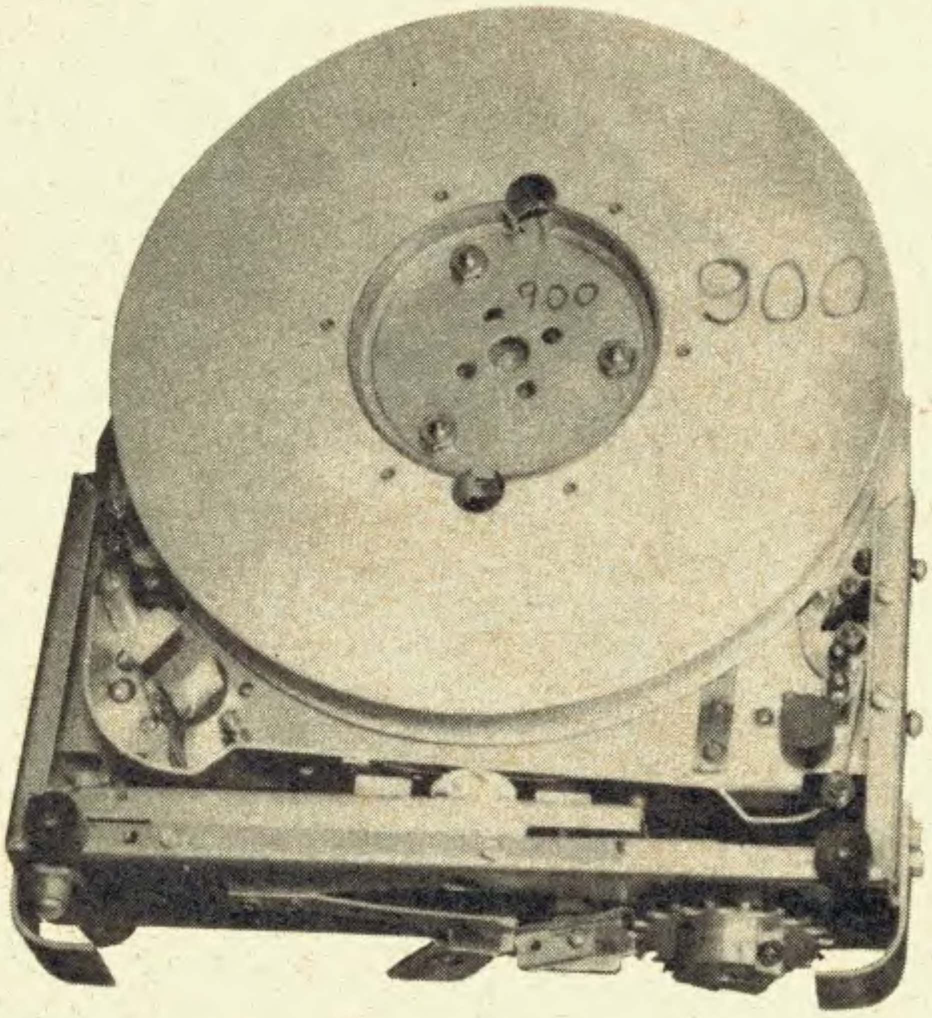

Fig. 2a. Interior view of the Mark I cassette using concentric spools. The upper and lower (out of sight) sections are identical. The replay head is just seen in the centre with one of its connecting clips on the left. The push button track change ratchet wheel is shown on the front

This is the procedure adopted for each of up to 18 tracks of the Mk. 1 cassette (shown on the left, Figs. 1a and 2a). The later model Mk. 2 (shown on the right) is very much smaller and lighter, and is not turned over at the end of each track. To change track it is kept in the same plane, turned through 180 degrees, and replaced on the machine.

The record/replay head is mounted on a moving arm, which is actuated by a ratchet system to position it on the correct track.

SLIPPING CLUTCH DRIVE

The large spindle in the centre of the deck is a 1·375in diameter shroud which houses a slipping clutch mechanism with spring loaded balls. It is so arranged that under normal driving conditions the large spindle does not slip because the balls are engaged in holes in the inner spindle. Under severe resistance the balls are forced out of the holes, causing the inner spindle to turn while the outer spindle is held stationary. The tape will not break under these conditions and no damage can occur.

The centre spigot and pins locate in the holes in the centre plate of the tape spool. This is the only form of drive to the tape, consequently the tape does not run at a constant linear speed due to the varying diameter of spooled tape. This can be a serious disadvantage, but is overcome by recording on the tape with a variable pre-emphasis of treble. The resulting quality on replay is fairly constant.

The Mark 2 cassette (below) is about two-thirds the depth of the Mark I version (left) due to both hubs being positioned on the same side of the baseplate

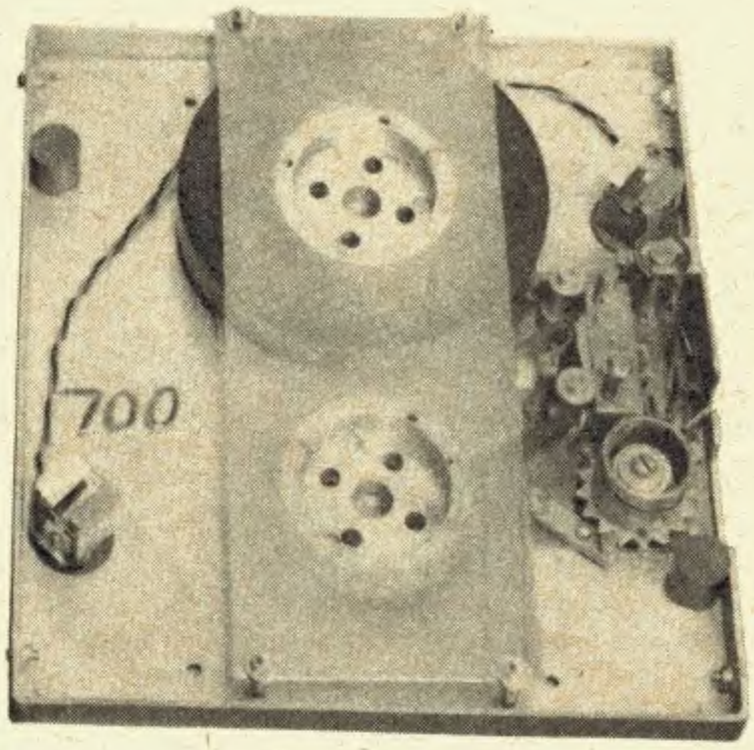

Fig. 2b. Interior view of the Mark 2 cassette using two hubs for the tape. The head and track change mechanism is on the right. The head connecting clips are on the lower left and upper right. Both of these cassettes will fit the standard playback machine

To prevent the tendency of the spools to free run after the machine has stopped, automatic brakes are fitted. These can just be seen on the left hand side of Fig. 2a.

The two spools are mounted independently one above the other on ball races. Contact with the replay head, which is inside the cassette, is made via the two-way plug on the deck. There is provision for 18 tracks on 3600ft of half inch wide tape allowing up to 20 hours of recording.

Since the average book does not often exceed 16 hours the smaller model (Fig. 1b) was designed to cater for this. The tape is wound on two hubs which are set in ball races in the case. The track change mechanism is operated on a ratchet principle with a helical groove to locate a pin on the head mounting.

Fig. 3. Master tapes being reproduced at high speed from an original studio master on the the left. The operator is speeding up the machine with an auto-transformer control. The recording equipment and the master copying equipment are at the head offices of the Royal National Institute for the Blind in Great Portland Street, London

MASTERS

The original recordings are made on professional tape recorders to a high standard of quality using long play tape 0·25in wide and run at 3¾ inches per second. The three R.N.I.B. studios in London are treated with anti-reverberant material and are separated from the control rooms by cavity walls and twin doors.

Each studio is equipped with an identical pair of recording machines so that a stand-by machine is always available in the event of a breakdown. Facilities are provided for intercommunication between the reader and operator. Even the possibility of the reader wishing to pause to cough is catered for. He only has to press a muting button and his microphone is short-circuited to prevent unwanted noises being recorded. The readers in the studios are not normally required to read for more than two hours in one session since there is often the likelihood of his reading quality falling off.

Each master recording is passed to the "overseas copying" room where additional masters are made for Commonwealth countries. Fig. 3 shows the equipment used for this process. It comprises a master deck which replays the original master recording and passes the signal to four slave decks.

Each machine is coupled by a toothed belt so that they run at identical speeds. No matter how fast the original master runs the slaves will follow suit. It is convenient, therefore, to run machines at four times the speed at which the original was recorded.

Automatic compensation for the recording and replay characteristics as well as a much higher bias frequency are incorporated. The higher bias (220kc/s) is necessary to avoid audibility on subsequent replay at 3¾ inches per second. In Fig. 3 the operator is speeding up the machine by means of a variable auto-transformer. All tapes are synchronised so that they speed up together.

Facilities are provided for copying both tracks of each master at the same time. Since the machine is speeded up the speech becomes unintelligible but the mean level on each track is monitored by a meter on the control panel. Fast spooling is performed either on each deck individually or on all decks together.

This copying machine has been specially designed and built for the purpose although many proprietary components are used.

CASSETTE COPYING

The original master is sent to the Central Library and cassette copying department at Alperton. This is where the cassette recording comes in. A selection of some of the equipment used is shown in Fig. 4. Part of the actual copying console is shown at the rear. It resembles the master copying console in Fig. 3 except that the conventional tape decks are replaced by special decks which carry up to 20 cassettes.

The master recording and pre-recorded announcement tapes are placed on the master decks at the left hand end. The cassette tape is wound on to one of the cassette spools from a reel of half inch wide tape on the machine in the right foreground. The cassettes are then placed on the copier ready for copying. Recordings are made on the cassette tapes simultaneously using the heads in the cassettes and running the whole machine at six times the original speed. Compensation of recording and replay characteristics is also performed automatically when the machine is speeded up.

When the copying is complete the tapes are rewound to the beginning. The cassettes are then inserted in their metal containers and shelved to await the blind readers' requests.

The machine in the left foreground of Fig. 4 is used to rewind the cassette tapes at high speed when returned by the borrower to the library.

EXPANSION

This article has described the system for producing talking books on the Mk. 1 cassette. The smaller version Mk. 2 is at present undergoing extensive field trials while an even smaller version Mk. 3 is being developed with a view to being able to post it in a standard postal letter box.

It is further anticipated that regional centres will be set up, where local distribution will relieve the Central Library of an increasing volume of work and limited storage space.

The system described is by no means confined to the United Kingdom; equipment has been supplied to other countries throughout the world from New Zealand to Russia and Mexico, to name only a few.

One aspect of this service which has not so far been mentioned is that of installation and servicing of the playback machines. This very important but simple function is essential to the happiness and confidence which can be given to blind people by nearly 2,000 volunteers, many of whom are members of the R.S.G.B.

It is estimated that about 6,500 new blind readers are enrolled each year and it is becoming an increasingly difficult problem to recruit new volunteer helpers who are asked to spend only a few hours to instal and repair these playback machines. They are not required to repair cassettes since this is done at the central library.

STUDENTS' LIBRARY

A recent venture started by the same department of the R.N.I.B. is the students' library. The same machines are used except that they have chapter location and fast rewind and forward facilities. One of the tracks on the tape is coded with a low frequency signal so that on fast forward spooling the blind student can refer to another section in the book.

For this service the original master tapes are made on commercial recorders owned by volunteers who undertake to read textbooks for subsequent copying on to cassette tapes.

Any registered blind student may request a standard text book on almost any subject. Arrangements will subsequently be made to have the book made available or ask a volunteer reader to record his reading on his own tape recorder at home. This recording is sent to the students' library for copying.

It is further hoped to be able to use talking books for map reading, whereby the blind listener can follow the directions given in the talking book to locate places on his braille map.

A system of coding could be used to indicate land heights. This would entail a variation in pitch of a signal emitted by the talking book tape while the student follows a raster-like course with his fingers over the map. Place names could be recorded on a separate track.

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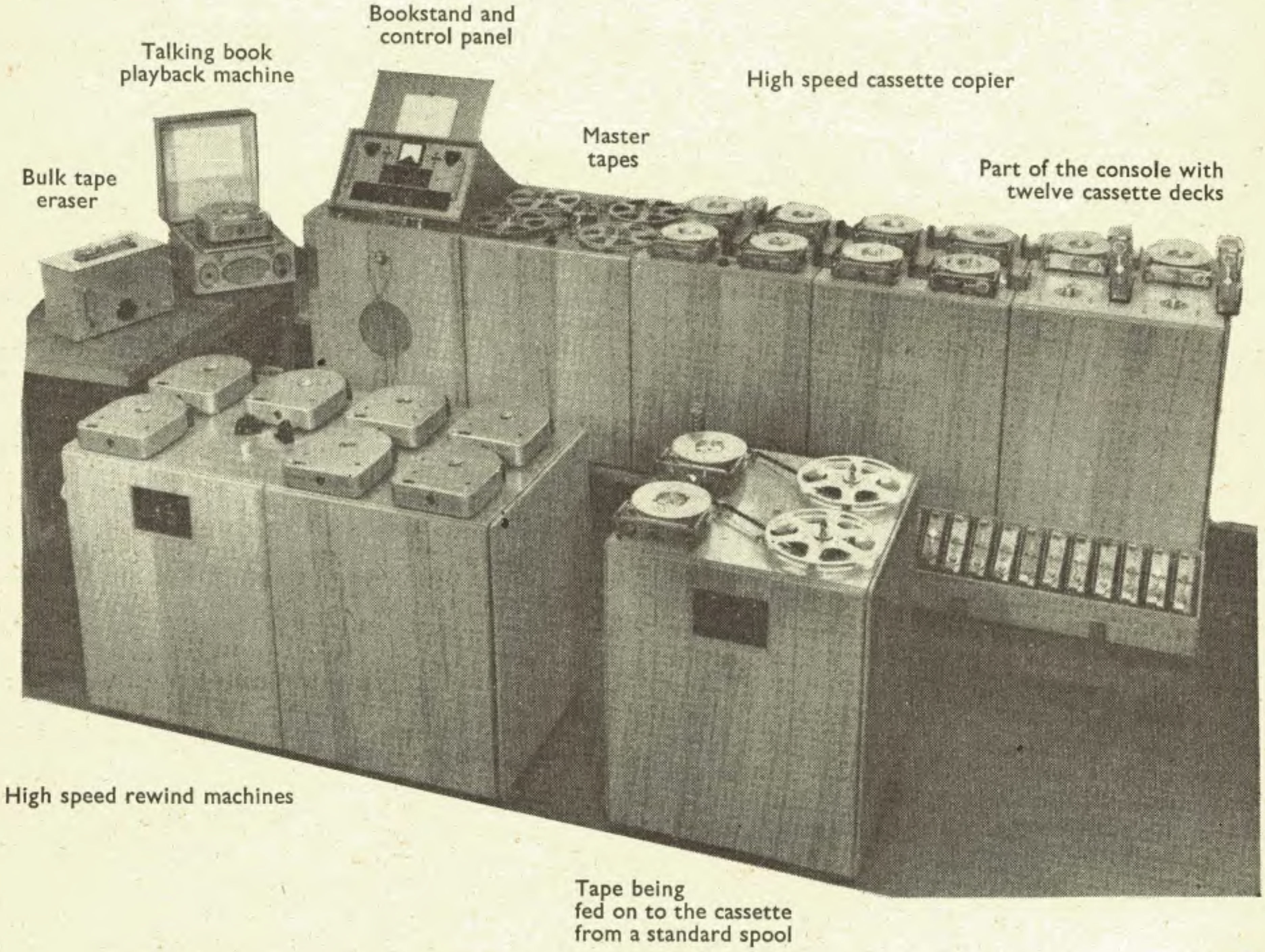


Fig. 4. Group photograph of talking book equipment

ELECTRONIC FLASH GUN

BY B.J. CROWE

PART ONE

POWER UNIT

BULB FLASH photography, though not initially expensive to buy or to operate, rapidly becomes prohibitively so when used with any frequency, particularly in 35mm photography. A commercially produced "EN-print" from a 35mm negative costs approximately 9d, and a 35mm colour transparency about one shilling. The most commonly used size of flash-bulb (PF1, AG1, etc.) costs 8d or 9d, so that to expose a frame by flash-bulb roughly doubles the cost of a monochrome print and adds 75 per cent to the price of a transparency. A rechargeable electronic flash gun, having no operating expense, has therefore a very strong economic attraction apart from any other advantages. Unfortunately, such units of useful power output cost between £15 and £25, and expendable battery-powered units not less than about £10.

The author decided, therefore, to construct a gun from available components, the aim being to produce a gun small enough to fit on to the camera, and having a guide number not less than 50 with 50 A.S.A. colour reversal film, and about 80–100 with 125 A.S.A. monochrome film, and a recycling time (time taken to recharge the capacitors) of about 10 to 15 seconds. The gun described in these articles is something of a compromise, conforming to the latter points of the specification but not to the first, since it proved to be too heavy and bulky to be mounted on the camera. The gun is therefore divided into two parts: the power pack, which may be carried in a coat pocket or on a shoulder strap; the flash-head is mounted on the camera or on a tripod, as required.

PRINCIPLE OF OPERATION

The heart of the electronic flash gun is the xenon discharge tube, a glass or quartz envelope containing xenon at low pressure. In its "rest" condition the tube can hold-off quite high potentials between anode and cathode (for amateur-used tubes, typically 250–500 volts) without conducting. However, upon the application of a trigger pulse to a third electrode (typically 4 kilovolts) the gas is partly ionised and the tube passes an "avalanche" current, often reaching peaks in the order of thousands of amps, the energy passed being converted into light energy. In order to allow the passage of such high currents the energy must be drawn from a low impedance source, almost invariably a capacitor or bank of capacitors.

The capacitor bank must of course be charged up for each flash, and this may be done in one of three basic ways. First, from a suitably rectified mains supply, but then the gun cannot be truly termed portable; secondly, from high tension storage batteries, but these are heavy, bulky, expensive, and run down quickly, so that it becomes costly to run the flash gun; thirdly, from a low voltage source, using an inverter to obtain the required voltage. It is the latter type of gun which is to be described here.

DESIGN CRITERIA

Having decided on the specification, it is necessary to convert the figures into hardware. In order to do this relationships between guide number and light output, and light output and stored energy are required. The following formulae have been found to work well in practice:

$$G = \sqrt{(0{\cdot}005 \times L \times M \times S)} \qquad (1)$$

where G = guide number,
L = light output in lumen seconds,
M = reflector magnification factor,
S = film speed (A.S.A.).

$$L = 50J \qquad (2)$$

where L = light output.
J = stored energy in joules.

Substituting for L in equation (1) we have:

$$G = \frac{\sqrt{(JMS)}}{2} \qquad (3)$$

Since it is required to calculate J for a given value of G, it is convenient to re-write equation (3) thus:

$$J = \frac{4G^2}{MS} \qquad (4)$$

It is obvious that to use equation (4) something must be known about M, the reflector magnification factor. For the average bulb flashgun reflector $M \simeq 4$, but it is generally accepted that the contemporary miniaturisation of electronic guns is due largely to greatly increased reflector efficiencies, M being raised to the order of 10. Realising the difficulties of constructing an efficient reflector from available materials, the author aimed tentatively at doubling normal efficiency, i.e., $M \simeq 8$. This therefore is the figure used in the calculations below.

Using equation (4) it is found that, assuming a guide number of 100 with 125 A.S.A. film, the stored energy J must be 40 joules, and for a guide number of 80, 26 joules. Similarly, to give a guide number of 50–60 with 50 A.S.A. film the available energy must be between 25 and 36 joules.

It was decided to use the Mazda FA10 xenon tube, since this appeared to be the most suitable in terms of availability and cost. The maximum operating voltage of this tube is quoted as 275 volts therefore, since

$$Q = \tfrac{1}{2}CV^2 \qquad (5)$$

where Q = stored energy in joules = J,
C = capacitance in farads,
V = volts.

A capacitance of about 670μF for 25 joules energy and 1,060μF for 40 joules is required at 275 volts. The higher figure is chosen to give some sort of design safety factor for losses and inefficiencies unaccounted for.

The above energy storage figures also show some of the information required to design the invertor circuit. Since, according to the specification, a maximum of 40 joules is required to be transferred in not less than 10 seconds, the average power rating of the circuit will not be greater than 4 watts (joules = watts × seconds). Although the transient switch-on conditions will exceed this rating, components chosen to cope with 4 watts will generally be adequate.

INVERTER CIRCUIT

The circuit used in the author's flash gun is basically a blocking oscillator switching a low impedance source through a 50 : 1 step-up transformer. Although it may seem a strange choice of circuit compared with the more usual relaxation oscillator type of inverter, it has the advantages of using only one transistor instead of two, and utilising a common output transformer costing far less than a comparable inverter transformer. The circuit diagram for the power pack is shown in Fig. 1.1.

Several combinations of transistor and transformer were tried, and the most efficient (in terms of step-up voltage and power transfer rate) of those tried was found to be the one shown, i.e. OC35 power transistor used with the 50 : 1 tapping of a Radiospares "Midget" output transformer. There are probably more efficient combinations yet to be tried. Several attempts were made using transformers wound on ferroxcube cores, but none was as efficient as the combination indicated.

The accumulator was chosen to have as low an impedance as possible since this directly dictates the recycling time of the unit. In practice it was found that to achieve a 90 per cent power transfer in 15 seconds a source with a capacity in the order of 1 ampere-hour was required. Only two accumulators generally available were considered sufficiently com-

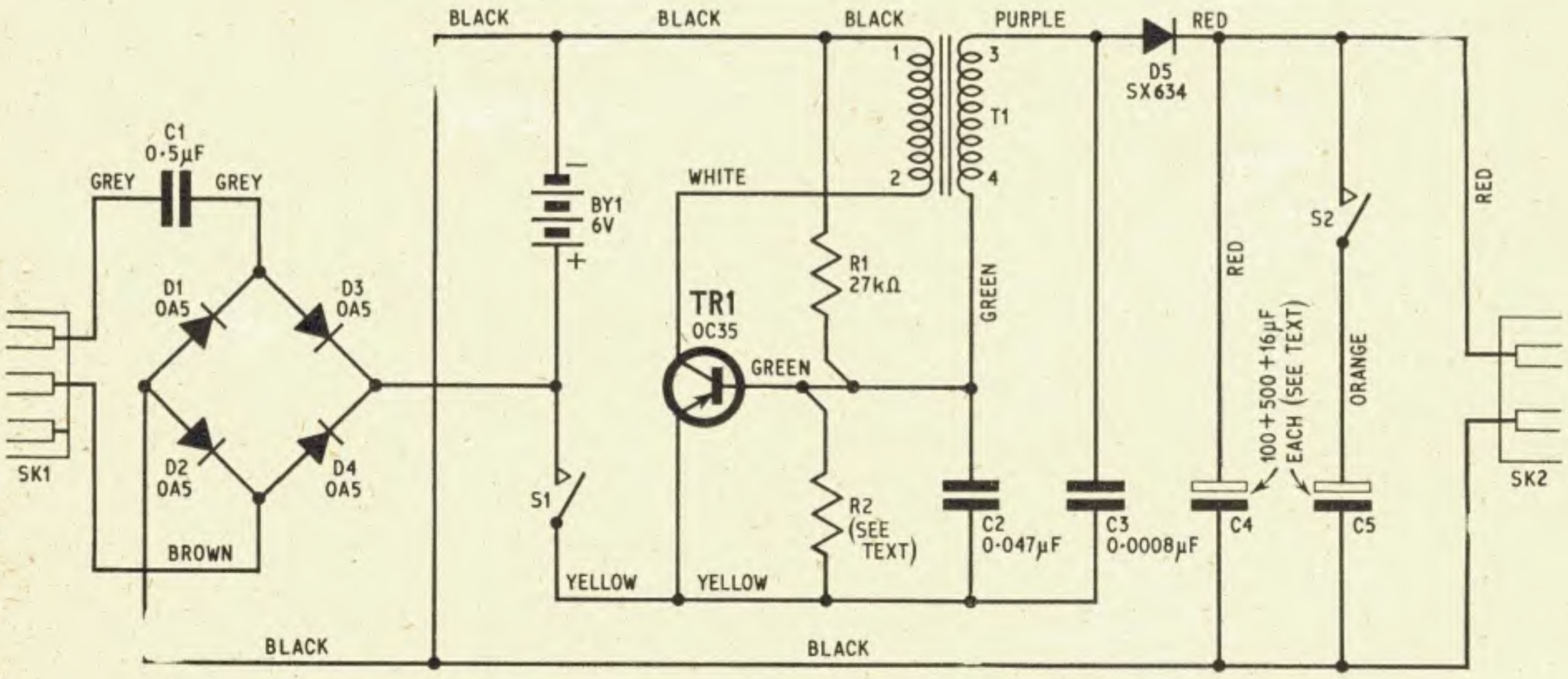


Fig. 1.1. Circuit diagram of the flash gun power unit. SK1 is the recharge socket; SK2 is the output socket to the flash head. Switch S1 is the on/off switch; S2 is the half/full power switch

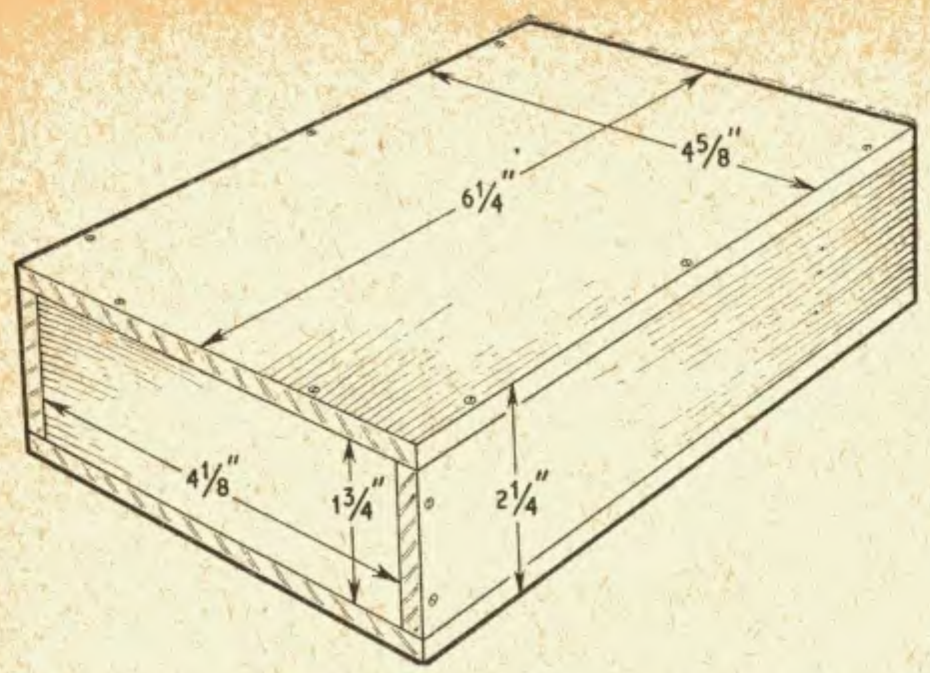


Fig. 1.2. Main constructional dimensions of the power unit case made from wood $\frac{1}{4}$in thick

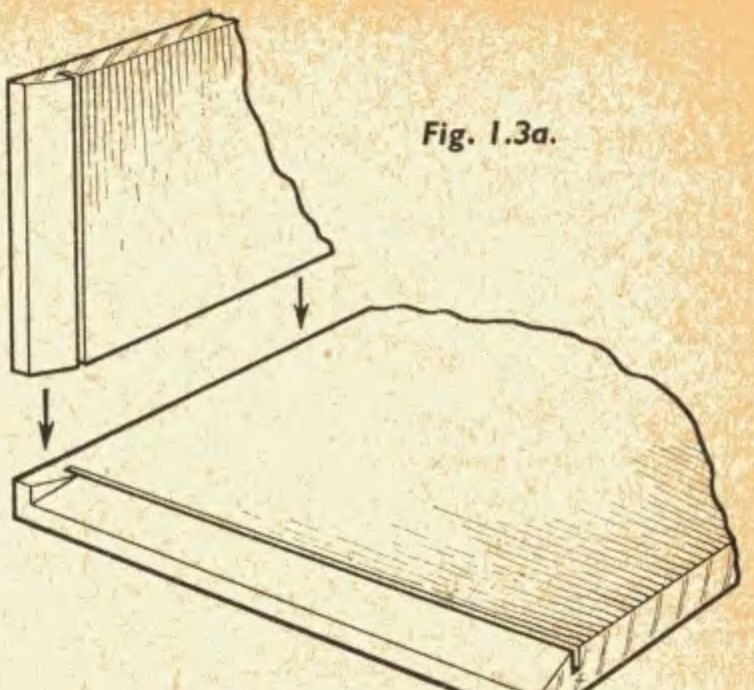


Fig. 1.3a.

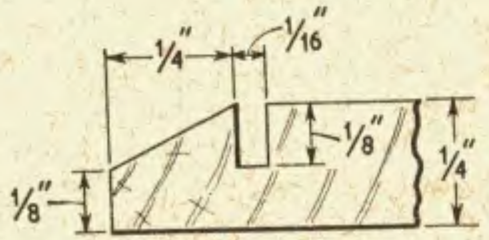


Fig. 1. 3b.

Fig. 1.3a. Chamfered ends and groove for the control panel

Fig. 1.3b. Dimension details of the chamfer and groove

pact: the "Deac" 0·5AH nickel-cadmium cells; and the "Dryfit" lead-acid accumulators of 1AH capacity. Despite the very desirable characteristics of the nickel-cadmium cell, two such banks would be required in parallel and would be bulkier than, and almost three times as expensive as the lead-acid type, which has a much more conveniently shaped case.

The remaining component values are chosen to give the best efficiency with the transistor/transformer combination used. The oscillator shown runs at about 1kc/s, which was found to be the optimum frequency for this particular transformer. Different transistor/transformer combinations will require a different set of components, the values of which will best be determined by trial and error. A combination similar to that in the author's gun will call for very similar component values, but the substitution of other values around those shown will probably yield improvements in efficiency for the particular transformer used.

The initial operation of the circuit was made without R2, and it was found that the oscillator switched off before it had reached its maximum output voltage. It was suggested that this was due to the leakage path across C4 and C5 formed by the reverse leakage current through D5 and the base-emitter junction of TR1 via the secondary winding of the transformer. The reverse impedance of D5 is typically 50 times greater than the base-emitter junction of TR1 so that something like 5 volts appears on the base of TR1 at a charge potential of 250 volts, driving TR1 into the cut-off state.

Lowering the base-emitter diode resistance by the parallel resistor R2 (about 10 kilohms) allowed the oscillator to run continuously, drawing a quiescent current of about 100mA from the accumulator. It was then found that, by careful adjustment of the value of R2, it was possible to utilise the "knee" in the I_c/V_c characteristic of TR1 to make the oscillator

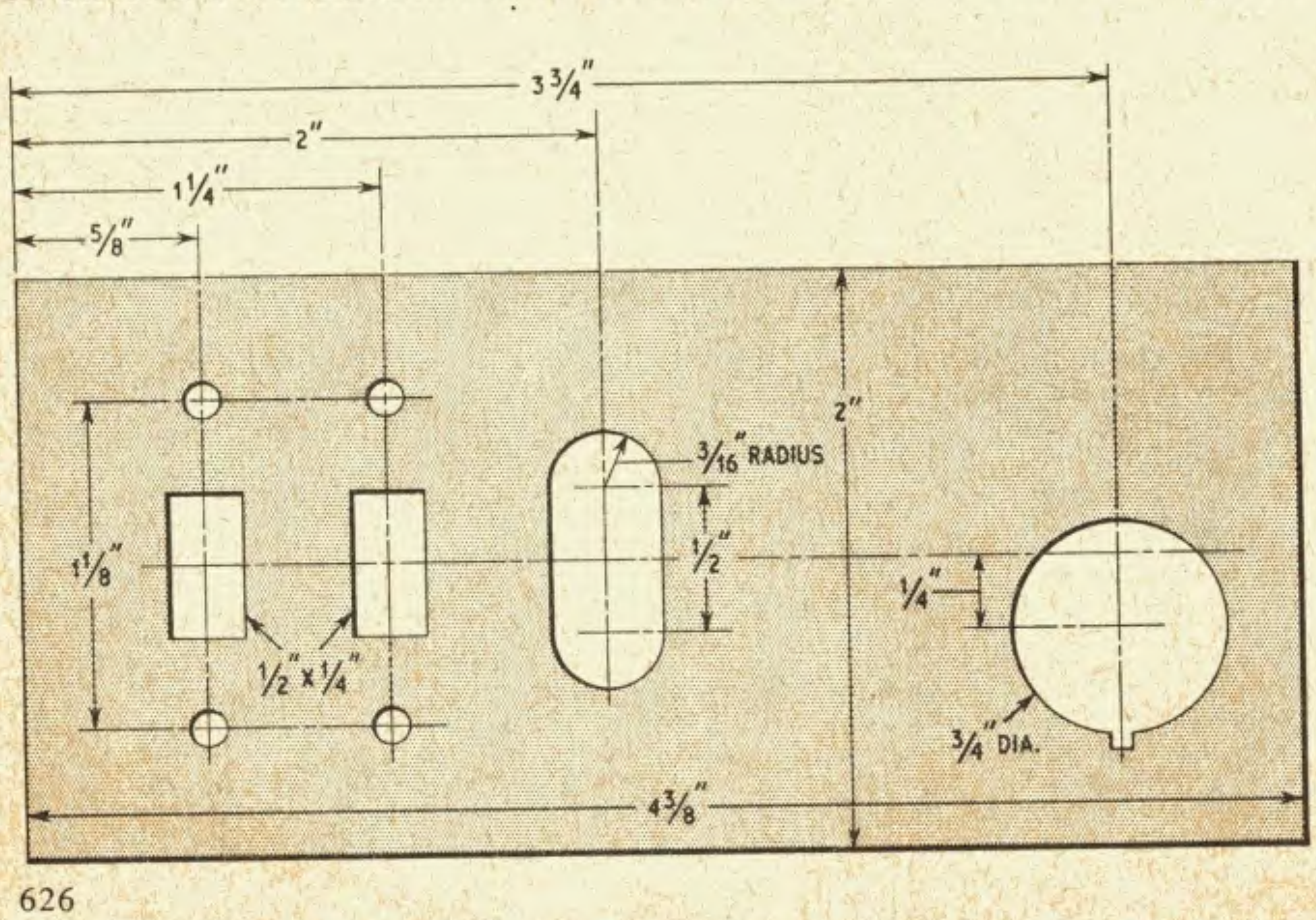


Fig. 1.4. Cutting details of the control panel which is made from $\frac{1}{16}$in thick aluminium

self-regulating, switching off at 100 per cent of the charge voltage, running at 45mA for about one minute, switching on again at 98 per cent charge voltage and running at 100mA for about 20 seconds. Thus about 80 per cent of the power is conserved for a 2 per cent voltage regulation error. To achieve this the value of R2 was found to be 320 kilohms, but it seems to be rather critical and must be determined for each particular circuit by experiment.

CASE CONSTRUCTION

The construction begins with the building of a case to enclose the components. The case of the author's pack is made from ¼in plywood, since this was considered more robust than a plastics case, and avoided the insulation problems inherent in a metal case. Obviously a case could be made from these or other materials with a possible reduction in volume, provided sufficient care is taken in the design.

Cut the five pieces of plywood to the dimensions shown (Fig. 1.2), keeping the edges as square and as clean as possible. A slot ⅛in deep must then be cut in the two sides, the base, and the lid to accept the switch panel (Fig. 1.3). This may be done with a hacksaw or, if available, on a pillar drill or milling machine using a 1/16in end milling bit. The top edge of each of these pieces is then chamfered as shown in Fig. 1.3b and the base, bottom and sides then screwed together.

Cut the switch panel to size from 1/16in thick aluminium (Fig. 1.4) and check that it fits the box, widening or deepening the slots as necessary. When the fit is satisfactory the base, sides and bottom may be screwed and glued together, and when dry, the whole box should be sanded to a good smooth finish. The panel in the author's gun was cut from plastic-coated steel with a black "crackle" finish, and labelled with white lettering. These trimmings are obviously not strictly necessary and the panel could equally well be made from aluminium or even copper-clad printed circuit board, and the switch functions entrusted to memory.

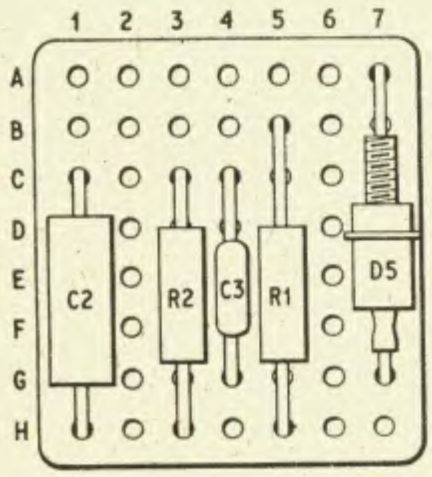


Fig. 1.5a. Top view of the oscillator component board

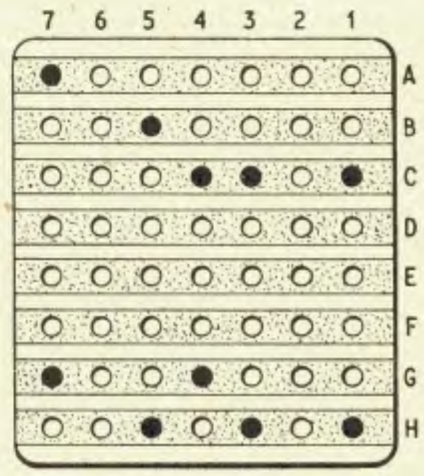


Fig. 1. 5b. Underside view of the oscillator component board

The holes are now cut in the switch panel to suit the particular switches and sockets to be used (Fig. 1.4). In the author's gun a Radiospares "flex-connector" set was used for the h.t. output, the socket being fitted to the pack and the plug, with the exposed pins, to the flash-head. The plastic socket is slightly tapered and it was found that if an oval hole is cut in the panel and enlarged carefully the socket may be made a push-fit in the panel, being secured with Araldite if necessary. Check that the switches and sockets fit the holes and slide the panel into the case once more with them in position to ensure that they do not foul the case.

At this stage the required finish should be applied to the case and panel. The box described was finished by filling the screw-head recesses and exposed ends of saw cuts in lid and base with plastic wood and then treated with grain-filler and sprayed gloss black from an aerosol spray. Suggested alternatives are natural wood or leathercloth. If transfers are used on the panel it must be protected with a clear varnish.

OSCILLATOR

The oscillator components should now be mounted on a piece of Veroboard as shown in Fig. 1.5. The values of these components would best be determined from a "bread board" set-up of the oscillator before final assembly. Short lengths (about 6in) of fine p.v.c. covered wire should be attached to each of the following points on the Veroboard before assembly with the transformer; a convenient colour-code is suggested which facilitates subsequent wiring:

Veroboard Location	*Colour*
A4	Red
B1, B3, B4, B6	Black
C2, C6	Yellow
D2, D6	White
G6	Purple
H4, H6	Green

Fine instrument wire (7/·0048) should be used if possible since space is limited.

The Veroboard panel may now be strapped on to the transformer as shown in Fig. 1.6 using lacing cord or fine p.v.c. covered wire, and the following connections made:

B1 — Pin 1
D2 — Pin 2
G6 — Pin 3
H4 — Pin 4
} Transformer pin numbers as in Fig. 1.7

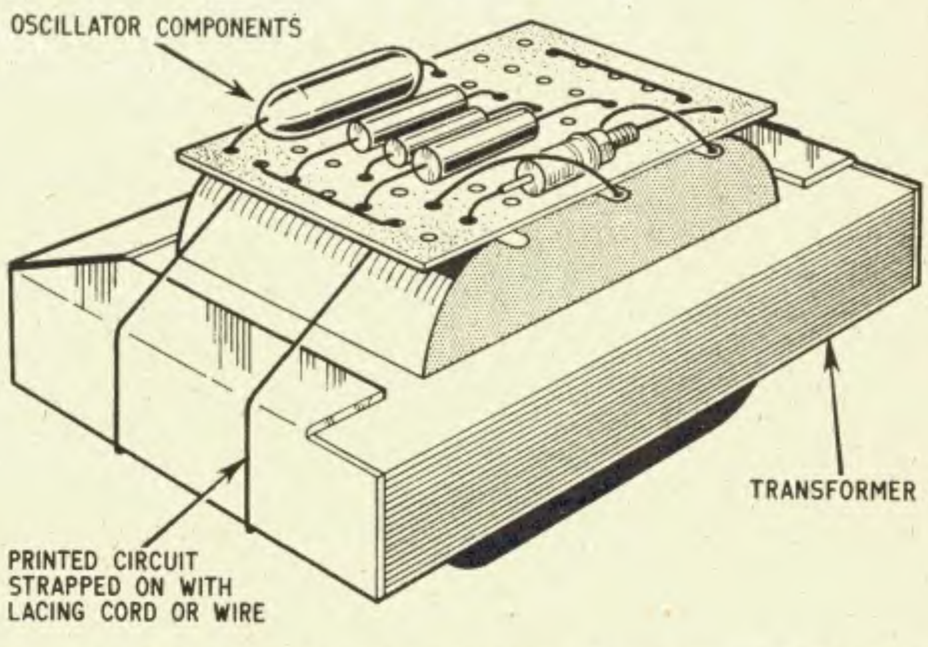


Fig. 1.6. Method of securing the oscillator component board to the transformer

Components . . .

Resistors
R1 27kΩ
R2 See text

Capacitors
C1 0·5μF, 500V paper (Radiospares)
C2 0·047μF, 125V polyester (Mullard)
C3 0·0008μF, 30V ceramic (Radiospares)
C4, C5 } 100μF+500μF+16μF, 275V elect. (Radiospares)

Diodes
D1–4 OA5 or similar (Mullard)
D5 SX634 (750mA, 400 P.I.V.) (G.E.C.; Mullard)

Transistor
TR1 OC35 (Mullard)

Transformer
T1 "Midget" output transformer (50 : 1 tapping) (Radiospares)

Accumulator
BY1 6V, 1 amp-hour (Dryfit "Sonnenschein")

Switches
S1, S2 Radiospares slide switches

Plugs and Sockets
SK1 Belling Lee miniature mains socket (with plug L14.36/P)
SK2 Radiospares flex connector socket (with plug)

Miscellaneous
Piece of Veroboard: 8 holes × 7 holes (1·1in × 1·0in)
Plywood: ¼in thick, about 15in × 8½in
"Stelvetite" plastic-coated steel: 16 s.w.g. or Aluminium about 4½in × 2in × 1/16in
Scrap of ⅛in balsa wood (see text)
Two battery clips for accumulator
16 1in × No. 4 brass countersunk woodscrews
Some 12in lengths of 7/0·0048 p.v.c. covered wire (various colours, see text).

Take one of the Radiospares 400 + 100 + 16μF main storage capacitors (C4) and connect together the three positive terminals with short lengths of insulated wire (ensuring that they do not short to the can) thus forming one 516μF capacitor. Treat the other capacitor (C5) similarly and strap the two side by side with adhesive tape, joining the negative terminal on each can by a short length of wire. The capacitor assembly is completed by soldering an 8in length of black wire to the common negative terminal, 8in of red to the common positive terminal of C4, and 8in of orange wire to the common positive terminal of C5.

Assemble S1, S2, SK1 and SK2 on the switch panel and solder a 4in length of grey wire to the "live" pin of SK1 and a 4in brown wire to the "neutral" pin. Slide the panel into position in the box. Lay the C4–C5 assembly in the box as shown in Fig. 1.8 and take the leads up the side and along the base of the panel to S2, the orange lead to the centre pin and the red lead to the upper pin. The black lead from the common negative terminal is taken to one pin of SK2 and a short length of red to the other terminal of SK2 from the upper pin of S2.

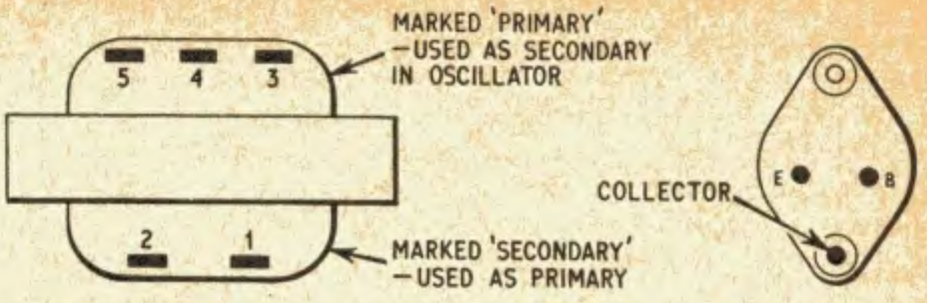


Fig. 1.7. Transformer and transistor tag identification. Tag 5 on the transformer is not used. The transistor is viewed from the underside

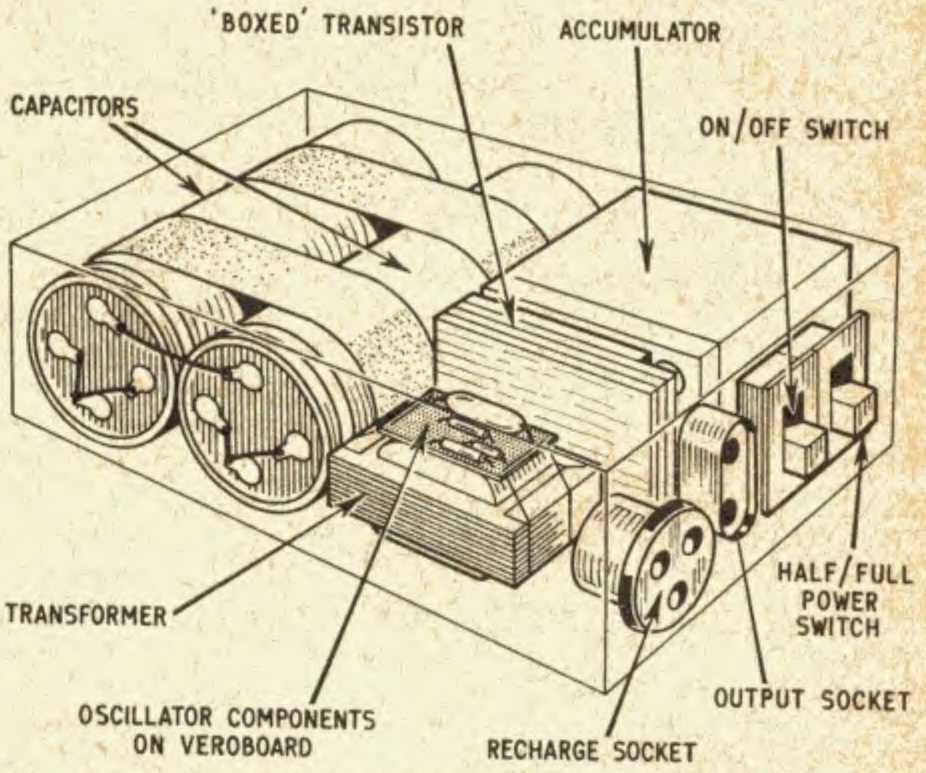


Fig. 1.8. Layout of the main components in the case. This should be taken as a rough guide only. If the components used are larger than those specified in the components list a correspondingly larger case should be made

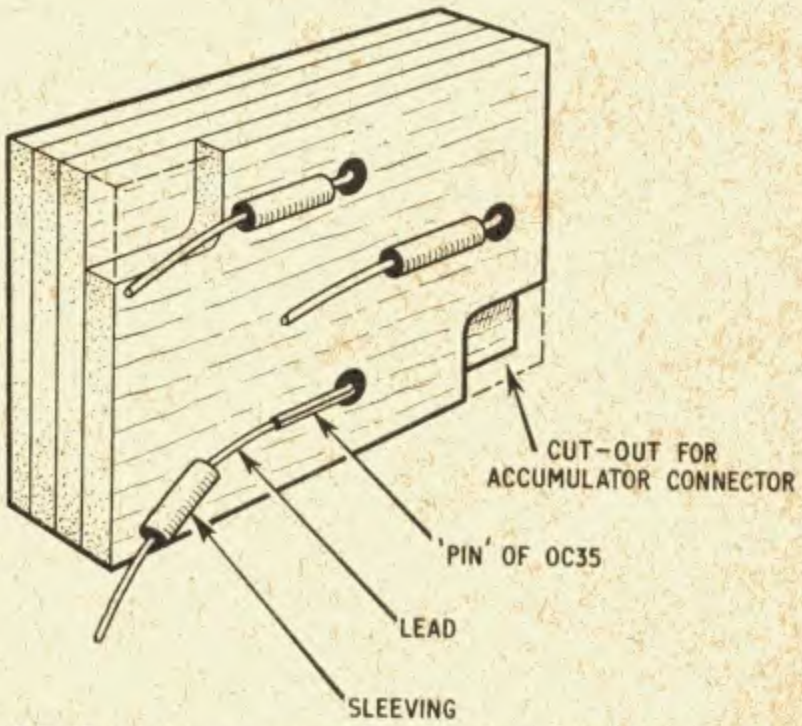


Fig. 1.9. Transistor mounting chamber showing the wires from the transistor

Place the transformer assembly in position in the box as shown in Fig. 1.8, soldering the lead from B4 on the Veroboard (black) to the common negative terminal of C4 and C5, and the red lead from A4 to the top pin of S2. The yellow lead from C2 is taken to the centre contact of S1. Attach two 3in lengths of yellow wire to the upper pin of S1, and on the end of one of these solder the positive battery clip. The negative battery clip is attached to the free end of the black lead from B3. The accumulator should now be placed in position and the leads clipped on.

TRANSISTOR MOUNTING

The transistor fits between the accumulator and transformer, and since the case of the OC35 is at collector potential, some form of insulation is desirable to prevent short circuits. Since some degree of packing is necessary to keep the components firmly wedged in position, it was decided to **"box"** the transistor as shown in Fig. 1.9. Although this arrangement is the exact antithesis of a heat sink and is generally very bad practice, no perceptible temperature rise was noted in the OC35 after 20 rapid successive cycles and so heat dissipation was not considered to be a problem.

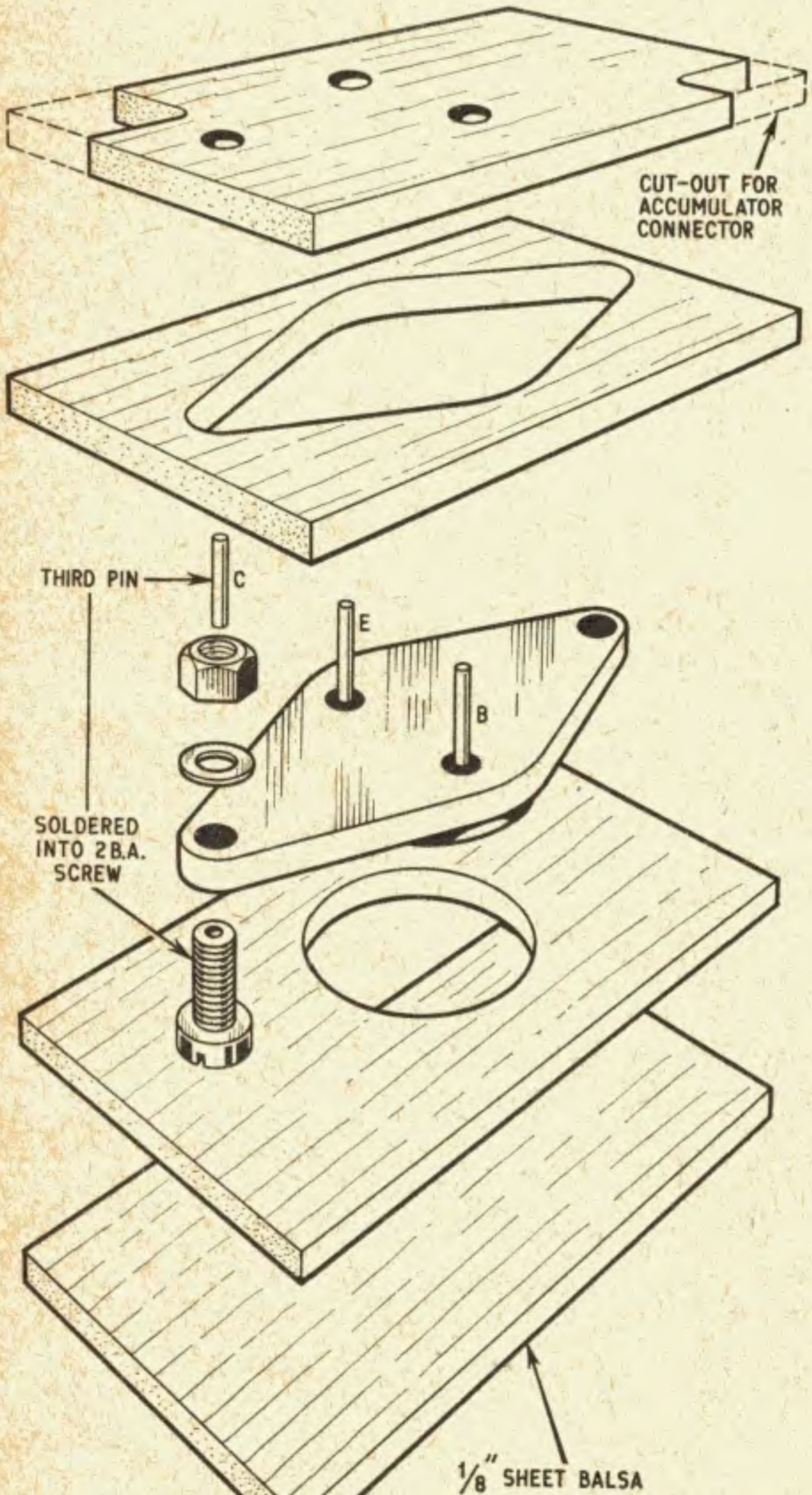


Fig. 1.10. Exploded view of the transistor mounting chamber. The collector pin should be soldered into the 2B.A. screw before assembling

A short 2B.A. screw is fitted in one of the case holes in the OC35 and a short length of tinned copper wire soldered into a hole drilled in its end to form a third "pin" for the collector (see Fig. 1.10). The four pieces of ⅛in balsa wood are cut to shape as shown in Fig. 1.10 and glued on either side of the OC35 with balsa cement. Notches are cut out of the top piece to accommodate the accumulator clips.

The white lead from D6 is taken to the collector pin of TR1, the green lead from H6 to the base and the yellow lead from C6 to the emitter pin, covering each pin with p.v.c. sleeving. The accumulator can be lifted out of the box, the transistor located between the clips, and the two components pushed back alongside T1, locking all three items firmly into the box.

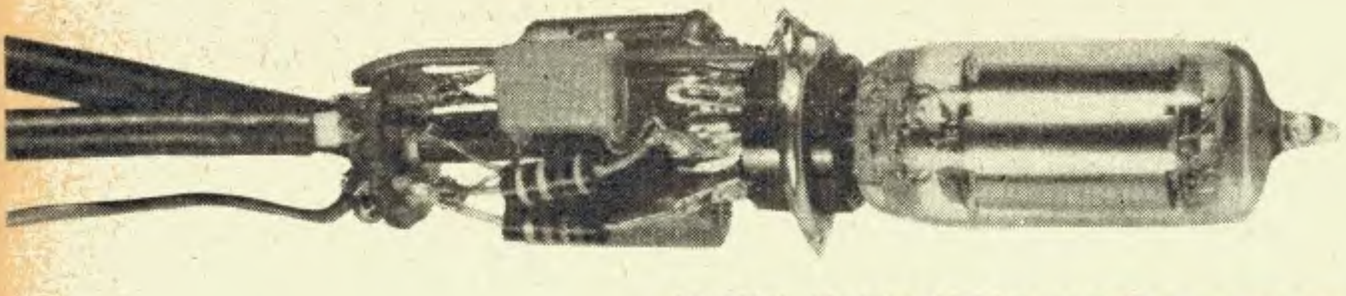
The charging circuit bridge diodes D1–4 are taped together and the appropriate connections made, the positive side of the bridge being soldered to the yellow lead from the top pin of S1 and the negative side to the black lead from B5. The brown lead from SK1 is taken to one input point on the bridge and the other (grey) to the reactive dropper C1. The other side of C1 is soldered to the grey lead from SK1. The bridge assembly is fitted into the box so that it lies at the bottom of the box alongside the panel and beneath SK1. The reactive dropper is placed between the switch panel and transformer, above SK1 and the leads tucked inside, completing the wiring.

Difficulty may be experienced in obtaining a capacitor of sufficiently high voltage rating and yet small enough to fit into the box as indicated. A Radiospares 500 volts tubular paper capacitor has a ⅛in plastic shell which may be filed to enable it to fit snugly over SK1. Failing this or similar operations, C1, and if necessary, diodes D1–4, may be incorporated into the mains lead remote from the box. Do not use a capacitor for C1 whose voltage capability is suspect, since in the event of this component going open-circuit, 250 volts a.c. appears on the bridge resulting in its destruction and endangering the accumulator.

BATTERY OPERATION

The oscillator has been successfully operated from penlight batteries, though with some reduction of maximum voltage and increase in recycling time. The cells used were Ever Ready U12/D14 1½ volt cells. In fact eight of these cells could be accommodated in the volume occupied by the accumulator, two 6 volt banks in parallel. The use of the new type U7 cells in such a configuration should provide a power source very similar to the accumulator. No figures are available for the number of useful cycles from such a bank, but the use of this system reduces the initial cost of the gun by about £2 10s 0d.

Next month: The Flash Head
Full constructional details



VALVEHOLDER MODULES

by N. J. Cornford

THE TECHNIQUE of using prewired modules based on valveholders is by no means new, but it is one which is still extremely useful in a number of applications in both experimental circuits and complete equipment. Using these modules, it is possible not only to reduce equipment in physical size, but also to increase component accessibility for servicing and replacement. If required a complete modular stage can be quickly and easily located and replaced.

LAYOUT

When working out the component layout for a module from a given circuit, it is perhaps best to consider the module as a kind of circular tag-board, with the components arranged radially from a central valveholder. An example of this method as applied to a simple audio stage is shown in Figs. 1, 2 and 3.

Access to components is made much easier as it is usually possible to remove a module sufficiently far to work on it without disconnecting any circuit leads; even complete withdrawal is easy. If the module has been carefully designed, it should not be necessary to unsolder any wires from the valveholder itself as all interstage wiring can be connected to the disc end of the components.

BASIC PARTS

The module consists of three basic parts, namely the valveholder, the extension pillar, and the disc to which the end of the component remote from the valveholder is secured (see Fig. 4). The author has found the moulded phenolic and ceramic types of miniature valveholder to be most satisfactory for this application, as they have the metal-centre spigot, to which the extension pillar may be secured, and also the metal surround, to which earth or chassis connections may be made without recourse to soldering tags. If a paxolin or similar valveholder is used, these tags will of course be necessary.

The best material to use for the pillar is ebonite rod. For a typical module on a B7G or B9A valveholder, this needs to be about 2 inches long and not less than $\frac{3}{8}$ inch diameter. This latter dimension is governed primarily by the diameter of the spigot on the valveholder, as a hole must be drilled in the end of the extension pillar to accommodate the spigot with a tight press fit. For a B9A holder, this hole must be $\frac{3}{16}$ inch diameter; for a B7G or B8A unit, $\frac{1}{8}$ inch diameter.

The disc to take the end of the components is best fixed to the pillar with a 6 B.A. bolt, as this will screw straight into a $\frac{1}{8}$in hole in the top of the pillar. The disc itself is made from thin ($\frac{1}{16}$in thick) plastic or paxolin sheet, and is one inch in diameter. The centre hole (for fixing the disc to the pillar) is a little

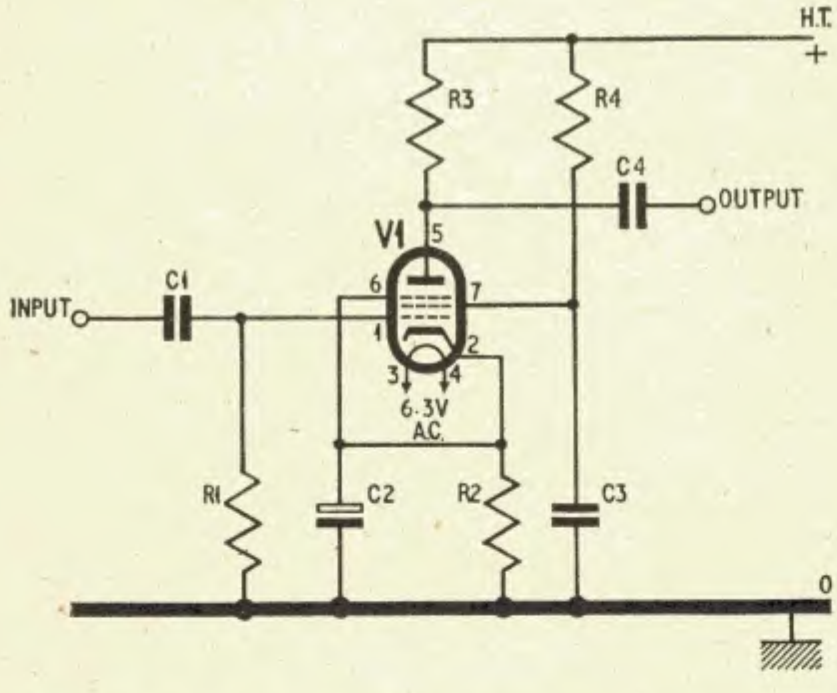


Fig. 1. A typical circuit diagram of a single stage amplifier which may be wired in the method described. The valve connections in this case are for an EF91, but any similar circuit can be adopted

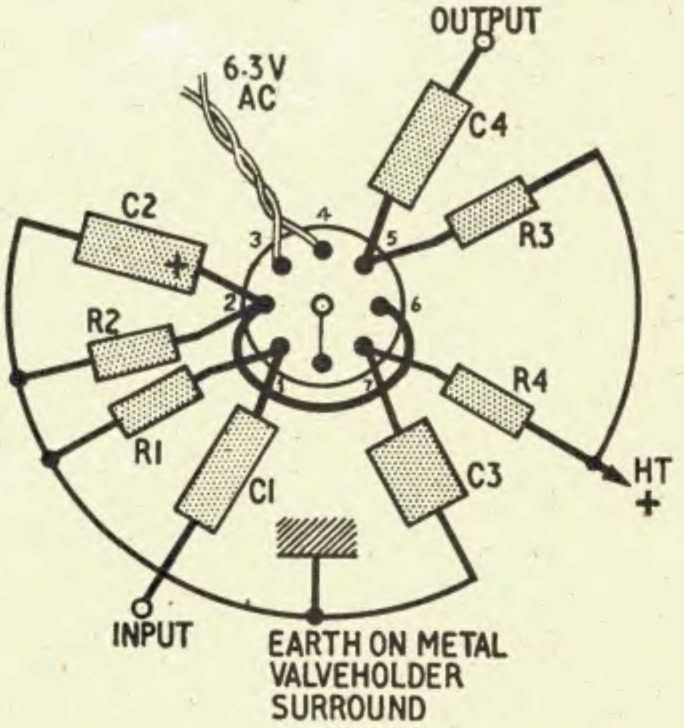


Fig. 2. "Radialised" design layout

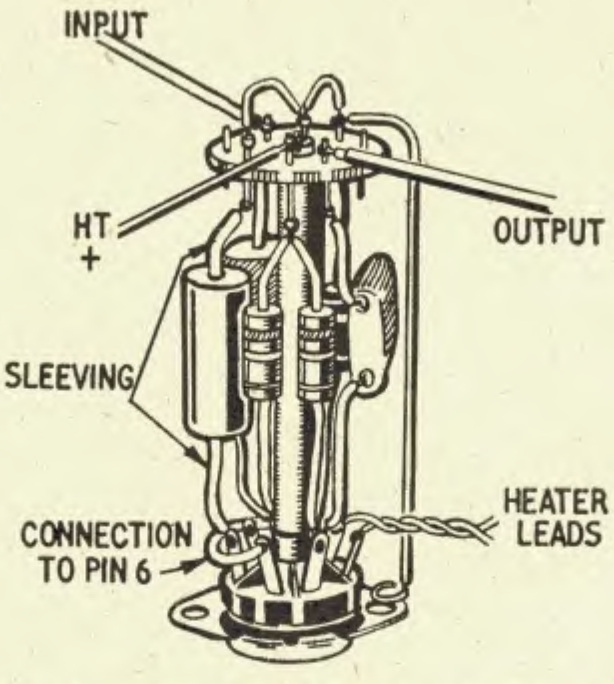


Fig. 3. Side view of the module showing how the components are mounted

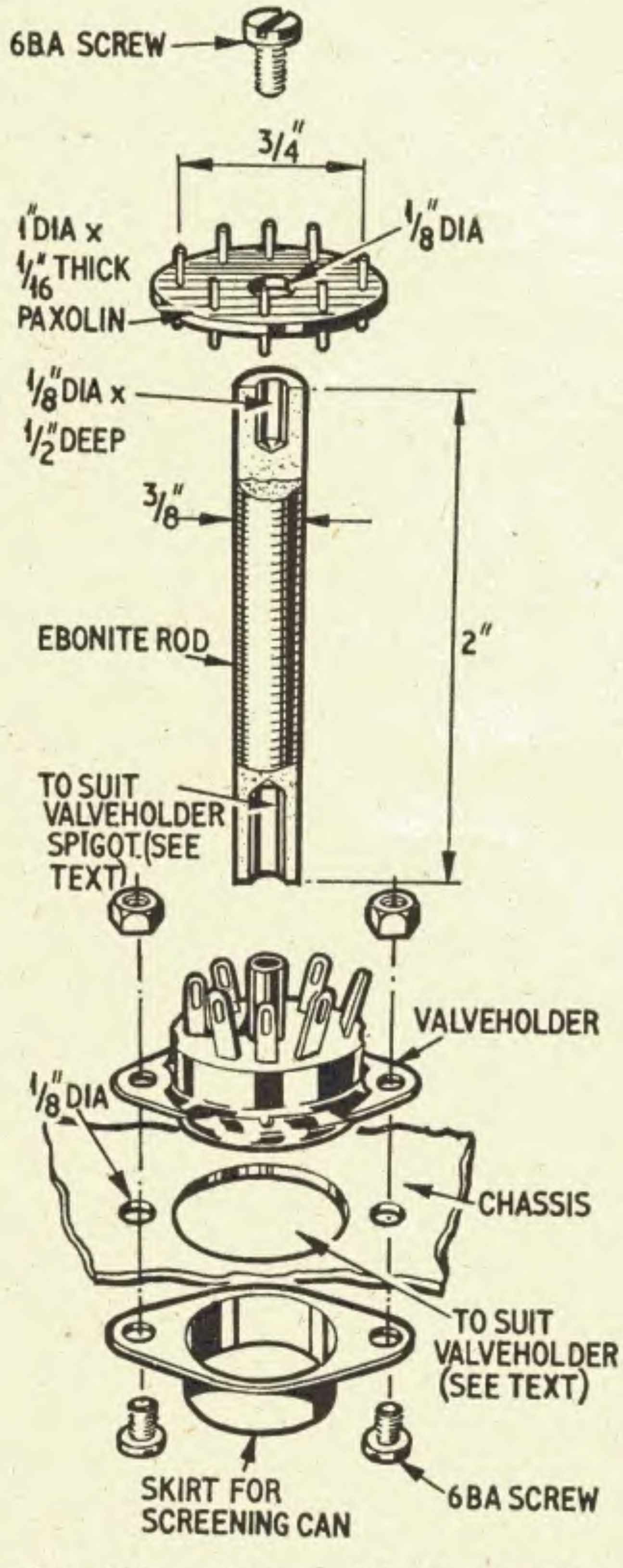


Fig. 4. Exploded view of the module showing the construction, dimensions and chassis drilling details

over ⅛in diameter, the holes for attaching the components are 1/16in diameter, and are equally spaced around a circle. Accurate spacing is not critical, but it is recommended that one hole is made for each tag of the valveholder. For example the B7G valveholder has eight tags including the earthing and location tag; B9A has ten tags.

WIRING

Wiring up should present no problems, except that components must have long and, if possible "bendable" wires. One end of the component is soldered to the valveholder in the normal way, and the other end is soldered to the appropriate pin in the disc (see Fig. 5), and soldered to any other relevant wires such as those to other parts of the circuit. Flexible wires to rather bulky components such as transformers or large electrolytic capacitors may be soldered on to the module component wires with the greatest of ease. It is stressed that all possible wiring must be done before the modules are mounted on the chassis.

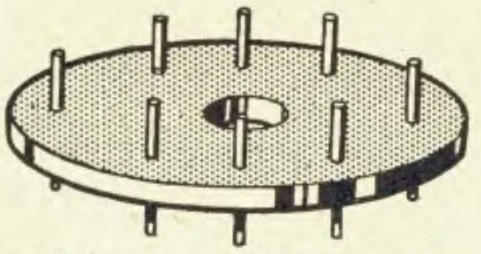


Fig. 5. Positions of the soldering pins on the disc

Fig. 6. Earthing tag on the valveholder is connected to the metal surround by soldering. Alternatively the earthing wire can be clamped under the fixing nut as shown in Fig. 3

Heater wiring does present a slight problem, but the author has found that the method of wiring up the heater connections of each module to a central tag block is quite satisfactory if tightly twisted twin flex is used throughout. Any further hum troubles can be reduced by using a transformer with the heater winding centre-tapped, or by using a 50 ohm potentiometer across the winding with the wiper connected to earth. Another way of reducing hum is by screening the module with copper or aluminium foil, the module first being wrapped with insulating paper or plastic. This method of screening has also been found very effective in curing feedback between modules. If the module shows any tendency to overheat, slits may be cut in the foil and paper to provide ventilation. All component leads should be sleeved in any case.

The completed modules are best mounted on the underside of the chassis. The size of hole in this is the same as that used when mounting the valveholder in an orthodox fashion; that is, ⅝in diameter for B7G and ¾in diameter for B9A. ★

Audio TRENDS...

A Commentary on Sound Reproducing Equipment by Clement Brown

SINCE the last *Audio Trends* article appeared we have passed the yearly peak of activity in this field—at least where official unveilings are concerned. Interesting new products, probably unprecedented in variety and technical merit, have been reaching the market from British and foreign manufacturers.

This article notes a selection of these developments, including some which were seen for the first time at this year's Audio Festival and Fair held in London in April. The emphasis is on items which will attract the amateur who, though formulating ambitious plans, seeks to cut costs while minimising sacrifices in quality.

Possibly the most important development of recent times is the increased variety of ceramic pick-up cartridges. It is unwise to pretend that this type of cartridge is as good as the more refined magnetics (which may cost three times as much); but for a few pounds each they represent remarkable value, and recent examples exhibit good consistency in performance.

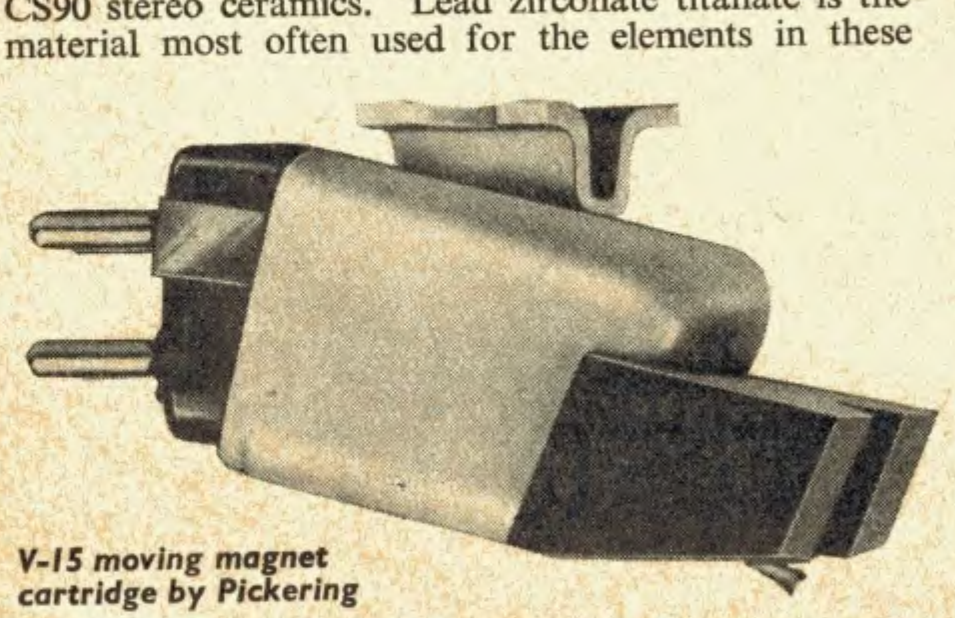
BUDGET STEREO

The point is surely that ceramic pick-ups open the door to disc stereo for those who are working on a tight budget. Consider, for example, the Sonotone 9TAHC, a new version of a ceramic marketed by Metro-Sound. It offers features which a few years ago would have seemed highly improbable at under £10: it has compliance and stylus mass figures which make possible a playing weight of 2 to 3 grams—yet it sells at £3 9s. 8d., including a diamond stylus.

Other low-cost ceramics include the Elac BST406. Incidentally, ceramic cartridges perform best with an amplifier input impedance of about 2 megohms. If the impedance is much lower, a crystal cartridge may be the wiser choice. There are fewer of those today, but Elac offer a crystal version of their cartridge—the KST106.

Then there are the Connoisseur, Deram and Goldring CS90 stereo ceramics. Lead zirconate titanate is the material most often used for the elements in these modern cartridges. It was announced recently that the CS90 is to appear in two versions—the standard model (£4 17s. 8d.) and a high-compliance version at just under £6. The latter has an elliptical stylus.

An elliptical tip, well shaped and carefully installed, can do much to reduce "end-of-groove" distortion. The idea is that the tip, fitting more snugly into the groove's smallest modulations, will cope more adequately with the extremely short wavelengths it encounters. Already common on advanced pick-ups, this type of stylus has been added to one of the less expensive moving-magnet cartridges, the Pickering V-15.



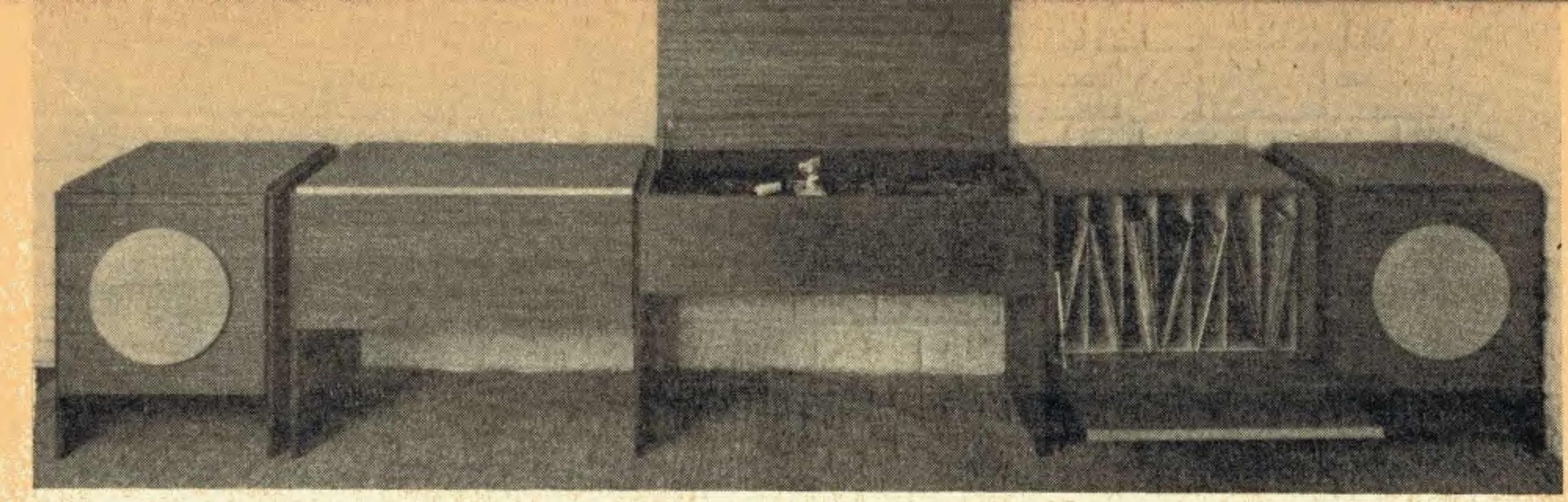
V-15 moving magnet cartridge by Pickering

NEW TURNTABLES

A reasonably priced turntable is of as much interest as a ceramic cartridge if low-cost stereo is the aim. Fortunately there have been further additions at this end of the range. Goldring's G66 is priced according to the pick-up fitted: it costs just over £12 if the CS80 cartridge is ordered.

Garrard's SP25 is basically the same as the Deccadec, already well known to enthusiasts. The latter, by the way, is now available in a version, costing 14 gns, on which the Decca "ffss" head can be used. Thus we have the unusual combination of a magnetic pick-up of advanced type with a player for the budget-conscious.

Braun PS400 transcription unit



Group 4 hi fi system for stereo discs and tapes

Turntables of the more costly transcription type now include the Braun PS400, exemplifying the best of continental practice. The robust turntable assembly, employing both idler wheel and belt drive, is associated with a tubular steel pick-up arm incorporating a lowering and cueing device. The PS400 is built into a plinth, fitted with a Plexiglass lid.

Braun turntables employ synchronous motors. Since they lock to the mains frequency, no fine adjustment of speed is necessary. Perpetuum-Ebner, with their PE34 player, are closer to U.K. practice, using an induction motor and a +1 to −2 per cent adjustment of turntable revolutions.

Another West German manufacturer is Dual. Their model 1011 provides a popular arrangement: single discs are played with either manual or automatic pick-up positioning, but insertion of a special centre spindle gives fully automatic record changing.

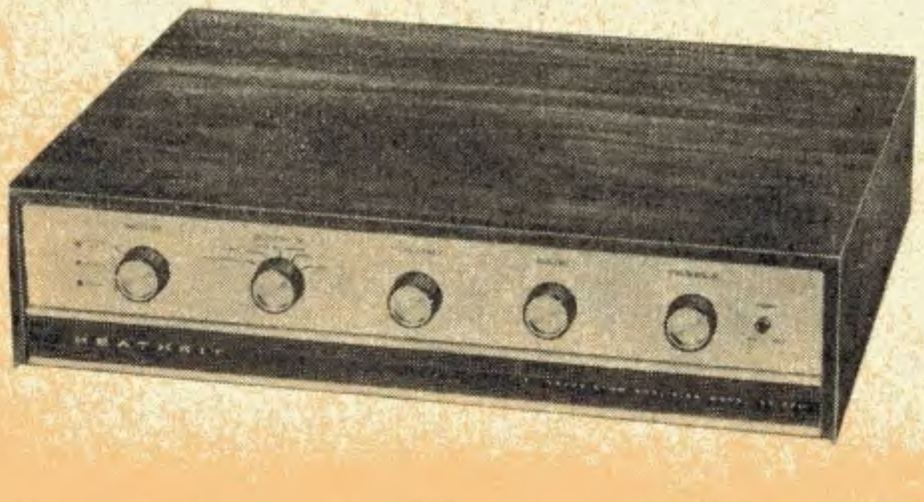
CABINET DESIGNS

Leading manufacturers of speaker drive units, such as Goodmans and Wharfedale, have long provided a service to constructors. Enclosure designs and crossover filter circuits are usually supplied. Enthusiasts should note that the 1965 issue of Wharfedale's cabinet construction sheet is available.

Tannoy's range is extended to the new Lancaster speaker; their brochure includes enclosure dimensions and instructions, and Celestion supply a design to suit the coaxial drive units which they introduced last year. These two are among the bigger reproducers and would not be the first choice for a very small room.

For the average music-lover, audio should look as good as it sounds. This requirement is taken more seriously nowadays: a look at the cabinets of Design Furniture, GKD, and Record Housing will show how things are shaping. A collaborative venture called Group 4 aims to show the uninitiated how hi-fi can look at home in the living room. The group in this instance consists of Armstrong, Goldring, KEF and Record Housing, and between them they have devised a most attractive outfit.

Heathkit AA-22U stereo amplifier



For the handyman without unlimited time to spare, the stylish audio furniture designs supplied free by Vipboard are worth having. Units can be made for turntable, amplifier and tuner, tape equipment and record storage. Write to GWE Boards Ltd., 6 John Street, London, W.C.1, or consult your local stockist for these.

STEREO AMPLIFIER

Transistors remain firmly in the news. Of special interest to those handy with a soldering iron is the AA-22U stereo amplifier just introduced by Heathkit. It has a fairly high output rating: the figures are 20 watts r.m.s. per channel for 8 ohm loads and 13·5 watts r.m.s. for 16 ohms using transformerless output with American transistors. The specification is impressive. In kit form this model sells at £43 18s., but an assembled version is available at a higher price.

FINAL LINK

Now to the other end of the audio chain. New loudspeakers and enclosures have continued to arrive in variety, and a high proportion of small "bookshelf" models is still a notable feature. Among the medium-sized systems, the Rectavox Omni is one of the most interesting.

Some readers will have observed the Omni's unusual shape, which is an aid to non-directional distribution of sound. Many people prefer this for stereo as well as for mono.

The standard Omni contains two KEF drive units, but a similar enclosure is being marketed in kit form to take a single 8in unit. The amateur can cut the cost in the first instance, although he can substitute the KEF units later if desired.

Many years have passed since the Ionophone was first demonstrated. This remarkable device, a high-frequency reproducer with no moving parts, now returns on a commercial scale: it is marketed, under the tradename Ionofane, by Fane Acoustics of Batley, Yorks.

Briefly, the principle is as follows. An oscillator signal, modulated by the audio signal, creates a radio-frequency discharge in a quartz tube. Pressure waves in the tube are made audible by the addition of horn loading. The lower cut-off is 1,500 c/s; the upper limit is far above the audio range.

In a practical system the device is connected, via a crossover filter, to conventional mid-range and bass units. Fane Acoustics can supply such units to constructors. The Ionofane itself sells at 28 guineas, including a mains power pack.

Beyer model M110 microphone

TAPE EQUIPMENT

Manufacturers are turning to transistors for tape equipment at all price levels. The latest in the line of EMI battery-powered machines is the L4, which uses a rechargeable 14 volt accumulator pack. A look at the specification will show the amateur what professional people—reporters, commentators, industrial users—expect from modern lightweight recorders.

At a much lower price level is the Optacord 416, newest of Loewe-Opta's ingenious portables. In the medium price range—and occupying that position with distinction—are the Truvox machines, including tape units for hi-fi systems as well as complete recorders.

In designing the new Series 100 mains-powered units, Truvox have gone over to transistors, benefiting from such advantages as freedom from ventilation problems. Again, modern tape recorder circuits are quite complex, and the use of transistors enables elaborate designs to take a compact form. Modular construction is used, and the separate record and playback heads are associated with independent amplifiers built on printed wiring boards.

Tape specialists have found several ways of providing long playing times while minimising such tasks as rethreading of tape. Enclosed cassettes are attractive to those who do not wish to handle or edit their tapes. To the active enthusiast and hobbyist, however, an inaccessible tape is more of a nuisance.

But now there appears to be a new trend: more firms are placing the emphasis on long, continuous operation of recorders. In the Ampex 2073 the automatic mechanism threads the tape and reverses the direction of tape travel. This gives upwards of six hours of stereo without a spool change.

The same basic advantage of long playing time is found in a new tape deck which will interest constructors. It is the Planet Projects CD2, available with speeds of either 3¾ inches per second or 1⅞ inches per second. Maximum convenience is achieved with ordinary spools. Direction reversal and track switching are initiated by a relay which is operated by metal foil at the ends of the tape. The deck has only nine moving parts.

HEADPHONES FOR STEREO

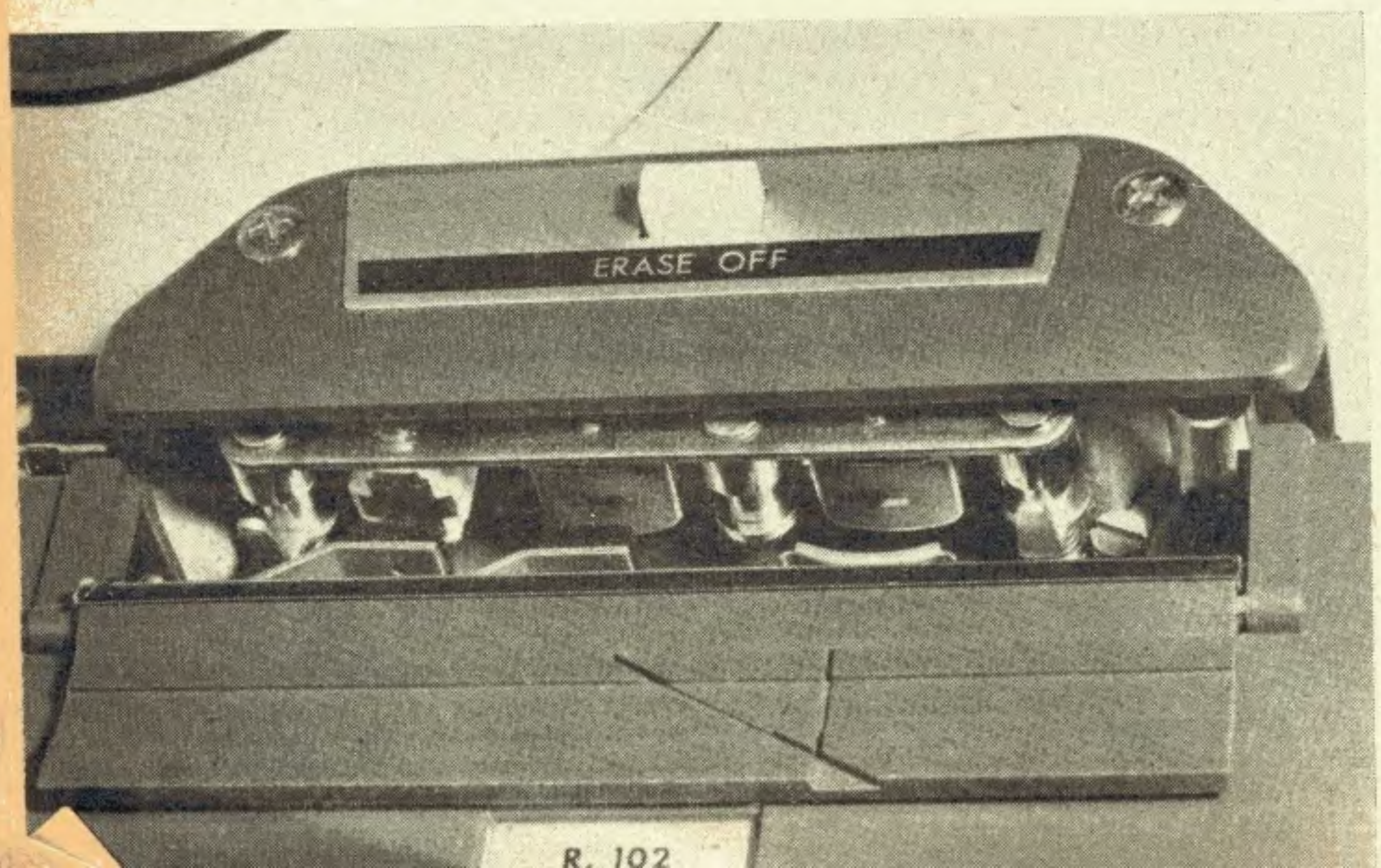
Interest has been quickening in the use of headphones for "personal listening" to stereo. Only good quality headsets are acceptable to serious enthusiasts who usually find other jobs, such as tape monitoring, to perform with them. Moving-coil models are especially suitable.

A.K.G., Koss and S. G. Brown are well known for their headsets, and their latest models feature lighter weights and more comfortable earpad fittings. S. G. Brown have extended their range to include the "Dynamic" and "Canada" moving-coil headsets; the "Diplomat" model is available with either magnetic or ceramic inserts.

MICROPHONES

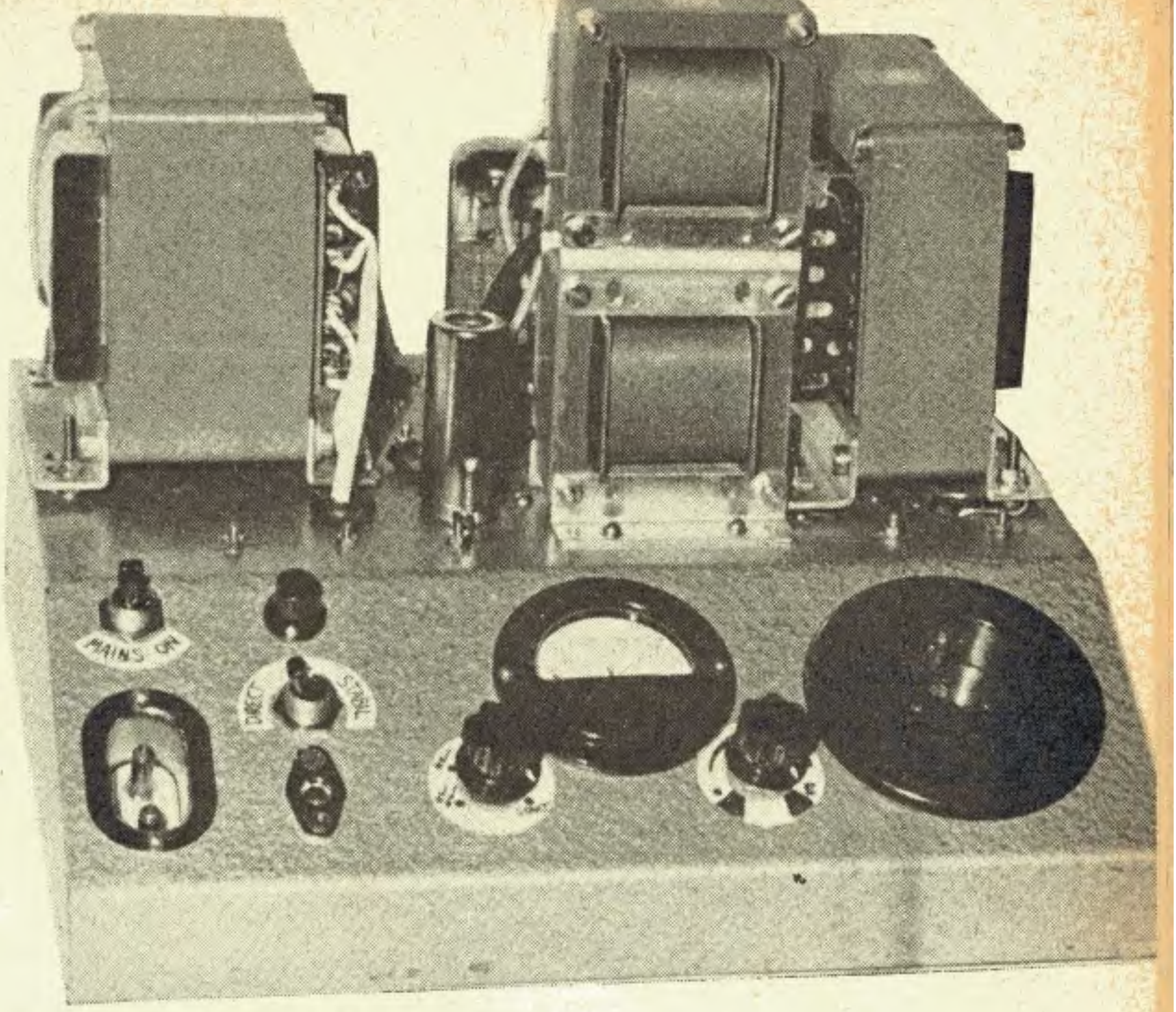
The tape enthusiast often starts with a very modest microphone, later finding it advisable to graduate to a better one in the interests of sound quality and sensitivity. New dynamic (moving-coil) models have been introduced by Fi-Cord and Beyer at prices from about £7.

Fi-Cord's models are the 801 and 901. The latter is a directional microphone, the type often needed by the amateur who goes in for recording music and special effects. This firm also markets the Beyer products, which include the M55 non-directional microphone. Frequency response is quoted as 70–16,000 c/s, and at £6 17s. including a stand this model should interest home recordists. The Beyer M110, with directional characteristics, is for more ambitious users. It can be worn on a neck halter, leaving the hands free for operation of a portable recorder. These are just a few examples from a number of recent introductions.



◀ ***Headblock of the Truvox 100 tape deck***

By M. L. Michaelis, M.A.



A.C. MAINS VOLTAGE STABILISER

Continued from page 563 last month

The principle of the finally adopted circuit is shown in Fig. 6 (see last month). A saturable reactor replaces the series regulator valve of the d.c. counterpart (Fig. 4), its grid controlled drive rectifier merely constituting a power output stage for the error amplifier since a saturable reactor consumes considerable control power; it is, of course, a current-operated device and not a voltage operated device such as a series regulator valve.

The only other difference compared with the d.c. circuit of Fig. 4 is to be seen in the output rectifier for the sample voltage fed to the comparator.

The complete circuit diagram is given in Fig. 7.

SATURABLE REACTORS

A saturable reactor is physically similar to a transformer, in that it consists of a conventional laminated core carrying a bobbin with one or more windings of enamelled copper wire. Normal transformers may indeed be rewound as saturable reactors, since the only difference is in the number of turns in relation to the core size. A saturable reactor has more turns for any given current than in the case of a transformer, so that the core can be driven into the region approaching magnetic saturation with accompanying drop in inductance, and thus drop in impedance, with rising current. The practical consequence of these remarks is that it is very easy for the reader to wind his own saturable reactors as required for this design.

The saturable reactor has a primary winding of many turns, through which the d.c. control current is passed. The effective permeability of the core decreases (increasing magnetic saturation) as the d.c. control current is increased, so that the inductance of the secondary is reduced. The secondary consists of fewer turns of thick wire and carries the main load a.c. current from the mains input to the stabilised a.c. output. The d.c. control current in the primary is thus able to vary the series impedance presented to the main load current, in order to compensate any voltage changes as required.

SIDE-EFFECTS

An important side-effect of the simple function of a saturable reactor as just described is its unwanted backward transformer action reacting back upon the d.c. control primary.

The main load a.c. current flowing in the secondary induces large a.c. voltages in the control primary, since the number of turns of the primary is much greater. Such induced a.c. voltages can damage or hinder the d.c. control circuit, if they are not compensated. Compensation calls for the use of two identical saturable reactors, with respective primaries connected in series in opposing sense, so that the induced a.c. voltages mutually cancel as far as the external connections are concerned.

Nevertheless, the high induced voltages still remain across the control primaries of the individual reactors, and due consideration must be given to the question of insulation in the design of satisfactory components. The worst possible conditions must be considered, namely a sudden short circuit of the output, when the full mains voltage is briefly applied to the secondary until the fuse blows.

Since, in the prototype unit, the required turns ratio was 11, eleven times the peak mains voltage, i.e. about 3·5 kilovolts, appears across the entire d.c. control primary. This is excessive even for a pair of reactors, so that two pairs had to be used. The d.c. control primary of each individual reactor can then carry transients of up to 1kV, and the insulation had to be designed accordingly. This is easily manageable with ordinary materials, using bakelite, paxolin or plastic bobbins with substantial full cheeks and avoiding the cheekless paper or cardboard bobbins. Furthermore, the windings must be carried out in neat layers interleaved with substantial waxed paper and when finished should preferably be impregnated in an approved manner.

THE CONTROL CIRCUIT

Diode D1 rectifies the output voltage at PL2 and charges C4 up to the peak of the output waveform.

The bleeder R10, VR1, R11 establishes the correct fractional sample of this peak rectified output voltage for comparison with the fixed d.c. reference voltage provided by neon V4. The comparator for the two voltages is the grid/cathode section of the error amplifier V3. The anode load of V3 is at the same time the grid leak of the valves V1 and V2 operated as grid-controlled rectifiers, so that changes of anode current in V3 control the rectifiers directly and thus influence the d.c. current through the primaries of the saturable reactor L1.

If the output voltage at PL2 should fall, the grid voltage of V3 drops in relation to the cathode which is held fixed by V4. Consequently anode current in V3 drops and the voltage developed across the anode load R6, R7 and applied as negative grid bias to V1, V2 falls, so that V1, V2 can pass more anode current through the primaries of the saturable reactor L1. The impedance of the secondaries of L1 consequently drops, so that the output voltage at PL2 rises to compensate the drop which initiated the sequence of adjustments.

If the output voltage tries to rise, a similar sequence of adjustments takes place (with opposite polarity), to restore the correct output voltage.

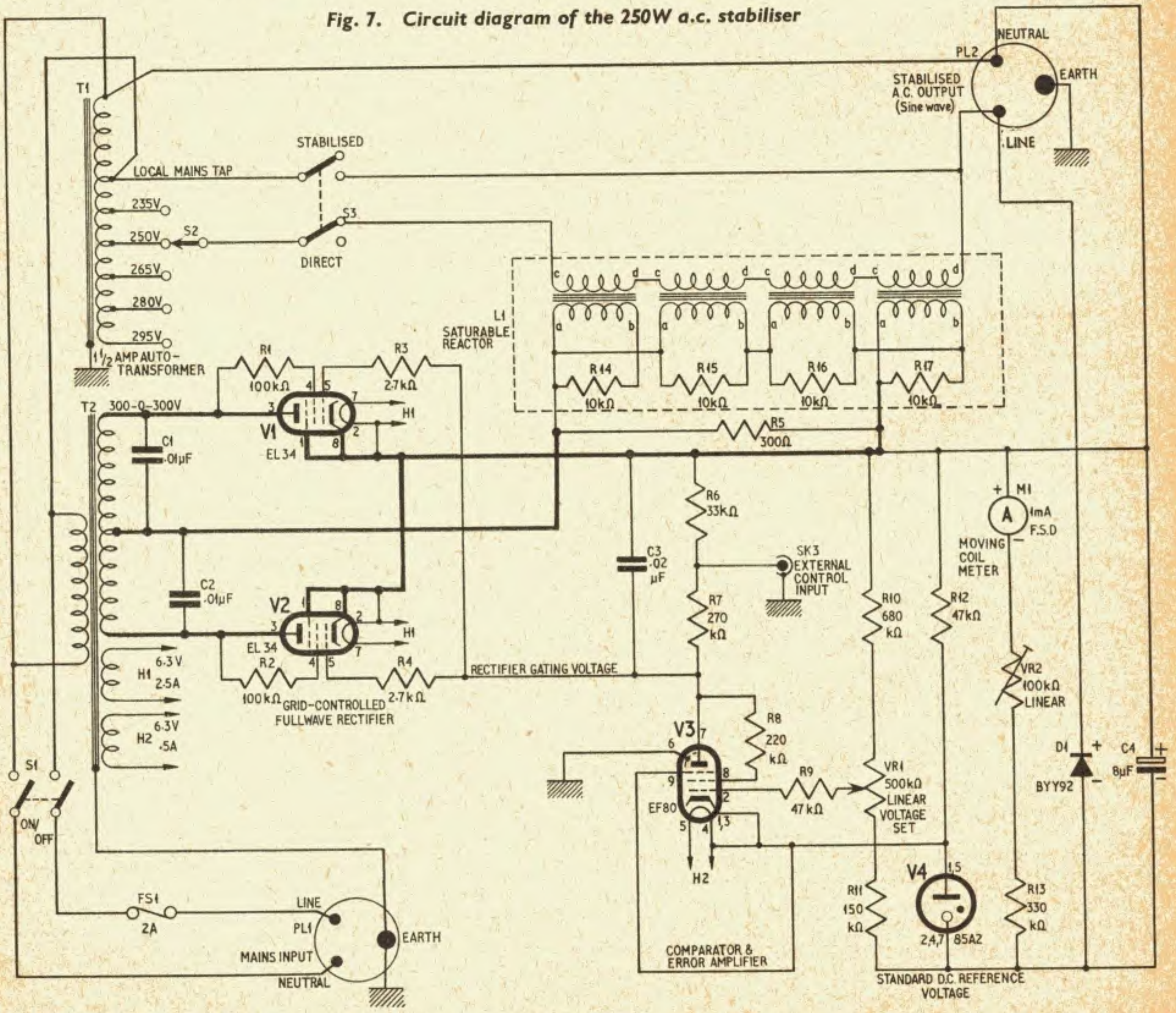
The absolute value of the output voltage which is held stabilised is determined by the setting of VR1 slider, such that the d.c. voltage there developed is very slightly less than the constant reference voltage developed by V4. VR1 is an ordinary low power carbon track potentiometer, nevertheless allowing full manual control of the output voltage of the unit at full power rating.

The stabilising action is effective at any voltage setting selected with VR1, so that the unit is in fact a stabilised variable voltage transformer with a control range from about 150V to 250V r.m.s. output and 250 watts power rating in the prototype.

GRID-CONTROLLED RECTIFIER

If one mentally imagines V1 and V2 as being ordinary rectifier diodes without grids, they are seen to constitute a conventional full wave rectifier circuit with the centre-tapped h.t. winding on T2. This is indeed their function, whereby the saturable reactor aggregate L1 in parallel with its overall damping resistor R5 constitutes the normal d.c. load for such a rectifier circuit connected between the commoned rectifier cathodes (h.t.+) and the centre-tap on the transformer (h.t.−). This circuit is traced in bold lines in Fig. 7.

Fig. 7. Circuit diagram of the 250W a.c. stabiliser



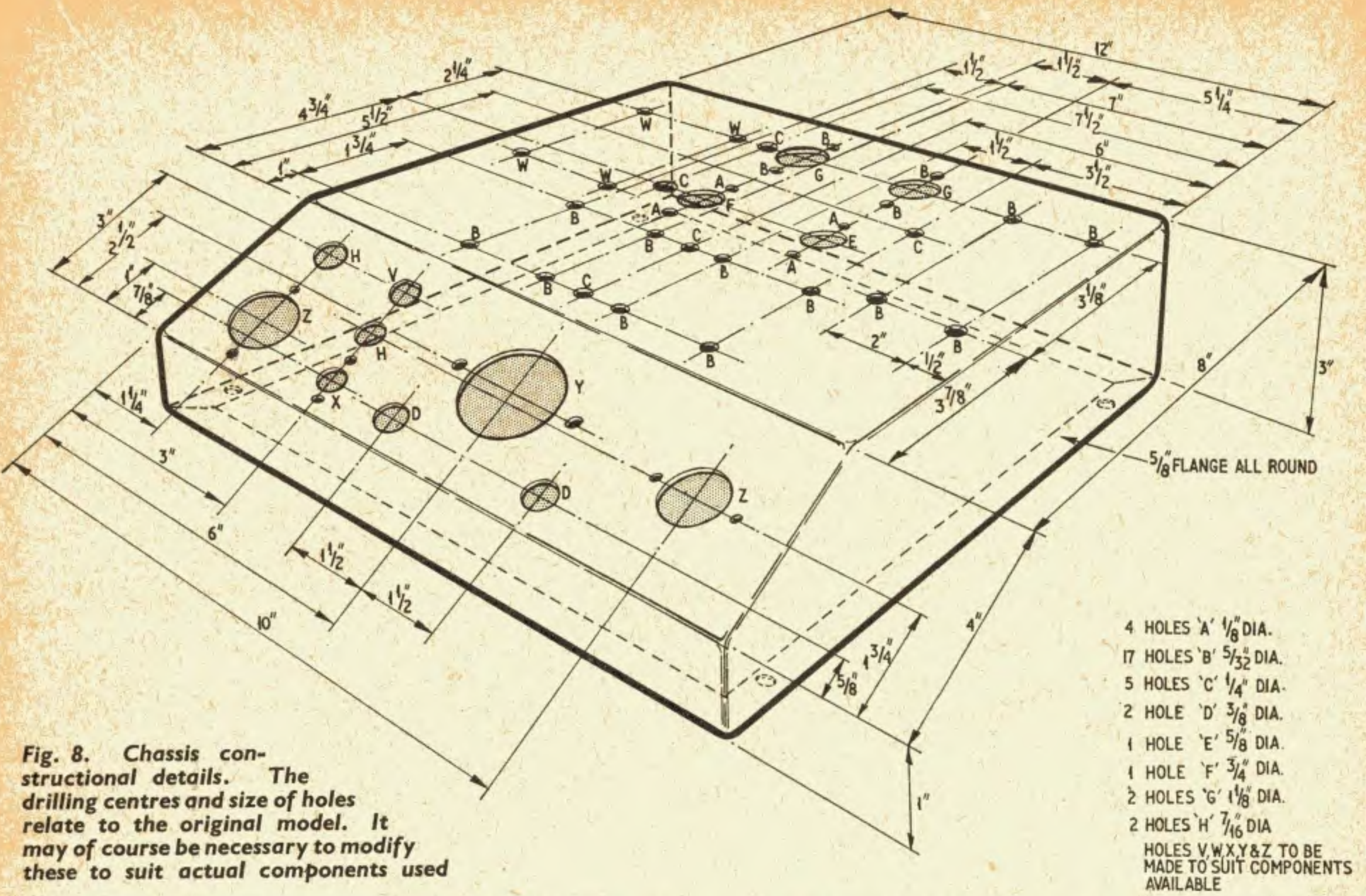


Fig. 8. Chassis constructional details. The drilling centres and size of holes relate to the original model. It may of course be necessary to modify these to suit actual components used

The fact that V1 and V2 are power pentodes instead of simple diodes permits control of the rectified current via the grids. If VR1 slider is moved to the bottom of the track, V3 is cut off and the rectifiers V1, V2 are without grid bias. This adjustment is required when V3 is to be cut off to allow injection of an external control voltage via PL3. The rectifiers V1, V2 must consequently be provided with a limiting device to keep the maximum current in the absence of grid bias to a safe value.

This requirement is met in a simple manner by the large value screen resistors R1, R2 which also act as screen stoppers to prevent parasitic oscillation.

R3, R4 act as grid stoppers to prevent parasitic oscillation in the grid circuit. C1 and C2 prevent modulation hum in r.f. equipment which may be operated off the stabiliser.

C3 constitutes a time constant of about 10 milliseconds in conjunction with R6, R7 to determine the response time of the regulator section consisting of V1, V2 and L1. This is definitely faster than the response time of the comparator dictated largely by the need for D1 to await the next negative peak of the output waveform to correct rises of output voltage, or for C4 to discharge through the effective loading (meter circuit and resistors around V3, V4) to correct falls of output voltage.

STABILITY

This choice of time constants meets the requirements regarding stability discussed earlier in this article. If occasional instability should arise at some loadings when the mains input voltage is suddenly increased, the effect of reducing C3 to 0·01μF should be tried; this will speed-up the response of the regulator in relation to the charging time of C4 via D1.

The value of R5 can also be reduced, but not to such an extent that excessive current from V1, V2 is drawn through the reduced-value resistor R5.

The primary function of resistors R14–R17 is to stabilise the output waveform of the unit by reflecting a principally resistive impedance over to the secondaries. Thus the values are largely dictated by other requirements than stability, though it can be borne in mind that a decrease of loading resistance improves stability. All four resistors (R14–R17) must be of strictly the same value, and all four sections of the saturable reactor must be identical.

The screen resistors R1, R2 must be adjusted when the final values of R5 and R14–R17 have been determined, such that the cores of L1 just saturate when V1, V2 are without grid bias. In the prototype the saturation current was found to be 65mA and the total d.c. resistance of the primaries 400 ohms. Thus 26V appeared across R5 which had to be made equal to 300 ohms to achieve reliable stability and so required an additional 86mA under saturation conditions of L1. The total maximum current required from V1, V2 was thus 150mA, and this was achieved by making R1, R2 equal to 100 kilohms.

If more current is required in a particular case, decrease R1, R2 accordingly, and vice versa. Observe the rating of T2 and of the particular valve types used for V1, V2. Twice the normal rated Class A standing anode current for a single valve may be drawn from the combination; this is 200mA for the EL34 or 807, so that the ratings are ample. If the screen resistors R1, R2 are not chosen correctly so as to prevent over- or under-excitation of L1, instability due to surge effects is possible under some conditions.

These remarks are not intended to imply that the author expects readers to have trouble with instability;

the circuit has been well tested by himself for the component values as published, and the discussion of stability questions is merely to forestall possible troubles if readers should wish to modify component values to make use of available items.

WAVEFORM CONSIDERATIONS

Serious trouble will be incurred if any attempt is made to interpose a smoothing circuit between the cathodes of V1, V2 and L1. Thus the d.c. control current through L1 primaries is pulsating d.c. Even if a large electrolytic capacitor is shunted across R5 to smooth this d.c., the circuit generally hunts under most loading conditions because the response of the regulator is then too slow in relation to the comparator.

Let us consider the factors leading to waveform distortion in L1, in order to understand the manner in which this is corrected through the joint action of the loading resistors R14–R17 of correct value and the *omission* of a capacitor across R5.

If all four loading resistors were omitted, the entire load current through the windings cd would go towards a.c. magnetisation of the cores, contributing towards saturation thereof. The saturation is greatest at the current peaks, roughly coincident with the input and output voltage peaks, since the main circuit impedance is the (assumed resistive) consumer load.

The inductive voltage drop across the windings cd will thus have clipped peaks and, being inductive, will lead by 90 degrees relative to the phase of the main voltage and current. The output voltage at PL2 will thus be approximately a sinewave from which a 90 degree phase-advanced squarewave of smaller amplitude is subtracted. This leads to a waveform with zero voltage transitions and low voltage regions roughly identical to the corresponding sections of a sinewave, but a hesitation at an intermediate voltage and late rise to an unduly brief peak voltage.

IMPROVEMENTS

The first improvement is given by adding the resistors R14–R17 loading each primary winding ab. These resistors cause a reduction of the reactive component of the a.c. current in the windings cd at any given total current, because of the transfer of power to the resistors by transformer action imposing a purely resistive load on the windings cd.

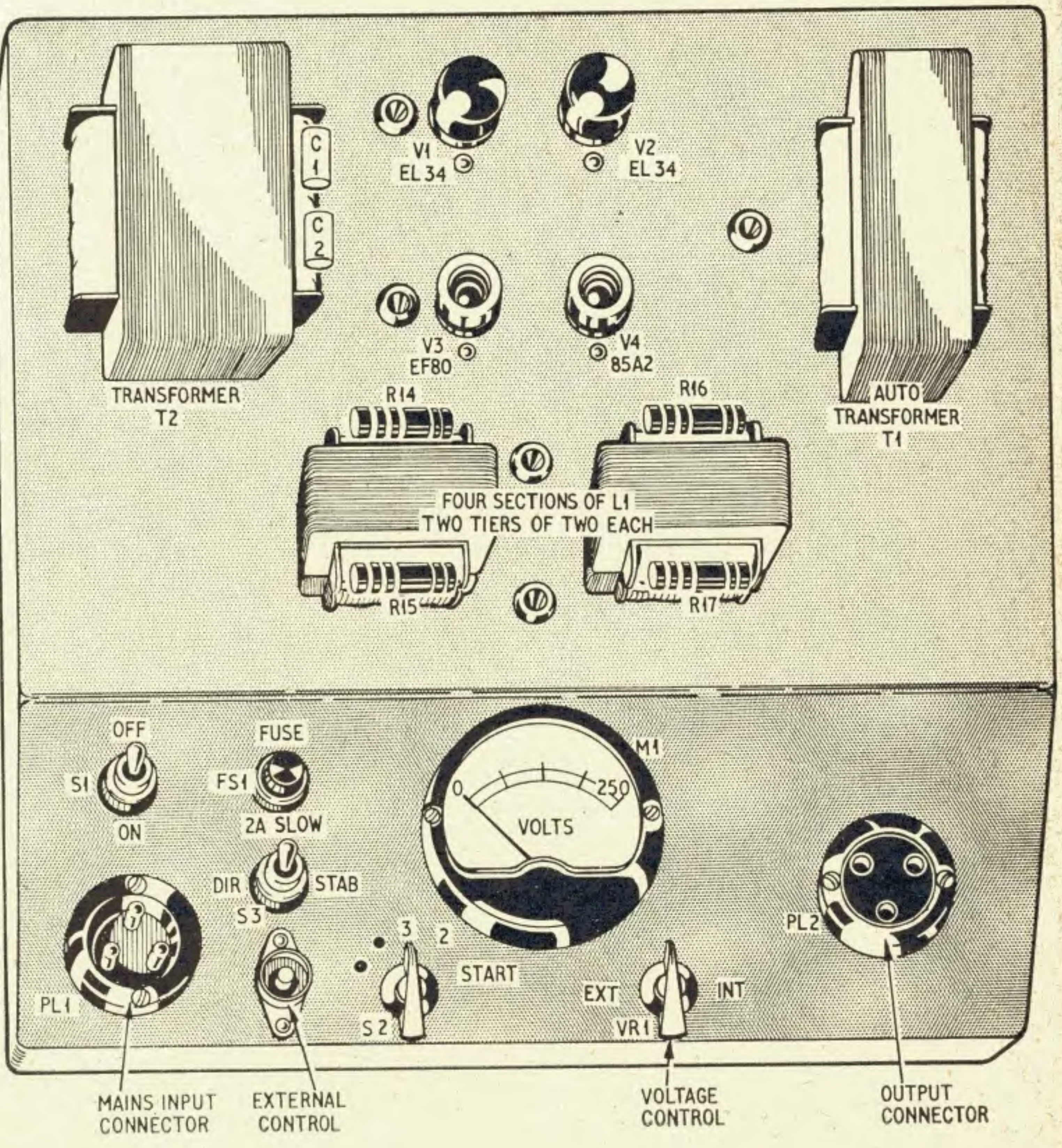


Fig. 9. Top view of chassis, showing layout of major components. In the prototype, the rear section is covered by a perforated metal hood, leaving only the sloping control panel exposed. The bottom of the chassis should be enclosed by a metal plate affixed with self-tapping screws and carrying rubber dome feet in the corners

Provided that the value of the resistors has been chosen correctly (best carried out empirically, observing the output waveform on an oscilloscope connected across various loads at PL2 and for various values of resistance), it is seen that the saturable reactor now behaves very nearly as a pure variable resistor with negligible inductive component.

A variable resistor cannot lead to waveform distortion. Being resistive and no longer reactive, the entire aggregate L1 now dissipates considerable power as heat developed in the loading resistors, which must thus be of high wattage rating. Good single-layer wirewound types, preferably cemented with a good ceramic material, should be employed, to prevent internal flashover on the high transient voltages arising should the output be short-circuited, in the brief interval before the fuse blows.

SAFETY MEASURES

As seen in Fig. 7, the entire circuit as such is left floating, i.e. it is not tied to chassis at any point, though the cathode line of V1, V2 is tied to the mains neutral when the input polarity is correct. The chassis is connected to the earth lead of the three-pin power plug of the mains input and output, and also to the cores of T1 and T2, as well as to the cores of the four sections of L1. The screen of V3 is connected to chassis, as is also the outer connection of the coaxial socket PL3.

This is the only safe arrangement possible. It would not be possible to connect the mains neutral line to chassis, for two reasons. Firstly, the chassis and entire casing would then be live at full mains voltage if the mains input plug were inadvertently connected the wrong way round, or if it were connected to an incorrectly wired power point. Secondly, such an arrangement with the mains plug the correct way round would either demand the omission of a true earth, or commoning of earth and neutral at the unit, both measures being forbidden by most electricity supply companies.

A possible alternative would be to make T1 a fully insulated transformer with separate primary and secondary windings, commoning one end of the secondary to chassis and mains earth. There is no objection to such an arrangement on the part of supply companies, but the author does not consider it safe, for the following reason. If the unit is connected

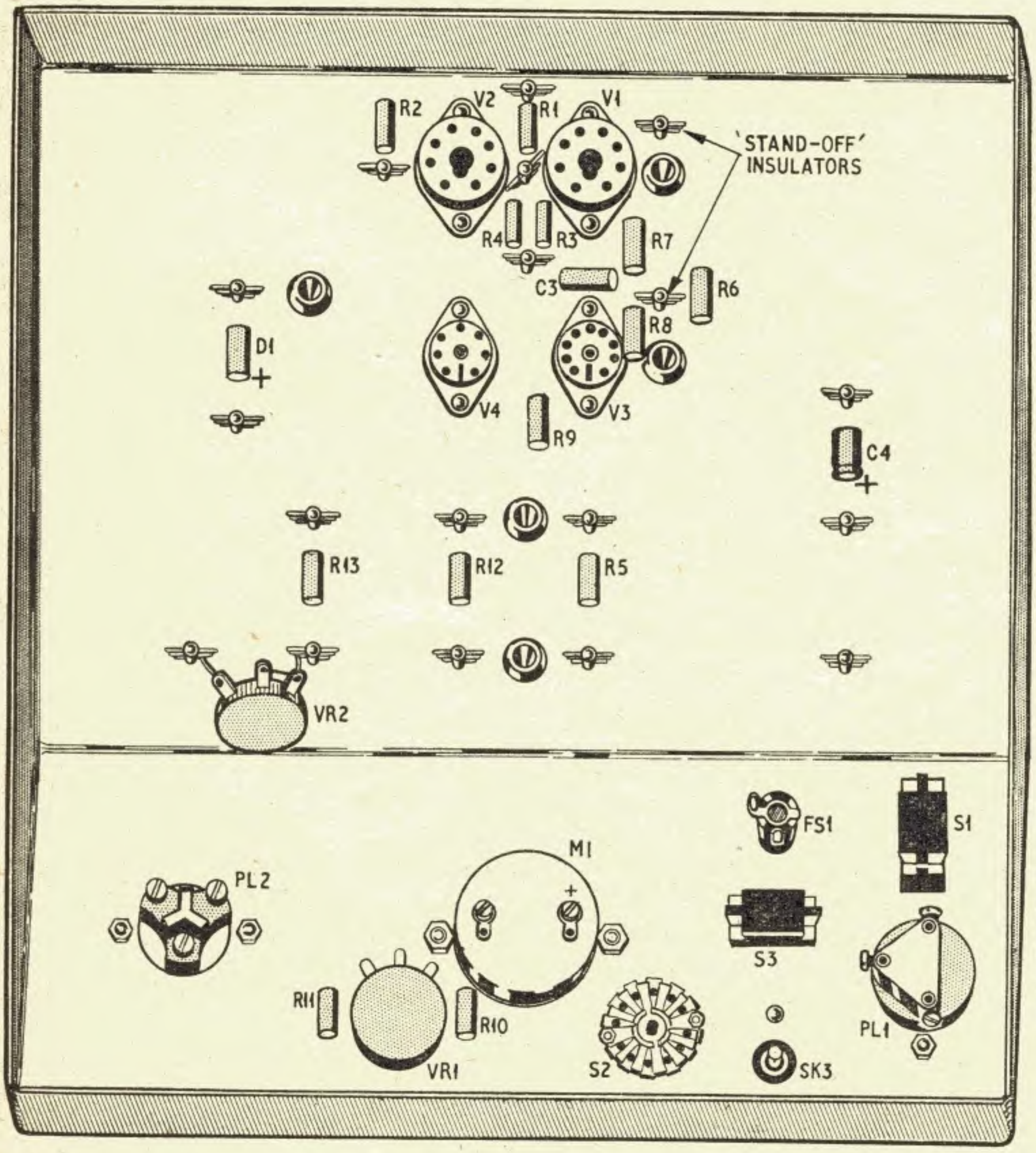


Fig. 10. Underside view of chassis. It will be noted that stand-off insulators are freely used since these facilitate wiring up. The components should be wired up in accordance with the circuit diagram, Fig. 7

CORRECTION—

Some components on Fig. 4 (last month) were incorrectly numbered.

As printed	*Should be*
V2	V4
V4	V2
R1	R5
R2	R3
R3	R4
R4	R1
R5	R2

Components . . .

Resistors

R1 100kΩ 1W
R2 100kΩ 1W
R3 2·7kΩ ½W
R4 2·7kΩ ½W
R5 300Ω 10W w.w.
R6 33kΩ 1W
R7 270kΩ 1W
R8 220kΩ 1W
R9 47kΩ ½W
R10 680kΩ 1W
R11 150kΩ 1W
R12 47kΩ 2W
R13 330kΩ 1W 1% H.S.
R14–17 10kΩ 20W w.w. (see text)

All ±10%, carbon except where otherwise indicated

Potentiometers

VR1 500kΩ, linear
VR2 100kΩ, linear, preset

Capacitors

C1 0·01μF paper 1kV
C2 0·01μF paper 1kV
C3 0·02μF paper 500V
C4 8μF electrolytic 450V

Valves

V1 EL34
V2 EL34
V3 EF80
V4 85A2

Plugs

PL1 Mains connector (Bulgin Cat. SA1861)
PL2 Output power socket (Bulgin Cat. SA1334)
PL3 Coaxial socket (Belling Lee)

Switches

S1 Double pole on/off toggle switch
S2 Single pole, 5-way, break before make rotary switch. High insulation 250/300V 1·5A
S3 Double pole changeover toggle switch

Transformers and Inductors

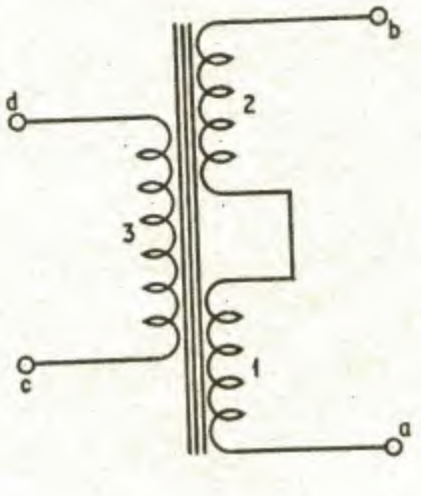
T1 Auto transformer. Winding rated at 1·5A, tapped at 235V, 250V, 265V, 280V, 295V, and local mains voltage
T2 Mains transformer. Secondaries: 300–0–300V 150mA, 6·3V 2·5A; 6·3V 0·5 or 1A
L1 Four-section saturable reactor for 1·5A maximum in d.c. windings. Each section as separate item with the following characteristics:
a.c. winding:
300mH unloaded, 2 ohms saturated; 150 turns; core M65
d.c. winding:
100 ohms d.c. resistance; 1,680 turns, saturation current 65mA; core M65, rating 20VA

Miscellaneous

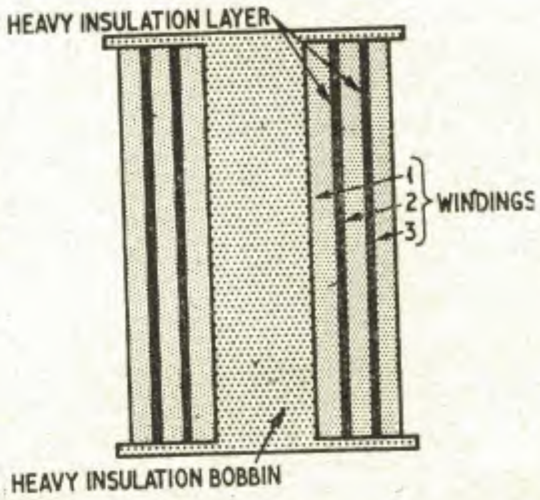
D1 Silicon h.t. rectifier, 1kV p.i.v., BYY92 (Brush Crystal Co.)
M1 Moving coil meter, 1mA f.s.d., scale 0–250V
FS1 Panel fuse, 2A slow

Two I.O. valveholders. One noval valveholder with screening can. One B7G valveholder with screening can. Tagstrips, rubber grommets, etc. Aluminium 16 s.w.g. for chassis and brackets.

Winding 1, 2 : 840 turns *each* (1,680 turns total) 34 s.w.g. enamelled copper
Winding 3 : 150 turns 20 s.w.g. enamelled copper

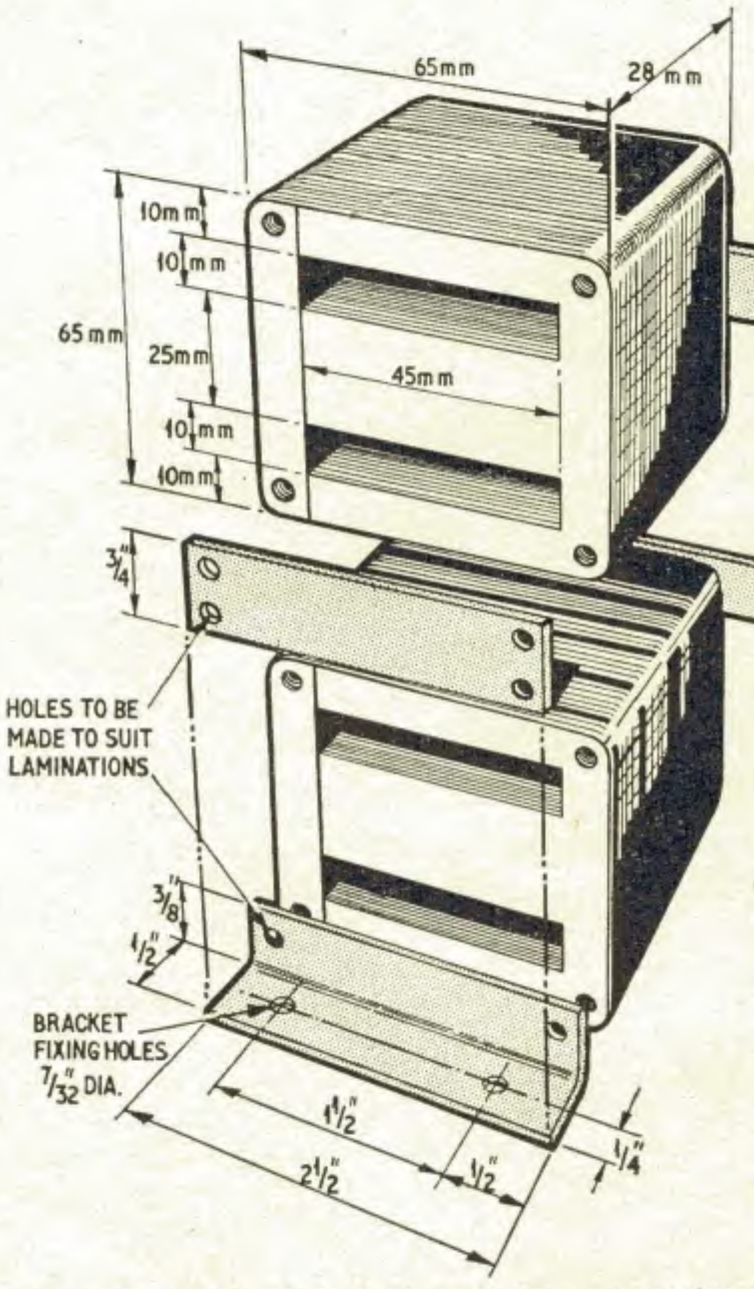


Connections a, b, c, d : see Fig. 7
1, 2 *in same sense* as connected
a is nearest core
a → b, c → d same senses



Heavy insulation bobbin i.e. Plastic—*not* paper or cardboard—cheeks *must* be present

Fig. 11. Winding and constructional details of the saturable reactor L1. Four of these components are required, and they must be strictly identical



56 laminations stacked alternately, as in mains transformer. Use old mains transformer core meeting these dimensions as closely as possible

to an a.c. input without an earth, or to one with a defective earth run, the chassis would be floating at the potential of an entirely unearthed secondary mains supply. If the other end happens to get connected to an earthed point of experimental equipment connected to the output, the chassis and entire casing would again go live at full mains voltage, in spite of T1 being an isolating transformer. Such conditions could well arise under amateur workshop conditions of usage of this unit. The safest procedure is thus undoubtedly to float the chassis solely on the mains earth pin, so that there is still a measure of safety even if the mains earth should be defective.

Care must be taken to assure that the mains plug is the right way round if intending to feed an external control input in at PL3.

OPERATING PROCEDURE

The unit will stabilise any voltage which can be set with VR1. In the prototype, this permitted continuous selection of stabilised output voltages from 150V to 250V r.m.s., for output loading up to 250 watts at any voltage within this range. For best stabilisation of a particular load and voltage combination, an optimum setting of S2 must be chosen. The setting of S2 is, however, not critical. Correct procedure is as follows:

(a) Throw S3 to "direct" to read the actual mains input voltage at the time. Consider that the local mains voltage can fall to 40 volts below nominal (for nominal supplies in the 200–250V range) under extreme conditions, and thus mentally calculate the number of volts that the mains voltage would have to fall from its present actually observed value to be 40 volts below nominal (see house meter or consult supply company for statement of local nominal voltage). Call this hypothetical further drop D.

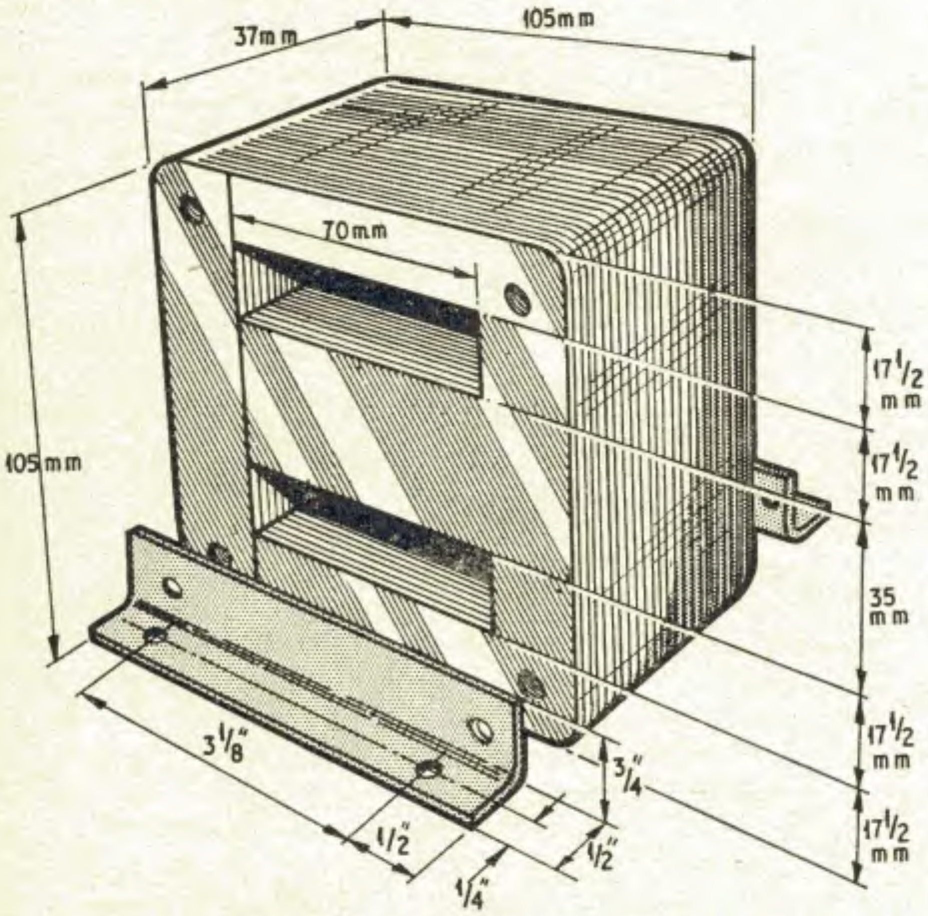
(b) Set VR1 such that the slider is at the top of the track (minimum output voltage) and set S2 to the lowest voltage tap on T1. Connect the load and throw S3 to "stabilised".

(c) Briefly advance VR1 to see whether D volts in excess of the desired output voltage can be reached. If not, switch to the next higher tap on S2. If the desired output voltage plus D volts can still not be reached, switch to a still higher tap on S2, until the condition can first be satisfied.

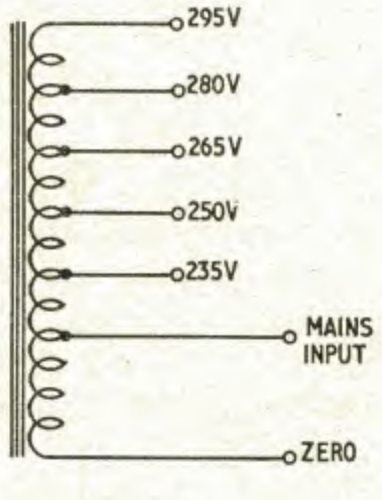
(d) Finally adjust VR1 for the correct desired output voltage, which will then be held stable for input mains voltage fluctuations of roughly +15 to −40 volts with respect to nominal. This holds true regardless of the actual output voltage selected.

In general, the range of manual control available on VR1 represents the range of automatic control present under the same conditions, i.e. if in a given setting it is found that the output voltage can be increased by 23 volts before VR1 reaches the high-voltage stop, then this means that the initial voltage is held stabilised as long as the mains voltage does not drop more than 23 volts below the prevailing value at the time. If at the same time it is found that the output voltage can be reduced manually by 19 volts before the slider of VR1 reaches the low-voltage stop, then this means that the initial output voltage is held stable as long as the input mains voltage does not rise more than 19 volts above its prevailing value at the time. The range of stabilisation in hand, in relation to the prevailing mains voltage, can thus be determined at a glance under any conditions of operation, and if not as required, it can be suitably corrected by selecting a different tap on S2.

The primaries of T1 and T2 should be wound to suit the nominal local mains voltage, or, in the case of universal primaries, connection should be made to the appropriate taps. Adjust VR2 once and for all for correct indication of M1 by comparison with a reliable multimeter connected to PL2. ★



74 laminations, stacked alternately



Wind coil in same sense through from zero to 295V, at 4 *turns per volt*
Between zero and lowest tap (immaterial whether 235V or local mains input): 22 s.w.g. enamelled copper
Between lowest tap and 295V end: 18 s.w.g. enamelled copper
Take all taps out through cheeks of bobbin as loops, i.e. do *not* bare and solder wire within windings

Fig. 12. Winding and constructional details of the auto transformer T1

PORTABLE STEREO

SIMPLE BATTERY DRIVEN HALF WATT TRANSISTOR AMPLIFIER FOR MONO OR STEREO USE WITH HEADPHONES OR LOUDSPEAKERS

THESE DAYS rooms are getting smaller, partition walls thinner, and children's homework more pressing. Thus conventional loudspeaker hi fi systems gather dust, and are almost squeezed into silence. Whether or not you have this problem, you may like to build this small portable record player and amplifier, which was designed to provide a "second set" for undisturbed personal listening on headphones to stereo and monaural gramophone records.

Before going into the circuit and constructional details, it is probably a good idea to discuss briefly what is involved. This article is primarily concerned with a stereo unit, but for simplicity it has been broken down to describing a single channel, which can be used for monaural use only. Additional details are given for conversion to stereo. If the constructor intends to adopt the stereo system from the outset, he can build two basic monaural amplifiers with the necessary balancing network for stereo described later.

It should be remembered that stereo pick-ups can be used for playing monaural records, but monaural pick-ups *cannot* be used on stereo records without severely damaging the recording.

It is often said that the loudspeaker is the weakest link in the chain and this is to some extent true. It is essential, therefore, that headphones and loudspeakers for stereo should be of a high quality, matched, and housed in separate enclosures. Inferior systems, while giving acceptable quality, can give some unnatural effects, particularly if the two channels are not matched.

The phase of the signal is very important. The two channels should be arranged to give the same phase as was used in the recording, otherwise a small degree of signal cancellation can be experienced. It is for this reason that many stereo units incorporate a switch which will reverse the phase of one channel; it avoids unsoldering loudspeaker or headphone connections and a quick comparison of the two conditions can be achieved from the listening position.

RECORD PLAYER

BY D.J.R.BOWERS

CIRCUIT

Fig. 1 shows the circuit diagram of a basic single-channel amplifier. The signal from a ceramic or crystal pick-up is fed in at the input point (A), and is delivered at up to 500 milliwatts into suitable headphones (or loudspeaker) connected across the output points (I) and (J). Two 9 volt batteries are used, making the amplifier and turntable motor independent of each other.

The first transistor (TR1) is an emitter-follower stage, designed to match a high-impedance pick-up to the low-impedance volume and tone control circuits between (C) and (E). The variable resistor (VR1) in the output from TR1 makes it possible to preset the gain of the whole system at a convenient level.

Potentiometers in a passive network (shown in Fig. 1) between (C) and (E) control the volume and bass response. Treble tone control is also provided by external variable negative feedback from the output point (H) to the collector of TR2 via (F).

From point (E) the signal passes to the base of the first amplifying transistor (TR2). It is further amplified in the "Darlington pair" of transistors TR3 and TR4 which together form a driver stage, d.c. coupled to the single ended, class B, push-pull, complementary-symmetry, output pair TR5 and TR6. Finally, TR5 and TR6 drive the headphones, or loudspeaker, via a coupling capacitor C10.

S1 switches the amplifier battery on or off; S2 selects either headphones or loudspeaker.

If the amplifier is used with a battery operated turntable, the interference caused by sparking from the brushes of the motor will be fed through the amplifier along the common battery line. Suppression circuits can be incorporated but may not completely eliminate the trouble. Much of the interference is of the airborne r.f. type, hence the screening and layout of wires and components is rather critical when a common battery is used.

A better plan is to use separate batteries for the turntable motor and amplifier, and route the motor supply wiring away from the amplifier wiring. The batteries should be spaced as far apart as possible to avoid interference being transmitted from one to the other. The interference will be reduced considerably but can be reduced even further by connecting a capacitor of about 16μF across the motor leads. This should be as small as possible in order to accommodate it inside the motor casing.

STEREO RECORD PLAYER

A pair of amplifier systems required for stereo reproduction is connected up as shown in Fig. 2. The volume, bass and treble controls used in the monaural version are duplicated and are now represented in Fig. 2 as twin ganged controls. The loudspeaker/headphones selection switch (S5) is double pole to enable both channels to be switched together.

Apart from the "doubling-up" of the controls there are certain features special to the stereo circuit. A 10 kilohms potentiometer VR6 is wired between the points (C_1) and (C_2) on the two pre-amplifiers, with its slider connected to earth, to enable the two channels to be balanced.

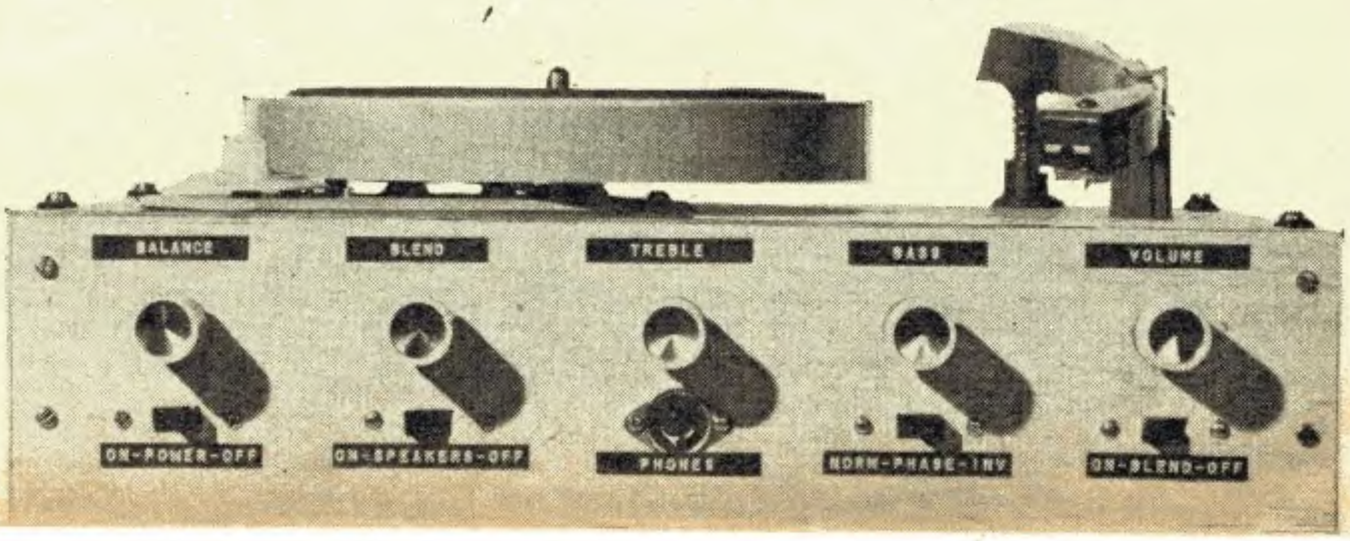
Another 10 kilohms potentiometer VR5 is also connected between the two points (C_1) and (C_2) but this time via a switch S3. When S3 is closed the two channels are cross-coupled through VR5 and this provides a variable level of channel mixing or "blend" if required. When headphones are being used, this blending is sometimes necessary to reduce the curious "separation" effect heard when playing stereo records. When the blend is switched in and the potentiometer VR5 is turned to its lowest value the two channels are combined to provide monaural operation of the amplifier.

The stereo system includes a "phase" changeover switch (S4) which enables you to invert the phasing of one speaker or earpiece insert to obtain correct balance and matching between the two signals with optimum control settings. When using the two amplifiers for monaural listening an interesting "pseudo-stereo" effect is obtained by switching one earpiece out of phase.

In the stereo version spurious cross-coupling between channels must be kept to a minimum, otherwise undue distortion and instability may arise.

AMPLIFIER CONSTRUCTION

Experienced experimenters can build up their own amplifier from the circuit diagrams in Figs. 1 and 2, but those without the necessary time or aptitude may welcome the suggested printed circuit board layout shown in Figs. 3 and 4. The board is drawn full size so that you can plan your own board to match or wire up point-to-point on a perforated board with holes spaced 0·1in apart. Ready made printed boards can be obtained from the supplier indicated in the components list for those who prefer not to process their own.



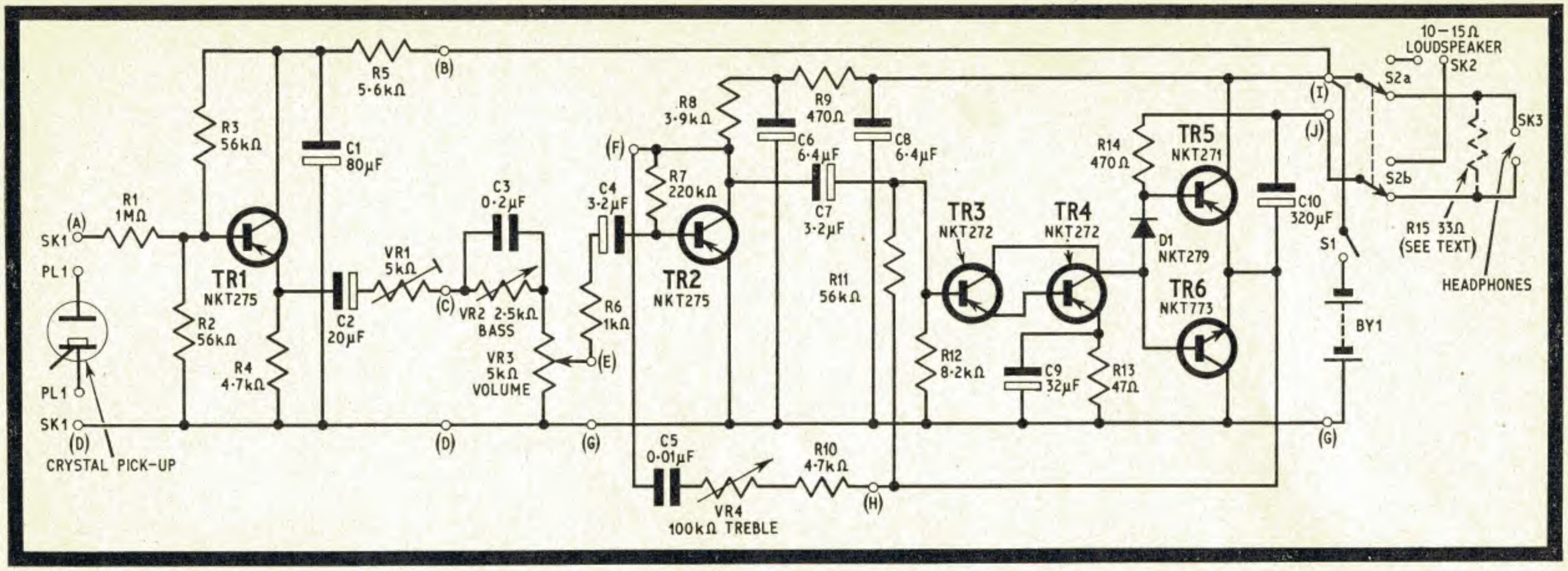


Fig. 1. Complete circuit for monaural (single channel). The tone control circuit between points C, E, F and H is not incorporated on the printed circuit board

COMPONENTS . . .

MONAURAL AMPLIFIER

** Components marked with an asterisk are used in the stereophonic version and are duplicated.*

***Resistors**

R1	1MΩ	R6	1kΩ	R11	56kΩ	5%
R2	56kΩ	R7	220kΩ	R12	8·2kΩ	5%
R3	56kΩ	R8	3·9kΩ	R13	47Ω	
R4	4·7kΩ	R9	470Ω	R14	470Ω	
R5	5·6kΩ	R10	4·7kΩ	R15	33Ω	(see text)

Potentiometers

*VR1	5kΩ carbon preset (Egen type 468 or similar)
VR2	2·5kΩ carbon antilog. (Egen type 181)
VR3	5kΩ carbon log. (Egen type 181 or similar)
VR4	100kΩ carbon linear (Egen type 181)

***Semiconductors**

TR1, TR2 NKT275 TR3, TR4 NKT272

TR5	NKT271	Matched set with β within 20% at 50mA and diode selected to give 2mA bias current in TR5, TR6
TR6	NKT773	
D1	NKT279	

***Capacitors**

C1	80μF 6V elect. (AM/C80)
C2	20μF 6V elect.
C3	0·2μF 30V (2×0·1μF) min. foil (Mullard)
C4	3·2μF 40V elect. (AM/G3·2)
C5	0·01μF 30V ceramic or min. foil (Mullard)
C6	6·4μF 25V elect. (AM/F6·4)
C7	3·2μF 40V elect. (AM/G3·2)
C8	6·4μF 25V elect. (AM/F6·4)
C9	33μF 2·5V elect. (AM/A32)
C10	320μF 10V elect. (AM/D320)

All capacitors are Mullard type C426 except C3 and C5

Plugs and Sockets

*PL1 and SK1	2-way non-reversible (Radiospares)
PL2 and SK2 PL3 and SK3	Recorder plugs and sockets D.I.N. pattern 3-way (Radiospares)

Switches

S1	Single pole, on-off, slide or toggle
S2	Double pole, two-way, slide or toggle

Batteries

BY1	9V (Ever Ready type PP9)
BY2	9V (six Ever Ready U2 cells in series)

Miscellaneous

Three knobs, 9 volt battery-operated turntable with crystal or ceramic monaural pick-up (B.S.R. TU12 or GU7, Garrard SRP10), monaural headphones 15 to 150Ω (S. G. Brown type K), *printed circuit boards (see text) available ready-made from Newmarket Transistors Ltd., battery tray (Pressac type 20/751), aluminium panel 13·5in × 3in and wood for case (see text), *cooling clips for TR6 and D1, battery connectors for PP9, flexible p.v.c. wire.

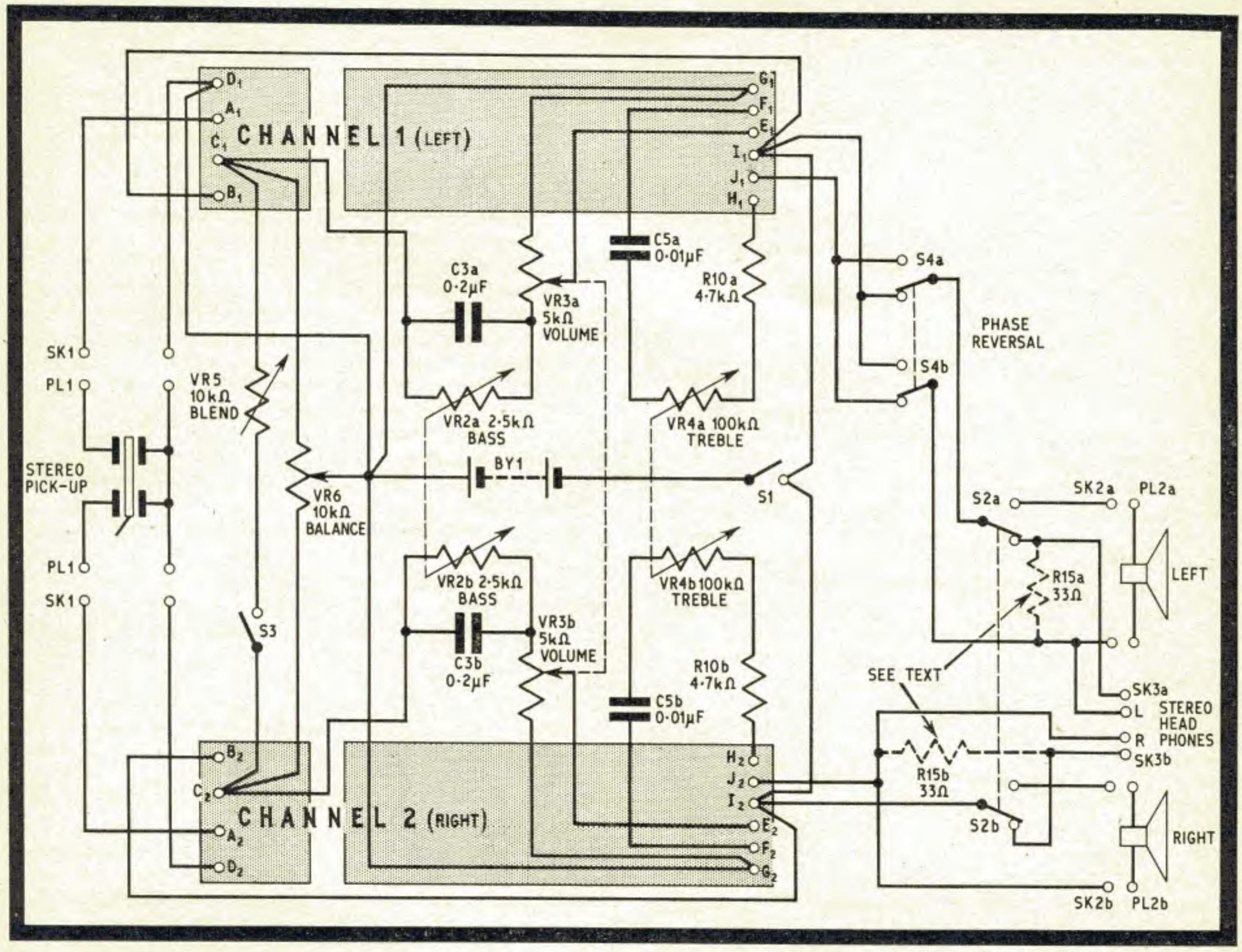


Fig. 2. Complete circuit for stereophonic listening. The printed circuit boards for channels 1 and 2 are identical; the circuit diagram of each of these is shown in Fig. 1

COMPONENTS . . .

STEREOPHONIC AMPLIFIER

All components with an asterisk (*) in the monaural version are duplicated for the stereophonic version. Other components are as follows:

Potentiometers

VR2a & b	2·5kΩ + 2·5kΩ carbon antilog. twin ganged (Egen 371)
VR3a & b	5kΩ + 5kΩ carbon log. twin ganged (Egen 371)
VR4a & b	100kΩ + 100kΩ carbon linear twin ganged (Egen 371)
VR5	10kΩ carbon linear (Egen type 181)
VR6	10kΩ carbon linear (Egen type 181)

Switches

S1	Single pole, on-off, slide or toggle
S2	Double pole, two-way, slide or toggle
S3	Single pole, on-off, slide or toggle
S4	Double pole, two-way, slide or toggle

Plugs and Sockets

PL2 and SK2 } Recorder plugs and sockets D.I.N.
PL3 and SK3 } pattern 5-way (Radiospares)

Batteries

BY1	9V (Ever Ready type PP9)
BY2	9V (made up from six Ever Ready U2 cells in series)

Miscellaneous

5 knobs, 9 volt battery-operated turntable with crystal or ceramic stereo pick-up (B.S.R. type C1), stereo headphones 10 to 150Ω each insert (Koss type SP3X or Lafayette type F767), battery tray (Pressac type 20/751), aluminium panel 13·5in × 5in and wood for case (see text), battery connectors for PP9, flexible p.v.c. wire.

The suggested printed circuit version is designed for modern "vertical component, high density" assembly. In this, all resistors, capacitors and transistors stand vertically on the board as illustrated in Fig. 3, and are all arranged close together. It is good design practice to mount all the electrolytic capacitors with the positive end to the board. The positive end is usually indicated by a plus sign, a red mark or a ring round one end of the casing.

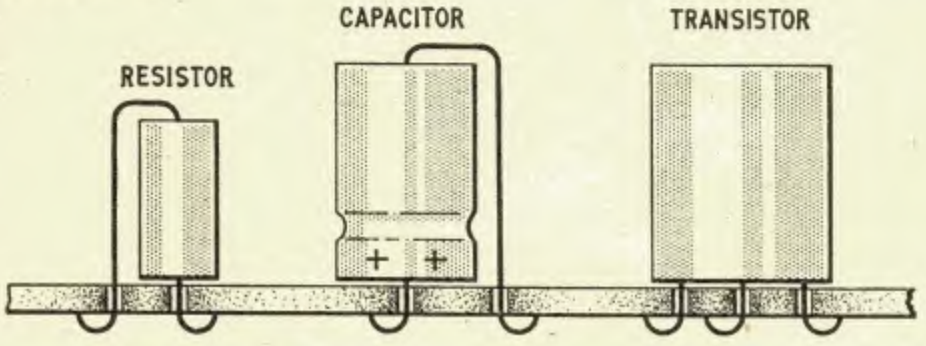


Fig. 3. Section of printed board showing how components are mounted

There is quite a knack in fitting components in this high density way. It is probably best to hold the component in position with one hand while pulling the lead wires through the holes in the printed board. Solder them on to the appropriate copper strips on the underside and clip off any excess wire. Use resin-cored solder and an instrument soldering iron. See that your iron is hot enough, so that each soldered joint can be made in a few seconds. Don't leave the iron on the component leads or the copper print of the board any longer than is necessary to make a satisfactory joint. The layout of the components side of the boards is given in Fig. 4 and the underside view in Fig. 5.

When the main amplifier is finished, connect the 9 volt d.c. supply to it. A multimeter set to the 100mA d.c. range is connected in series with one of the supply leads (negative of the meter to negative of the battery). The standing battery current (with no test signal applied) should lie between 10 and 15mA. If it is more than 15mA, try a selection of resistors from 1 kilohm downwards across the diode D1, until the current falls to this limit. At the same time check the d.c. voltage at the emitters of TR5 and TR6 and ensure that it lies between 4·5 and 5·5 volts. You can adjust this voltage by varying the value of R11; lowering the value lowers the common emitter voltage.

READY MADE

Some readers may prefer to dispense with the construction of the amplifier boards; they can, in this case, buy ready-made pretested packaged circuits from Newmarket Transistors. For the pre-amplifier the unit type PC9 is used and is an industrial module designed for matching high impedance capacitive transducers to low impedance amplifiers. It is just as suitable to this application. For the main amplifier, a PC3 packaged circuit is quite suitable. You are then left only with the wiring of the boards to the external controls, pick-up, and battery. When the pre-amplifier has been assembled, connect the d.c. supply to it and verify that the standing battery current is about 1 milliamp. If it is not, there will probably be either a fault in the wiring or a component failure.

The control panel for the stereo unit can be made from a piece of aluminium sheet 13·5in × 3in. Drilling details are shown in Fig. 6. Notice that the holes for the switches are rectangular to accommodate slide type switches. The headphones socket is in the centre. If the unit is to be used with loudspeakers the socket for these would be the same but mounted unobtrusively on the side or back. This is not shown on the photographs (Figs. 7 and 8) as it has been left to the reader's choice.

An additional multi-way plug and socket is also shown connecting the amplifiers with the batteries, etc., but these have been omitted from the circuit details for clarity. If it is used there should be no difficulty in selecting the connections. The most important point to remember is to keep the two battery pairs as far apart as possible.

The case itself needs little explanation since it consists merely of an open wooden box of overall dimensions 13·5in × 9·75in × 3in. The back and sides of the prototype was 0·75in thick. The floor was ⅜in thick. The motor board should also be strong plywood (about ⅜in thick) to avoid undue bending. The

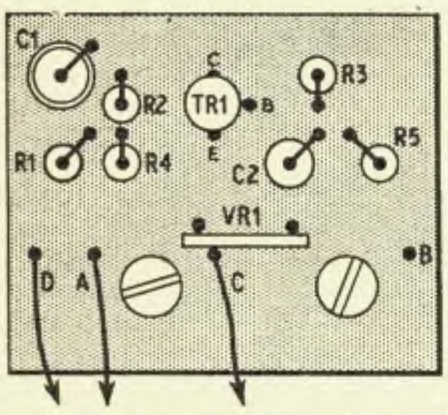


Fig. 4a. Component layout of the pre-amplifier on the printed board. For inter-panel wiring see circuit diagrams Figs. 1 and 2

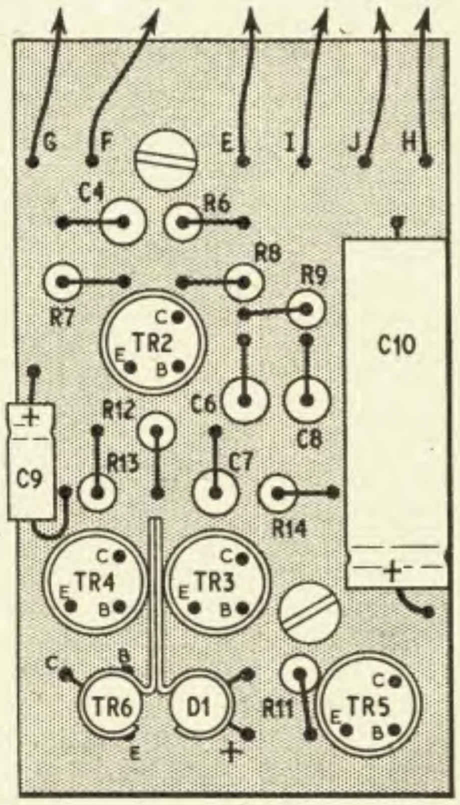


Fig. 4b. Component layout of the power amplifier on the printed board

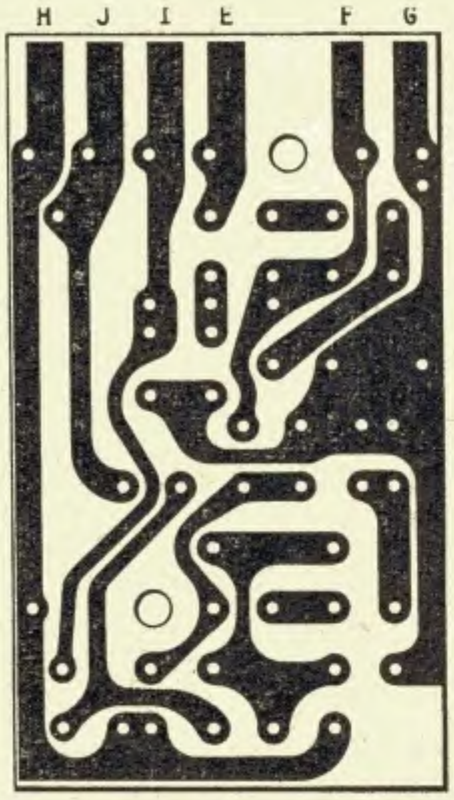


Fig. 5b. Pattern of the power amplifier printed circuit board shown in Fig. 4b

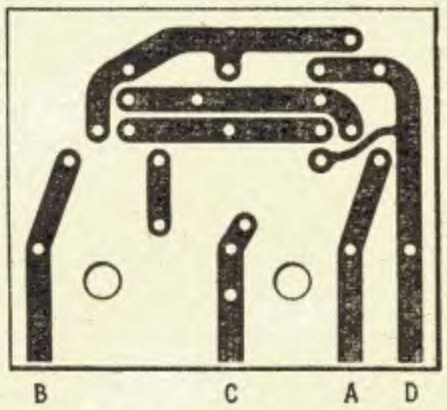


Fig. 5a. Pattern of the printed circuit on the underside of the pre-amplifier board shown in Fig. 4a

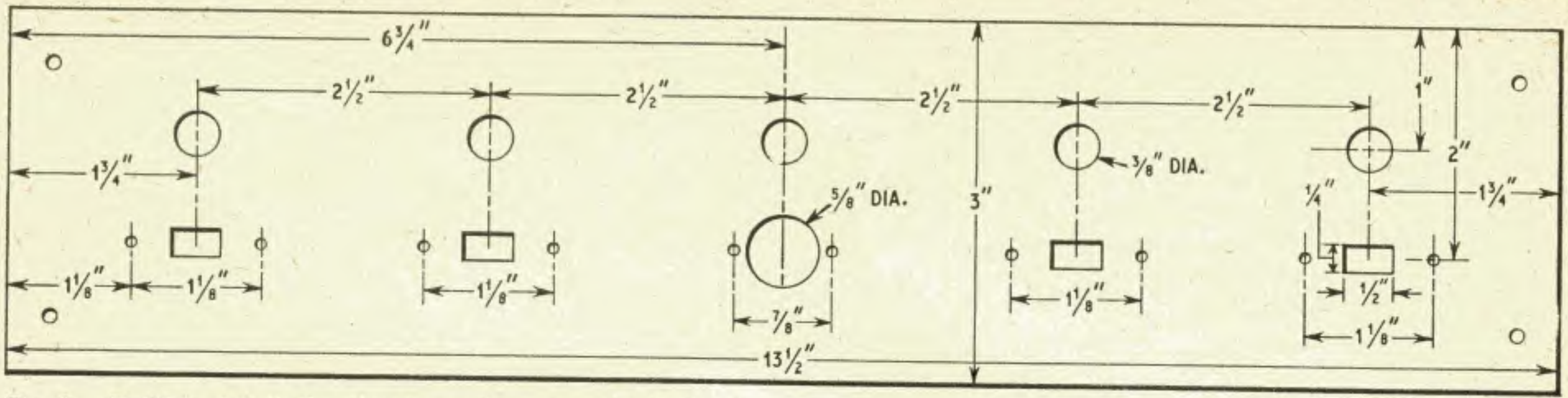


Fig. 6. Drilling details for the stereo front panel which can be made from thin plywood, hardboard or aluminium

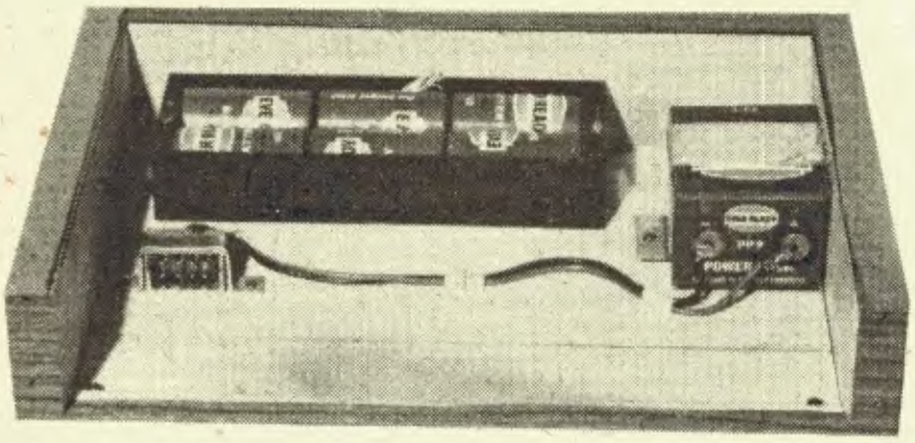


Fig. 7. Case of the stereo model showing the battery box on the left for the motor and the amplifier battery on the right. Wiring to these is separated to reduce any pick-up of interference

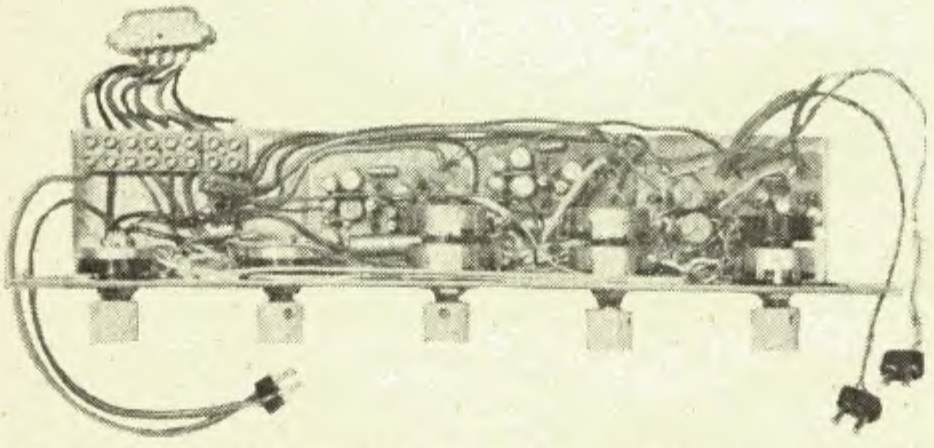


Fig. 8. The stereo amplifier complete with tone controls. The two-pin plug on the left connects the motor to the battery. The two plugs on the right connect the pre-amplifiers to the stereo pick-up

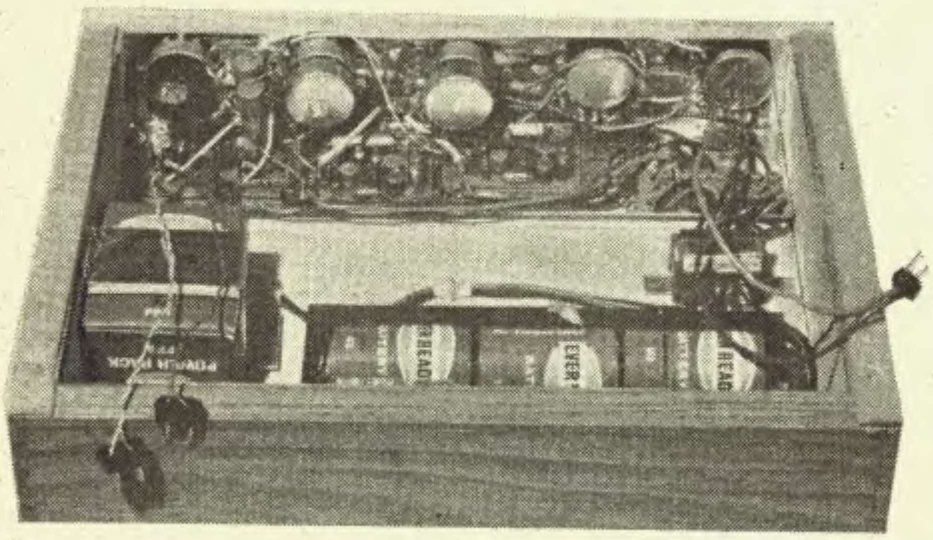


Fig. 9. The complete assembly (looking in the opposite direction from Figs. 7 and 8)

hole for the turntable assembly and pick-ups should be cut to the manufacturer's instructions. This is particularly important since the position of the pick-up relative to the turntable has been specially calculated to keep tracking errors, and hence wear, to a minimum.

The finished model was covered with imitation wood grain adhesive plastic but no doubt readers will have their own ideas on the finish.

The positive and negative battery leads for each channel should be run separately right back to the battery switch (for negative); to the battery terminal (for positive). Where the battery supply must run through a common lead (e.g. from the switch to the battery), use stout wire, preferably not less than 18 s.w.g. It is worthwhile using 18 s.w.g. wire throughout on power supply and earth leads.

In Fig. 7 is shown the Pressac 20/751 battery box containing six U2 1·5 volt cells, and screwed to the bottom of the case. This constitutes the battery supply for the 9 volt turntable motor. A separate 9 volt battery provides the d.c. supply for the amplifiers. The turntable and pick-up arm are mounted on the top of the cabinet.

The amplifiers and controls are mounted on the front panel as shown in Fig. 8. Viewed from the front, the controls are arranged as follows from left to right: top row—balance, blend, treble, bass, volume; bottom row—power on/off, speakers on/off, headphones socket, normal/inverted phase, blend on/off. The loudspeaker outlet socket can be mounted on the side of the case.

HEADPHONES AND LOUDSPEAKER REQUIREMENTS

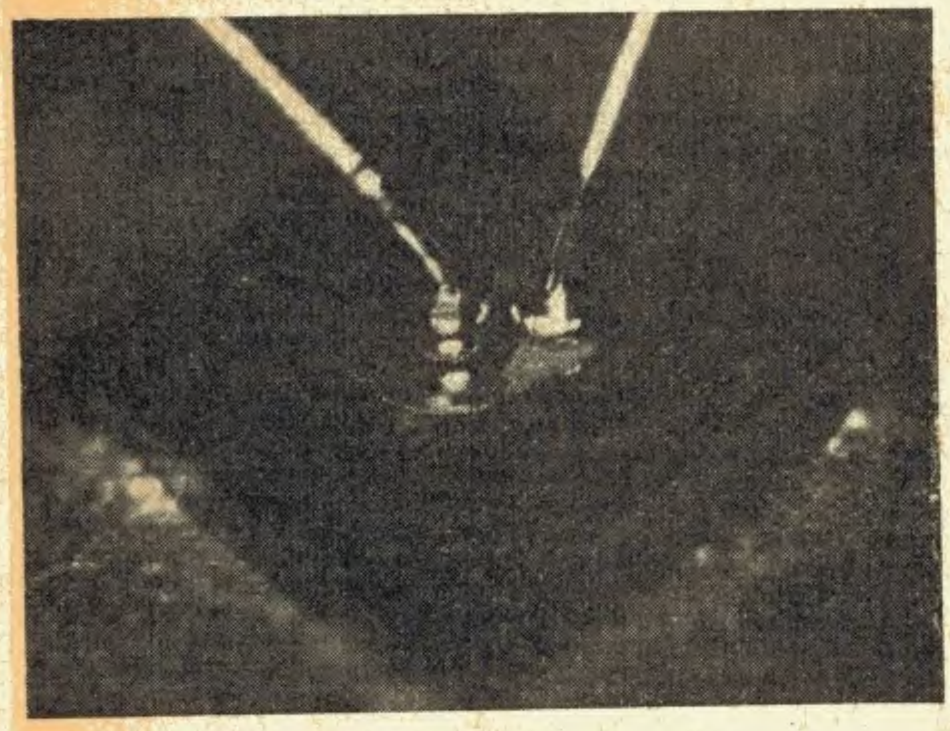
The main amplifier can provide up to 2·2 volts r.m.s. into load resistances down to 7·5 ohms. This means that the amplifier is suitable for driving most headphones from 8 ohms up to 300 ohms per insert. Because instability is possible if the amplifier is terminated with too high a resistance load, headphones of 200 ohms or more impedance should have a 33 ohm resistor connected across each insert. Most of the tests on this amplifier were carried out with a pair of Swedish "Pearl" headphones (200 ohms per insert) and Lafayette type F767 (8 ohms per insert).

If the amplifiers are to be used with loudspeakers, with the full 500mW output fed to them, a 10 ohm impedance is necessary, but higher impedances can be used with a consequent reduction of maximum power. The maximum power is inversely proportional to the speaker impedance so that a 15 ohm speaker, for example, would give up to 500mW × 10/15 = 330mW.

★

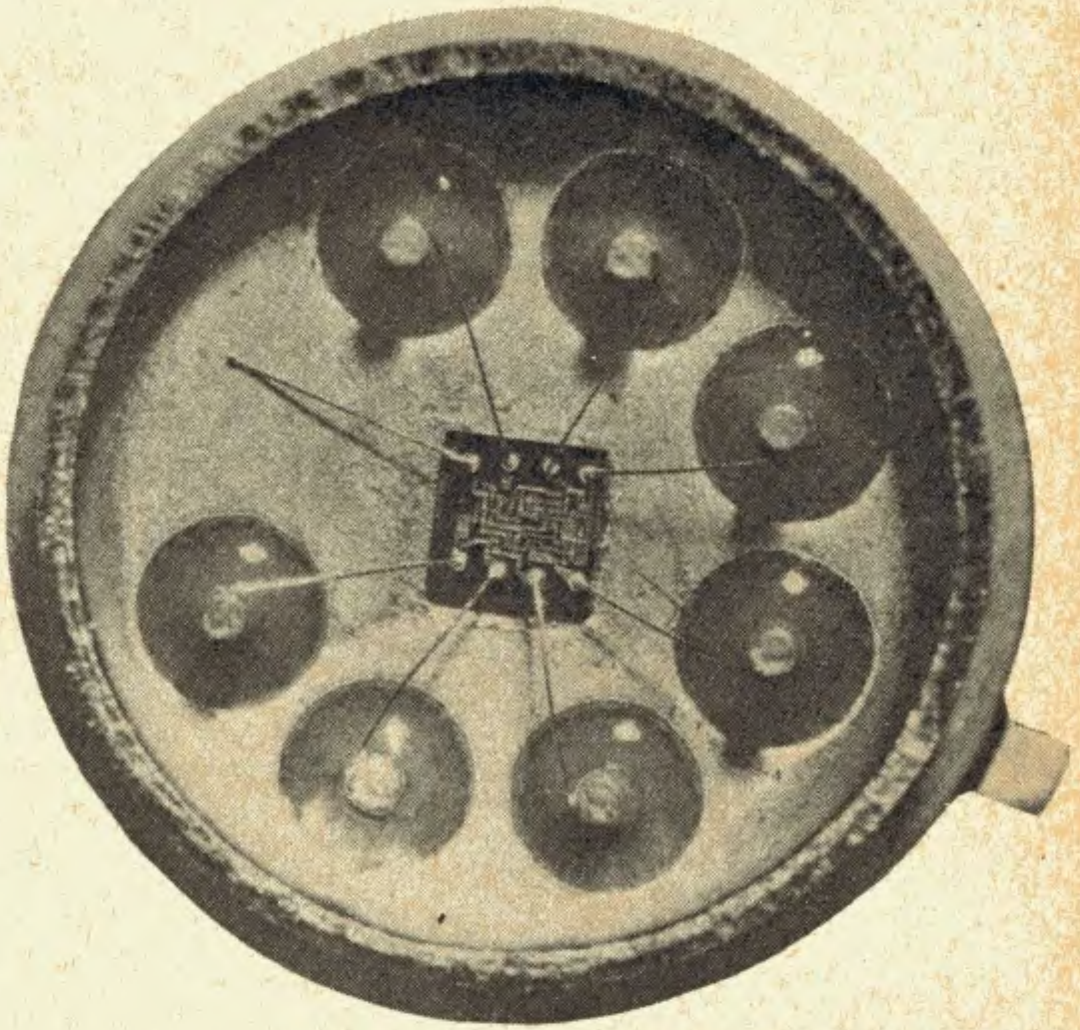
ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE



Transistor Junction

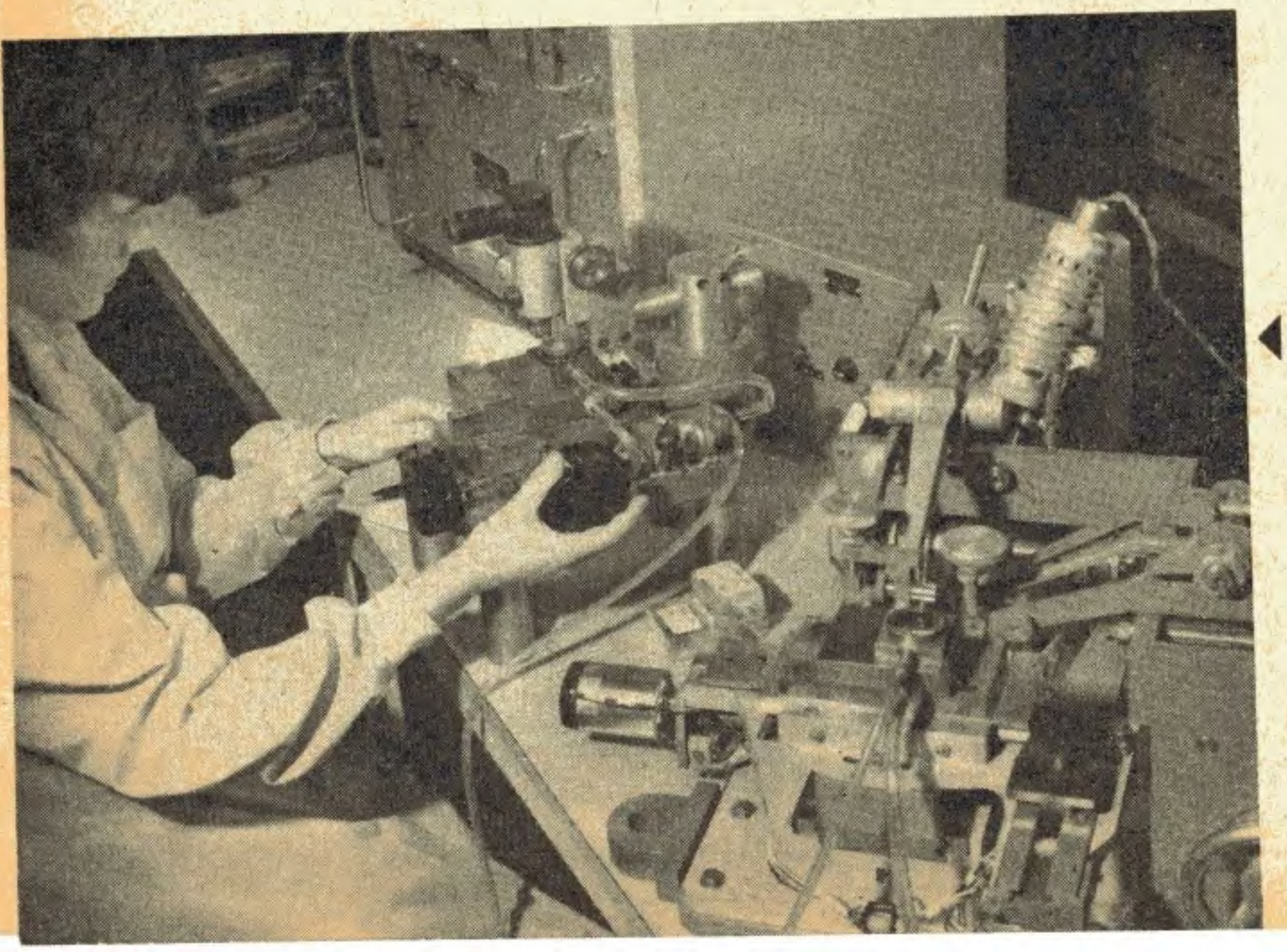
A MAGNIFIED view of a welded transistor junction is shown above, where 25-micron gold collector and emitter wires are welded to a silicon wafer and aluminised ring. The British Welding Research Association have been making investigations for the Post Office on some manufacturing techniques.



Silicon Planar Micrologic ▲

MANY industrial concerns are producing completely self-contained logic circuits for computers. The picture above shows a greatly enlarged view of an SGS-Fairchild silicon planar epitaxial micrologic element which is no bigger than a single transistor. The actual circuit in the centre is a complete counter-adapter which provides gated complementary outputs from a single valued input.

solid state techniques

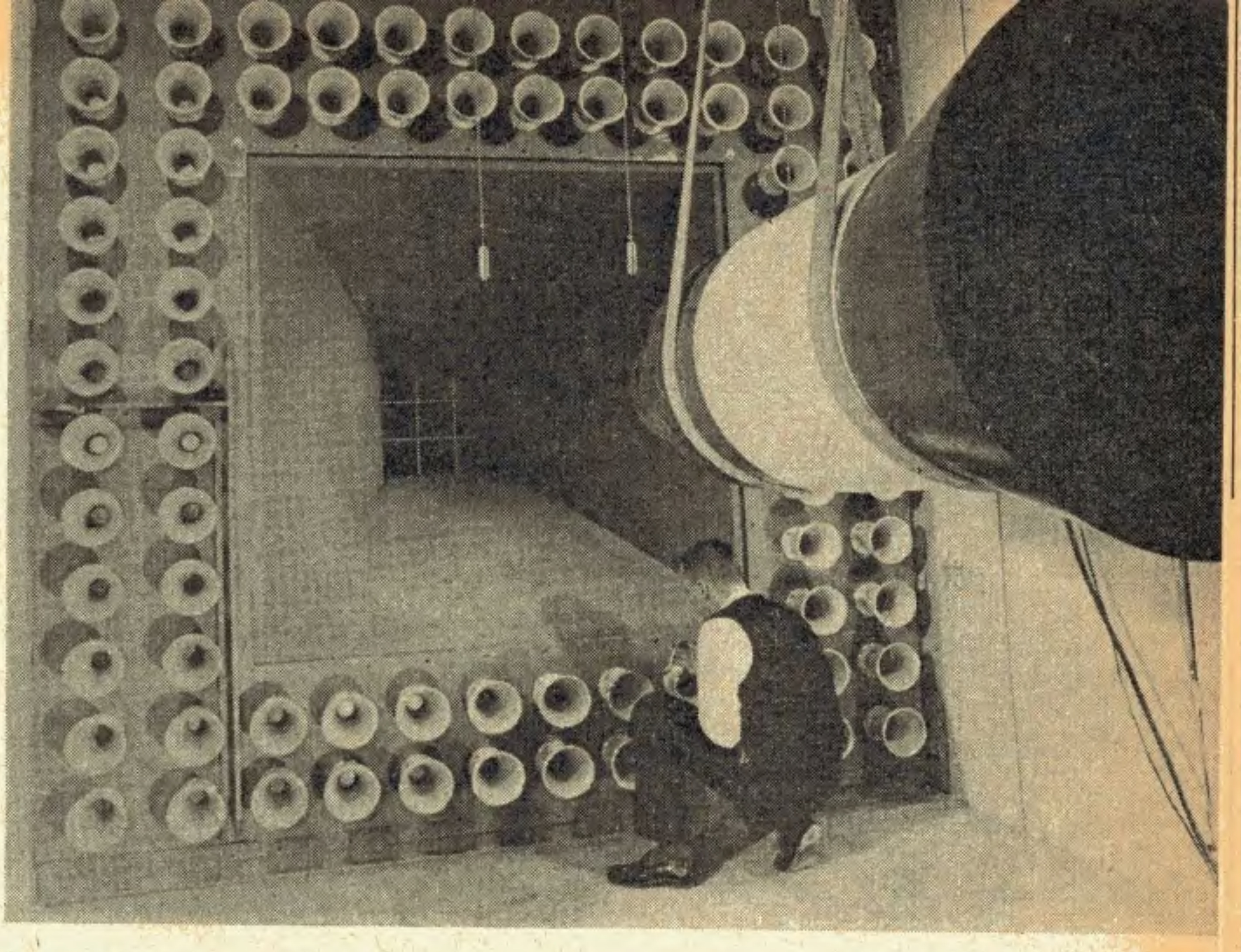


◀ Scribing Process

THE SCRIBING process in which several hundred integrated solid circuits on one silicon slice are separated into individual chips by Semiconductors Limited. The machine on the right of the picture is fully automatic; it replaces the manual operation on the left. This is one of the many product activities which will come within the new Components Group of The Plessey Company Limited.

King Size Noisemaker

THIS MULTIPLE loudspeaker chamber forms part of a newly developed acoustics experiment. The chamber is being used by scientists to simulate sounds and vibrations of high intensity such as those produced by an accelerating rocket. The work is being carried out in part of the Sandia Laboratory in New Mexico. The noisemaker was built by the Bell Telephone Laboratories.



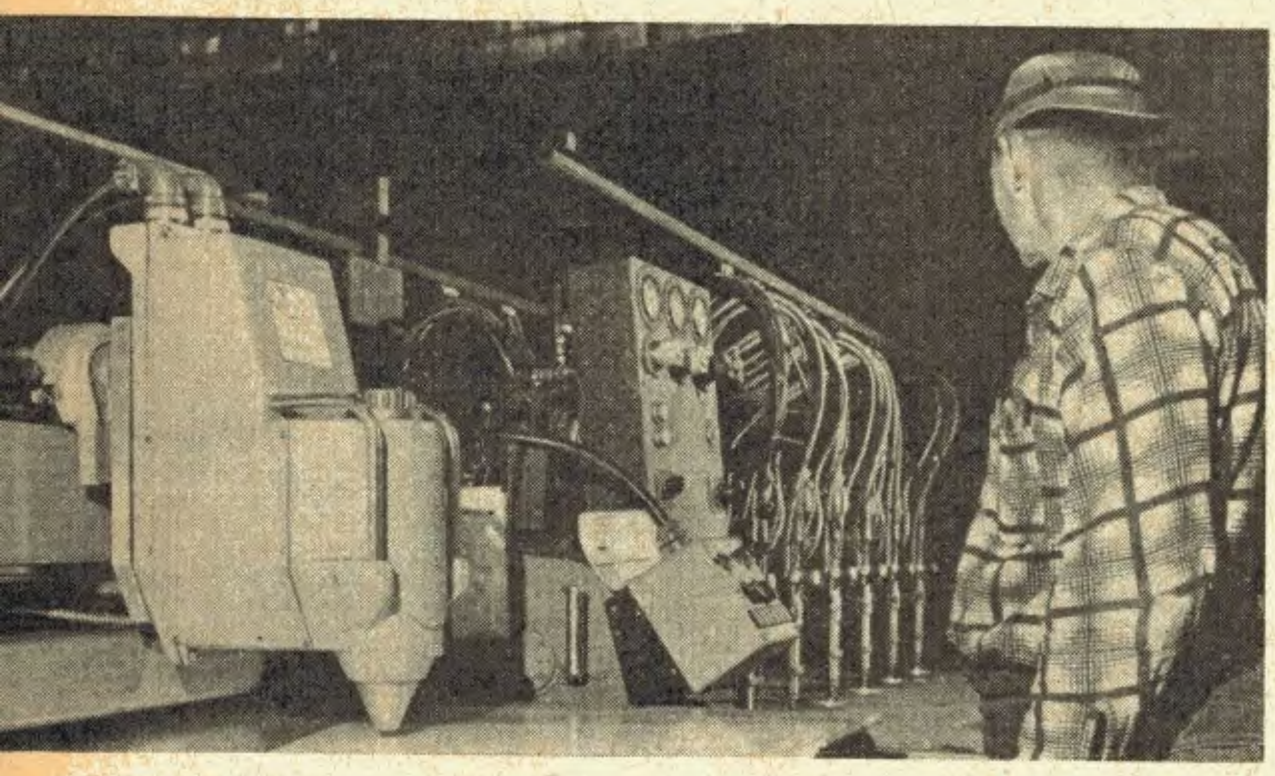


Image Transfer

AMONG the many electronically controlled machine tools now being used is this tracing system known as the Canadian Westinghouse Linatrol HL4. The system detects a flat line drawing, outline, or shadow and governs the operation of a machine tool by its projected image.

The process is achieved by using transistor circuits throughout.

Talking Typewriter

SOME TIME in the future, at a cost of about £14,500 per head, children may have the chance to read, spell, and type by using this "talking typewriter". Known as the Edison Responsive Environment System it combines electro-mechanical controls to teach the child to type the name of the subject displayed on the screen in front of him. He cannot type the wrong word or misspell because the memory system will only permit him to operate the correct keys in the correct sequence.

BEGINNERS start here... 9

An Instructional Series for the Newcomer to Electronics

LET us now continue with the experiments in electromagnetism and induction, using our "home made" coil described last month. We also require the galvanometer or a 1mA moving coil type meter.

EXPERIMENT NO. 2

Place the "I"s (or a large iron bolt) into the coil and using a "horse-shoe" permanent magnet, passed over the side of the coil, allow it to "stick" onto the bolt or "I"s, one pole at each end of the coil, see Fig. 9.1. A much bigger deflection of the galvanometer needle should be observed compared with the results obtained in experiment No. 1.

You should also note the deflection in the other direction when the magnet is pulled off.

EXPERIMENT NO. 3

Place the coil over the limb of the "T" or "E" lamination pile, connect the coil to the a.c. mains supply and then slowly lower over the remainder of the limb a coil of plastic covered wire or flex of about twenty turns (conveniently wound round your fingers first) to which is connected a 2.5 volt bulb. This is indicated as "a" in Fig. 9.2.

The bulb should gradually light up because of the induced currents by the alternating magnetic field. This is the a.c. transformer action.

The alternating field can be investigated if you place a knife or screwdriver blade on the end of the laminations: the 50 cycle buzz and vibration is very noticeable.

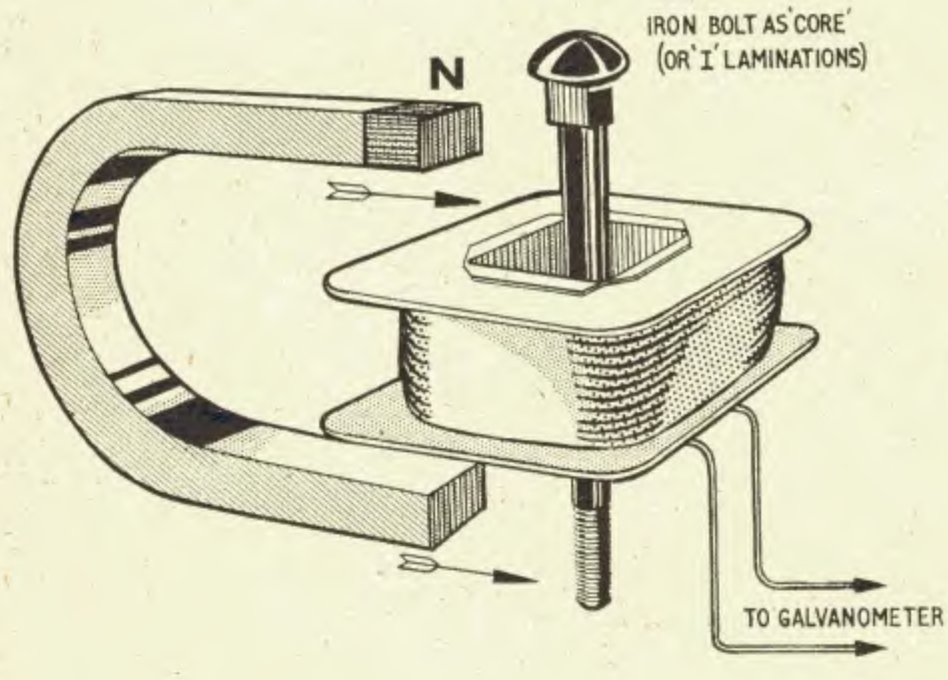


Fig. 9.1. The iron core concentrates the magnetic field, therefore the deflection obtained should be greater than that obtained in the first experiment

HAVE CARE

We issue a warning to you at this point. It is unfortunate that the mains supply is dangerous, and great care must be taken when you handle it, to avoid an accident. Never have bare leads or metalwork connected to the supply and always pay very good attention to insulation. If you wound the coil yourself, have it covered with a good thickness of insulation tape, and have thick insulated wires leading the current in and out. Use an insulated terminal block for connections. Always switch off and remove the plug when making adjustments to the circuit of course.

We must ask our young readers especially, to have an adult with you if you perform experiments using the mains: perhaps your science teacher, or of course father if you are at home.

EXPERIMENT NO. 4

A thick aluminiun, brass, or copper ring (see "b" in Fig. 9.2) is required for this experiment.

Place the coil onto the laminations. Then place the ring on top. Switch on the mains supply to the coil—stand back!—because the ring might shoot off the coil, and catch you unawares! On the other hand it may hover on the end of the laminations.

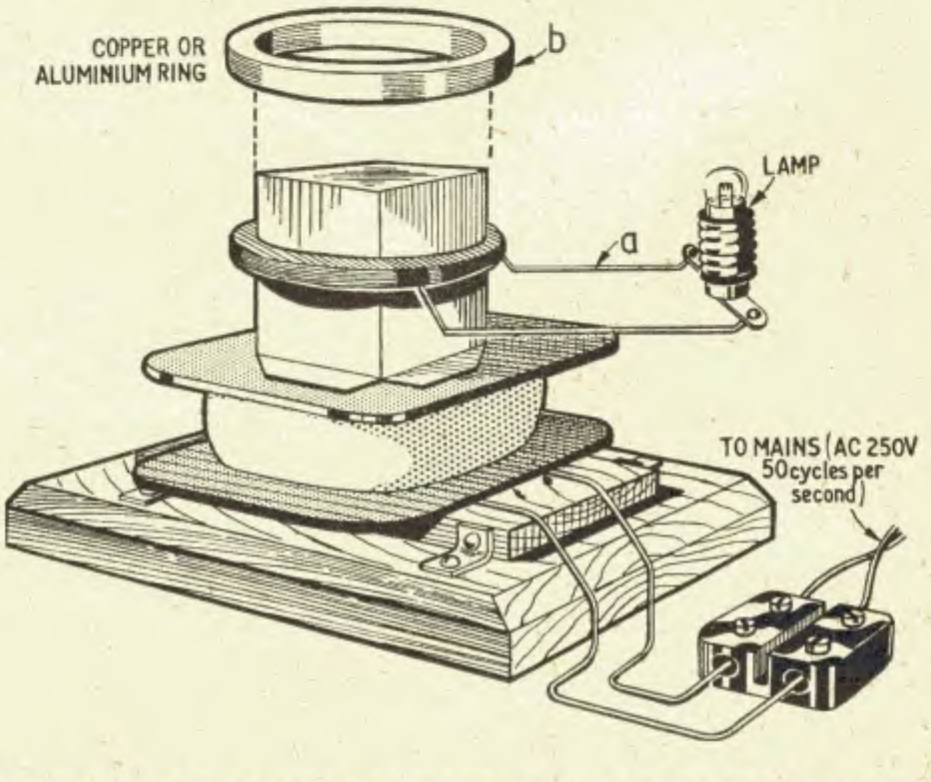


Fig. 9.2. The alternating magnetic field gives rise to a continuously induced alternating current in the coil connected to the bulb. Thus the bulb stays on all the time. In the fourth experiment the powerful currents induced into the ring "b" give rise to a magnetic field which reacts with the main field, and the repulsive forces drive the ring up the core

This force moving the ring is set up because of the large induced currents in the "short circuited" turn. If the ring is held down for a moment or two, it will get very hot, because of the heavy currents flowing in it. In fact if the ring is made in the form of a trough, and water is placed in it (be careful not to dampen the main coil!) boiling is soon observed—you have made an induction heater!

While performing the experiments with the mains on, the coil may get hot also. A precaution would be to switch off and test for this, and allow to cool if necessary.

PRACTICAL INDUCTORS

As in the case of capacitors, inductors are made in a variety of ways. You can see large iron cored chokes, used to assist in producing a steady, smooth direct current (d.c.) from varying or rippling supplies. (Remember the effect of self-inductance—it *opposes* the changes in current.) Also termed inductors are the tiny coils in cans no bigger than a little-finger nail, such as are used in transistor radio receivers.

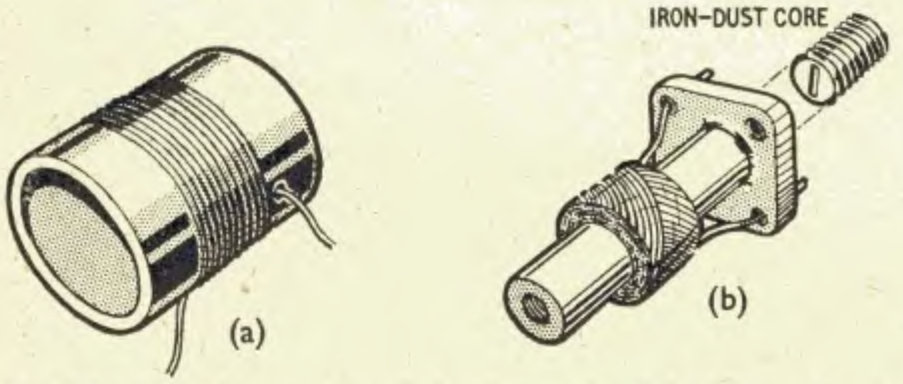


Fig. 9.3. An air-cored coil is shown in (a). The wire is wound around a tubular former made of cardboard or plastics material. An example of wave-winding is given in (b). This particular inductor is fitted with an iron-dust core—shown here completely withdrawn from the coil former

The large chokes and power transformers are wound with thousands of turns of wire and the core is made up of shaped iron pieces called laminations. These laminations are interleaved to form a large bulk of iron in and surrounding the coil. Many Henries of inductance are achieved in this way. The use of laminations is very important, as we shall see when talking about alternating current later.

Much smaller transformers, still constructed by the same methods as the large patterns, are found in electronic equipment. These smaller components are used to couple signals from stage to stage in amplifiers, to couple loudspeakers and some microphones to the amplifier, and for other jobs such as producing the "time base" deflection for television cathode ray tubes.

AIR-CORED COILS

Then there are air-cored coils, often found in tuning circuits of radio equipment. These are made in two ways. The first is by winding a layer of wire along the former, then fixing it with wax or a cement (see Fig. 9.3a).

The other method is known as wave-winding, and is always carried out on a machine. The wire is laid out zig-zag fashion, and forms a neat, compact "pie". This is illustrated in Fig. 9.3b. You may note that balls of string are often wound in the same way.

By varying the number of turns, the inductance can be changed. It usually ranges from five microhenries or so to perhaps a couple of millihenries in this type of inductor.

IRON DUST CORES

Many modern high frequency coils and transformers have iron cores again, but this time sheets of iron are not used. Instead a moulding of *iron dust*, or the ferrite material mentioned before, is found in these devices. Perhaps you have seen one of the most common of these, the "ferrite rod" aerial coil in modern radio receivers. Once again, it is vital to use iron dust or ferrite, and not solid iron. One advantage of these coils is the ease with which the inductance can be changed—by simply moving the core in or out of the winding.

Right back in the early days of radio, inductors were very large physically, being mostly wound on cardboard tubes about three inches diameter, or as "basket" coils. The tiny size of the present day high frequency inductors is mainly the result of the very efficient iron dust and ferrite cores just mentioned.

SKIN EFFECT

The greater the number of turns on a coil, the greater the resistance, therefore the worse the performance as an inductor. The high frequency a.c. resistance of coils is not the same as the low frequency, or d.c. value. This is because when the current changes rapidly enough, it begins to flow in the outer "skin" of the wire only (see Fig. 9.4). This is called, as you will probably think obvious, the *skin effect.*

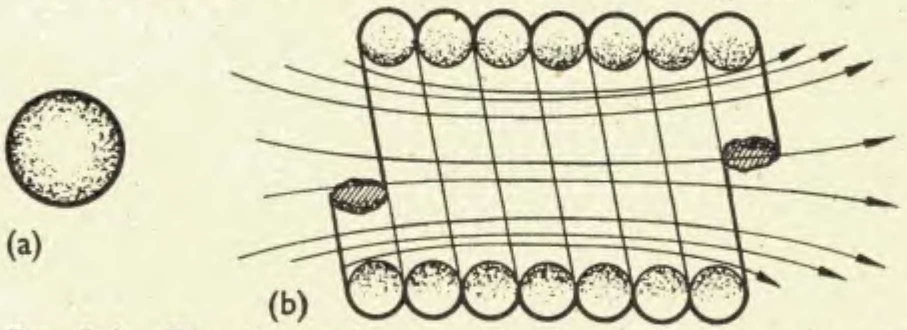


Fig. 9.4. The illustration on the left (a) represents the cross-sectional area of a piece of copper wire. It indicates how the current tends to flow more and more in the outer surface of the wire as the frequency increases. This phenomenon is known as the skin effect, and is further illustrated in (b) which is a sectional view of a coil

Many dodges have been thought up to help overcome this effect. One is the silver plating of coils carrying high frequency currents. Another is the use of "litz" wire. This is a shortened form of the German word Litzendraht which means *many stranded.* This type of wire is composed of many strands of wire, and each is insulated from its neighbour. Thus the current is divided among these strands. Due to the lower value of current flowing through each individual strand, this results in a better performance than the corresponding single wire as the effective resistance is lowered.

Another effect of importance in the construction of inductors is the self-capacitance. Each turn of wire forms a "plate" of a small capacitor with the adjacent turns. It is usually undesirable to have this "built-in" capacity, so steps are taken to reduce it.

By spacing the turns, the capacity can be reduced, but care is necessary should a varnish or dope be painted on the coil to fix the turns. Remember that the dielectric constant of materials such as these will tend to increase the capacitance. The ferrite cores employed in modern coils allow far fewer number of turns for a given inductance, so that a gain in performance all round is achieved—less resistance and less capacitance.

NEW PRODUCTS

New Tape Recorder

The Ferrograph Co. Ltd., 84, Blackfriars Road, London, S.E.1.

Whilst still keeping to the established conservative appearance of the Ferrograph tape recorders the above firm have finally made concessions to the demands for a more modern designed cabinet.

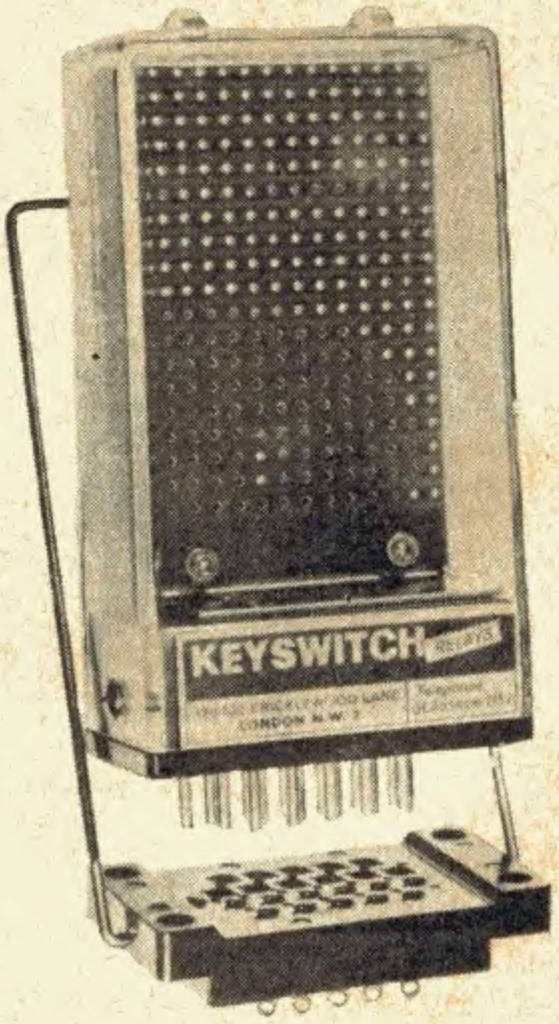
The new series 6 range of tape recorders are housed in two-tone grey cases with metal trimmings to withstand rough treatment. The tape deck and electronic stages are in no way changed.

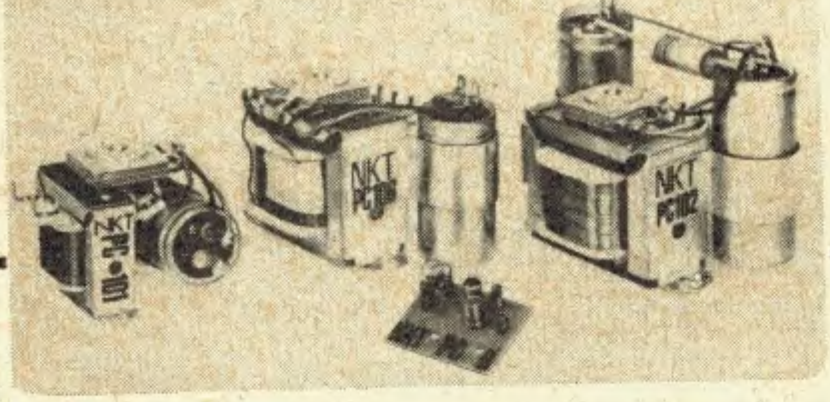
Plug-in Component Board

Keyswitch Relays Ltd., 120-132, Cricklewood Lane, London, N.W.2.

Puzzled by a large demand for their transparent dust covered units type P33, but without the relay, Keyswitch Relays Ltd. discovered that the plug-in base and dust cover was being used for module units which could easily be replaced by stand-by units in cases of damage. The damaged units can then be serviced later when convenient.

The outcome is that Keyswitch Relays are now producing their own plug-in component board units. Our photograph shows the complete unit with a laminated wiring board mounted inside the dust cover.





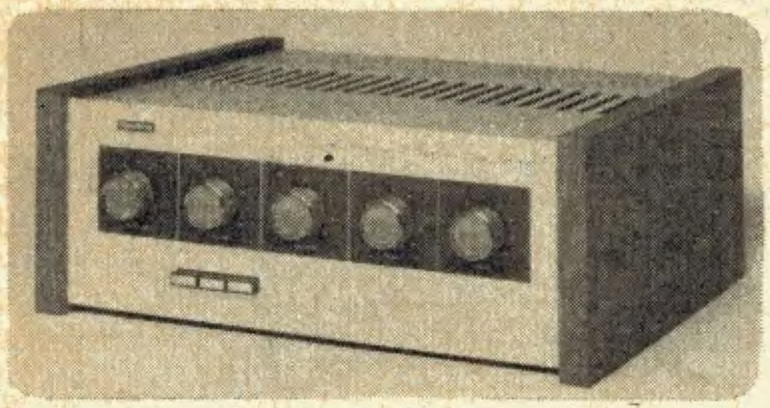
Packaged Circuits

Newmarket Transistors Ltd., Exning Road, Newmarket.

Four additions to the range of packaged circuits produced by Newmarket's are three mains power packs and a single-stage transistor amplifier; these are shown in our photograph.

The PC9 amplifier is designed to match high impedance transducers, such as capacitor sensing elements or ionisation gauges, to the low input impedance of standard range of amplifiers.

The mains power supplies are also designed to power standard amplifiers and their ratings are as follows: the PC101 gives 12 volts at 250mA, the PC102 21 volts at 330mA and the PC106 12 volts at 500mA.



Intergrated Stereo Amplifier

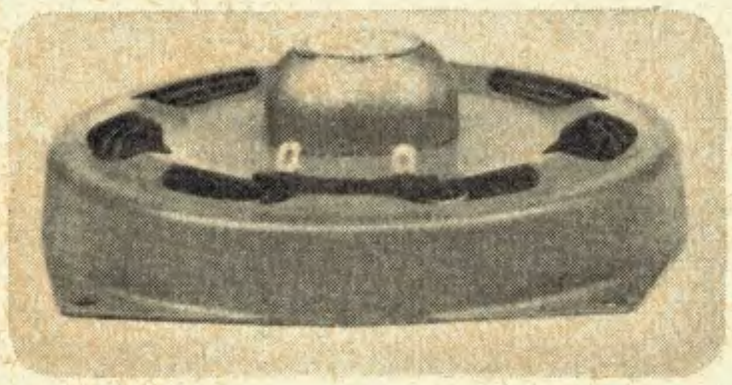
Armstrong Audio Ltd., Warlters Road, London, N.7.

Our photograph shows the new stereo amplifier type 221 which was first demonstrated at this year's Audio Fair. The 221 amplifier design is based on the less expensive 222 model but has additional facilities such as inputs for magnetic pick-ups, treble filter, tape monitoring, and a switched "loudness" control. The price of this amplifier is £33 15s. 0d.

Five-inch Inverted Cone Loudspeaker

Goodmans Industries Ltd., Axiom Works, Lancelot Road, Wembley, Middlesex.

Of particular interest is the 5in inverted cone loudspeaker shown in our photograph below. The cone is mounted in reverse compared with conventional types with the speech coil and magnet mounted in the concave section of the cone. The reproduction qualities are in no way hampered by this arrangement as the back of the cone reproduces sound just as well as the front. The great advantage is that the speakers are kept to a minimum depth and are ideal for building into shallow columns.



Electronic Piano-Organ

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

Just launched on the British market is the Philips "Philicorda", an electronic musical instrument of high quality and capable of being used for most kinds of music. Playing is simple and easily learned; yet the instrument has a number of features which will attract amateur and professional musicians.

The Philicorda, which is obtainable through any large musical instrument shop, is reasonably priced and small enough to be unobstrusive. It may be described as a modern version of the piano, but with greater range of possible variations in musical expression. It can produce music ranging from "classical" and "church" to current "pop" styles with remarkable authenticity.

The keyboard unit comprises 12 tunable Hartley oscillators which are completely stable and unaffected by temperature and voltage fluctuations. Frequency division is achieved by means of stable gas diodes.

The amplifier can deliver up to 3·5 watts into each of two built-in loudspeakers.

The instrument can be played in five different basic tones, or "voices", which can be combined with each other and with the three pitch ranges, thus giving a wide range of tonal colouring. The pitch switches enable a "two-foot", "four-foot", or "eight-foot" sound, or a combination of them, to be produced. The five tone switches produce a round mellow tone, a bright mellow tone, a "fill-in" tone at two foot pitch, a thin solo pitch and a full solo pitch. The vibrato switch introduces the tone to a modulation of 6c/s.

The instrument has facilities for earphones so that the player may practice without operating the amplifier unit and disturbing other occupants in the room.

Because of its small size and weight it is easily transportable even in a small car, so that it can be taken to parties, or other social functions. The keyboard unit weighs approximately 37 lb. The amplifier weighs approximately 25 lb including table.

Although the instrument is only quarter the size of an upright piano it has the equivalent of 73 keys, compared with 88 keys of a piano. The price of the Philicorda is 176 guineas.

VISIT TO SCIENCE MUSEUM

One Saturday in April twenty-five to thirty young readers met at the Science Museum, London. The first hour or two was spent in looking round the exhibits—this also enabled them to get to know one another of course! Then followed a conducted tour of the radio gallery to hear about some of the early methods and ideas concerned with wireless communication. After this the Lecture Hall became the centre of operations, and an attentative audience heard a fine account, with many vivid demonstrations, of "Signals in Space".

The Science Museum staff and lecturers, always helpful, must be thanked for their efforts in making this an entertaining and instructive day.

Footnote: This venture is something we feel could be repeated, with perhaps a few more suggestions from the keen boys who want to join in, so that even more ground could be covered. Also, there may be youth leaders or radio amateurs who would organise similar group outings—says organiser K Smith, G3JIX.

A group of the lads photographed before their tour of the Science Museum

• TRANSISTOR AND DIODE TESTER

An inexpensive unit that enables a series of d.c. tests to be performed.

• SIMPLE ANALOGUE COMPUTER

Mathematical operations such as multiplication, division, and the evaluation of powers and roots, can be carried out with this easy-to-build instrument.

• ELECTRONIC FLASH GUN (PART 2)

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ELECTRONIC BUILDING BLOCKS

PART FOUR

by R. A. DARLEY

WHEATSTONE BRIDGE

Most readers will recognise the circuit shown in Fig. 4.1a as that of the Wheatstone bridge, as used for measuring values of resistance. The circuit is re-drawn in Fig. 4.1b so that the method of operation can be easily understood. It can be seen that the circuit consists of two series pairs of resistors, fed from a common voltage supply. R1 and R2 form one series pair, R3 and R4 the other.

If the output voltage at the junction of R1 and R2 is measured it will be found to be a fixed proportion of the supply voltage, the actual value depending on the values of the two resistors. The two resistors act as a voltage divider network. If the values of R1 and R2 are 90 and 10 ohms respectively, the output voltage will be 1/10th of the supply. It is the *ratios* of the two resistors that dictate the value of the output voltage.

If the ratios of R1 and R2 are made the same as those of R3 and R4, the outputs of the two series divider chains will be equal. If points "a" and "b" are connected via a load as in Fig. 4.1b, no current will flow; this is indicated by zero reading on the microammeter.

It therefore follows that if R4 is made a variable resistor, which is then adjusted until no current flows through the meter (a condition known as "balance"), then at balance the ratios of R1 : R2 is known to be the same as that of R3 : R4. The meter is referred to as the "balance indicator" or "detector".

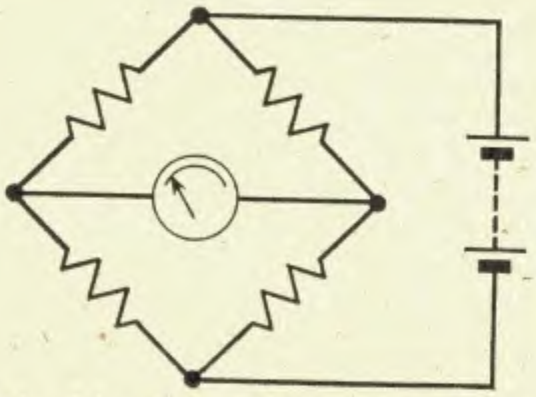


Fig. 4.1a. Simple Wheatstone bridge circuit

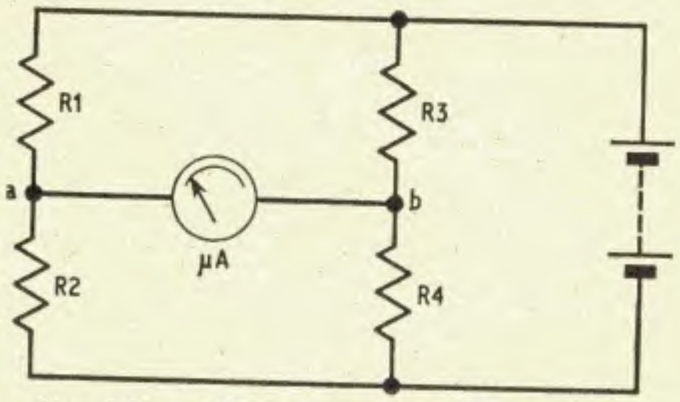


Fig. 4.1b. Alternative layout to show the voltage divider principle

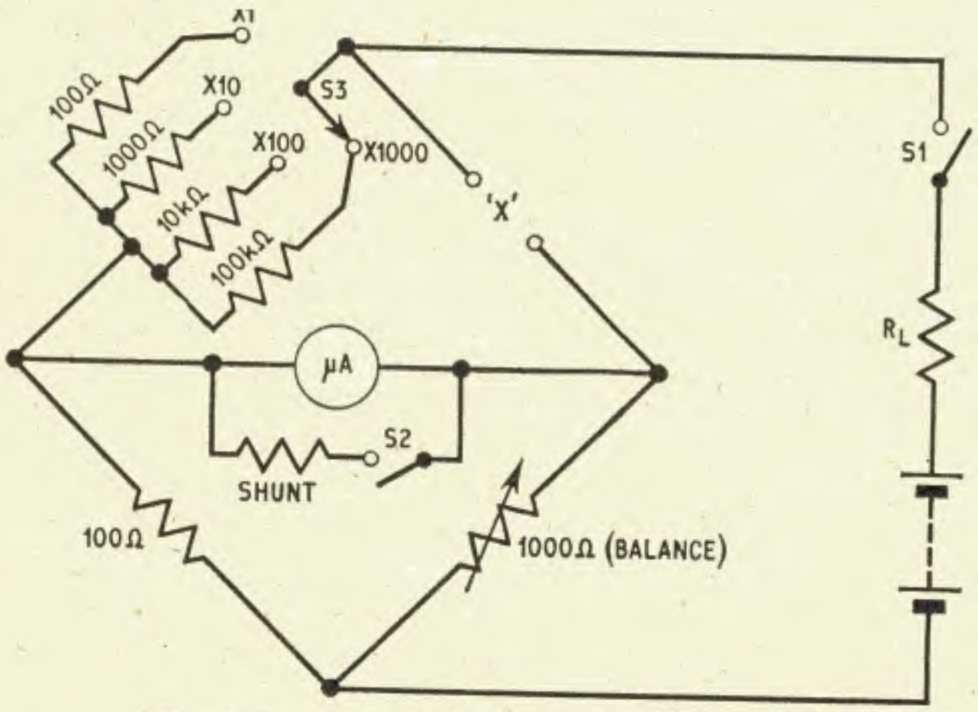


Fig. 4.1c. Practical circuit for measuring values of up to 1MΩ in four ranges

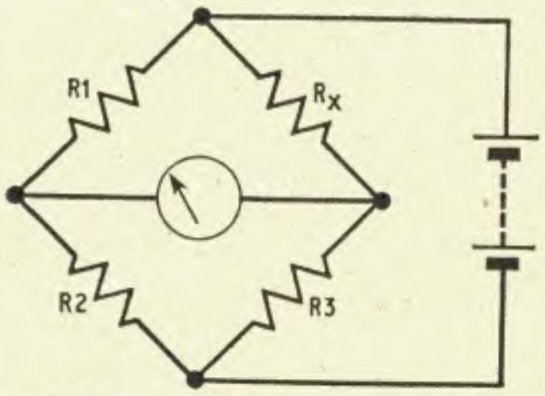


Fig. 4.1d. Illustration of accuracy when true value of all resistors is 100 ohms; the bridge is balanced. If R1, R2 and R3 are 1% types (i.e. R1 = 101 Ω, R2 = 99 Ω, R3 = 101 Ω) the value of R_x is 103 Ω. Therefore the error is 3%

At balance R1/R2 = R3/R4, and R1 × R4 = R2 × R3. From this expression the value of any one resistor can be found, given the values of the other three; for example R3 = (R1/R2)R4 at balance. Remembering that R1/R2 is a fixed ratio, it can be seen that the value of R3 is found by multiplying R4 by this ratio.

In a practical bridge circuit of this kind, R4 is either a calibrated variable resistor or a decade resistance box. R3 can be left out of the actual instrument and a pair of terminals substituted so that an unknown external resistor may be connected in its place. R1–R2, the "ratio arms", are made a precise decade value, and provision is usually made for changing the ratio by switching.

Fig. 4.1c shows the complete circuit of such a bridge, designed to measure from 0 to 1,000,000 ohms in four ranges. The variable resistor is calibrated 0 to 1,000 ohms, the four ranges being ×1, ×10, ×100, and ×1,000.

Switch S1 connects the d.c. supply to the bridge. Switch S2 switches a shunt across the microammeter, to reduce its sensitivity. To get a very sharp indication of balance a sensitive meter is needed, but when the bridge is greatly out of balance, currents of relatively high magnitude may damage the meter. It is necessary to make provision for adjusting the sensitivity of the detector, and this is the function of S2. S2 should be spring loaded so that the normal position gives the least sensitivity (with the shunt connected across the meter).

As an additional safety precaution, a limiting resistor (R_L) may be connected in series with the bridge voltage supply, to limit the maximum current drawn. With the bridge circuit described a *centre-zero* microammeter should be used as the detector.

A.C. BRIDGE CIRCUITS

It is not essential to use a d.c. supply; an a.c. supply can be used without altering the basic conception of the circuit. There may be some slight loss in accuracy, however, due to phase shift and reactances of the components, but if the supply frequency is kept low (say, less than 1kc/s), little loss in accuracy will be found. This scheme has the advantage that a pair of headphones may be used in place of the more expensive d.c. microammeter. The major drawback of this scheme is that it is not possible to use the bridge to determine the resistance of a reactive component, for example an inductor or capacitor.

If true accuracy is still to be obtained from the circuit when it is driven from a.c. the phase shifts must be taken into account. Hence the simple formula R1/R2 = R3/R4 must be replaced by $Z_1/Z_2 = Z_3/Z_4$ where Z is the impedance of the bridge arms. The bridge must be balanced for phase as well as magnitude. Hence we can measure the reactive components, and balance them against each other. Thus it is possible to use a modification of the Wheatstone bridge to read values of capacitance or inductance.

Fig. 4.2a shows a very much simplified version of a bridge for measuring capacitance. The "voltage divider" principle of the Wheatstone circuit is retained, but in this case the lower arm of each divider is replaced by a capacitor. The ratio of values now become $R_1 \times C_1 = R_2 \times C_2$. Therefore $C_1 = C_2\,(R_2/R_1)$ where the values of C1 and C2 are in the same units.

Note that in its finalised form, the frequency of the bridge source plays no part in the balance equation since any a.c. component here is common to both capacitors.

The simple circuit shown in Fig. 4.2a is, however, not practicable since there is no such thing as a *pure* resistance, nor a pure inductance or capacitance. Nevertheless, the exercise just carried out does illustrate that the frequency of operation does not necessarily have to be taken into consideration. In the case of the capacitance bridge, for example, most of the inherent stray components of a capacitor are due to series resistance or, to be more precise, an *equivalent* series resistance. In practice, this inherent series resistance can be balanced out by an artificial resistance placed in series with the capacitor in the complementary arm of the bridge; operating frequency is thus eliminated from the final balance equation. The de Sauty bridge, shown in Fig. 4.2b, uses this principle.

It may be desirable to find the values of these components, hence the "power factor", of a capacitor under test, and this can be calculated from the bridge component values at balance and the frequency of operation. Thus, in Fig. 4.2b, $\tan S = r2\pi f.C_s$, where $\tan S$ is the power factor.

This stray resistance can be represented as a parallel component as well as a series one, and some bridges operate on this basis. Their balance formula is thus modified.

Inductance could be measured, in theory, by replacing the capacitors in Fig. 4.2a by inductances, but this would hardly be practicable, bearing in mind the difficulty of obtaining perfect winding with minimum strays over a wide range of values.

Fortunately, an inductance can be regarded as a negative capacitance where phase is concerned; one has a positive, and the other a negative phase shift. In practice an inductance can be balanced against a capacitance in the *opposite* arm of the bridge. Series resistance can be allowed for in the way already outlined for the capacitance bridge.

Figs. 4.2b to 4.2g illustrate six of the most widely used a.c. bridge circuits, together with the relevant balance equations.

STRAY CAPACITANCE

As well as the characteristics of resistance, capacitance and inductance that are inherent in any individual component, there are also similar unwanted "strays" in any complete circuit.

The most pronounced way in which stray capacitance will effect a circuit is to "shunt" individual components. In the case of a bridge circuit, each of the four arms will be shunted by a small stray capacitance due to close wiring, but may be in the order of a few picofarads. One way to counter the effect of strays, therefore, is to ensure that the reactance of each arm is low compared to that of the stray. This can be accomplished in either of two ways: by care in the selection of components, or by limiting the operating frequency to a fairly low value.

In the case of home constructed LCR bridges for general use, the effect of strays can usually be ignored, providing the frequency of operation is kept below about 1kc/s, and no resistors greater than about 1 megohm, or capacitors smaller than about 1,000pF, are used in the bridge arms.

A point that should be clear is that, in the case of the home built LCR bridge, measurements of capacitors below a few hundred picofarads can be expected to show a high percentage of errors, the error increasing as the capacitance decreases, until, with no external capacitor connected across the "X" terminals at all, a reading of about 15pF may be obtained.

In some cases it is necessary that the frequency of operation should be kept high, often in the r.f. range. The methods of countering strays outlined in the preceding section cannot be applied. A partial solution to the problem is to screen all the bridge components, and earth part of the bridge, as shown in Fig. 4.3. The effect of the strays can then be allowed for in the calibration.

THE WAGNER EARTH

Although it is not practical to earth both the source and detector, it is possible to balance both points to earth potential, and effectively obtain the same results, without having them both earthed. Fig. 4.4 illustrates the principle involved, the circuit being known as a Wagner earth. The position of the balance control will depend on the ratios of the bridge arms. It will be necessary to balance the Wagner earth on each range of the bridge. The earth balance and bridge balance controls are used in conjunction in a practical instrument, and the final balancing can be quite an involved operation.

Fig. 4.2a. Simple capacitance bridge. Detector D may be an a.c. meter or headphones

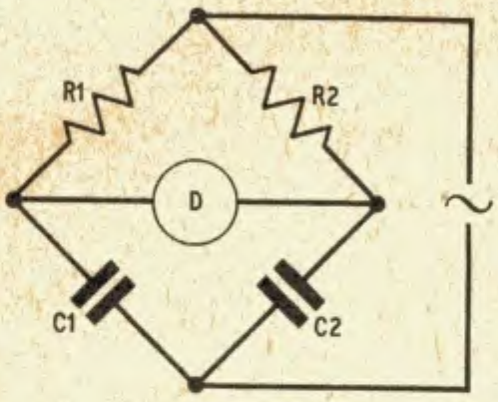


Fig. 4.2c. Schering bridge

$$C_x = C_1\frac{R_2}{R_1};\quad r_x = R_1\frac{C_2}{C_1}$$

$$\tan S = R_2 \times C_2(2\pi f)$$

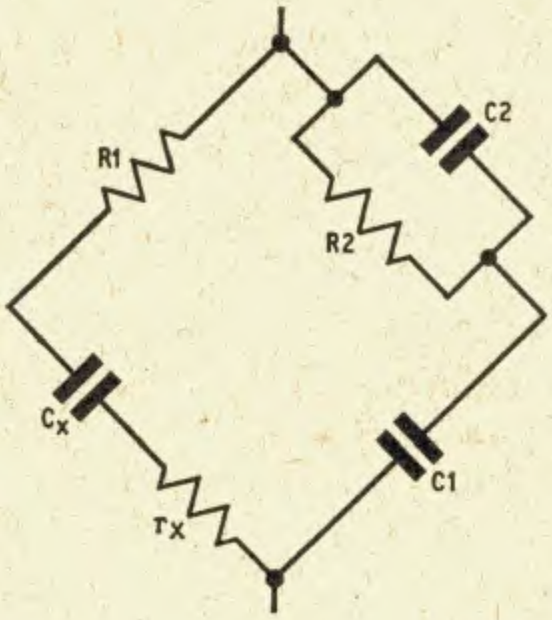
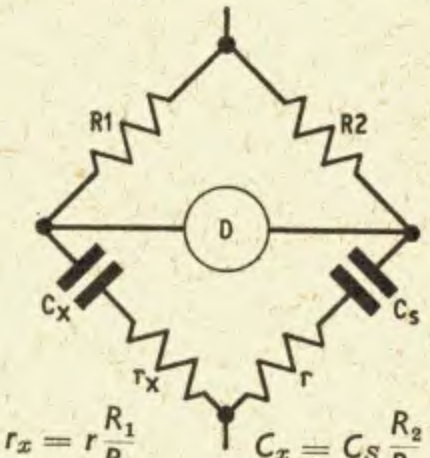


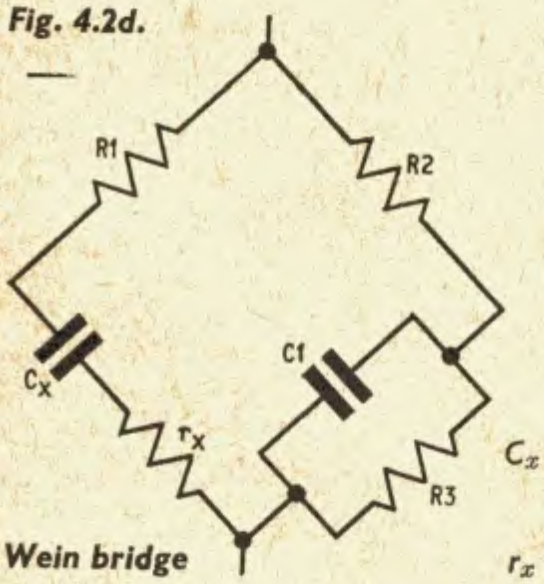
Fig. 4.2b. de Sauty bridge



$$r_x = r\frac{R_1}{R_2}\qquad C_x = C_S\frac{R_2}{R_1}$$

$$\tan S = r2\pi fC_S$$

Fig. 4.2d.



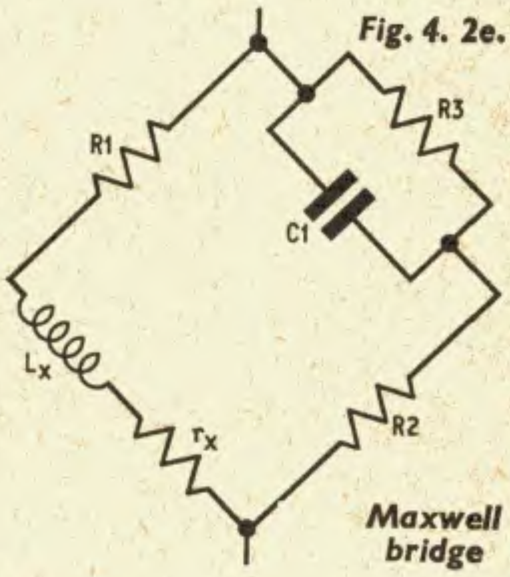
Wein bridge

$$C_x = C_1\frac{R_2}{R_1}\left[1 + \frac{1}{(R_3 2\pi f C_1)^2}\right]$$

$$r_x = R_3\frac{R_1}{R_2}\left[\frac{1}{(R_3 2\pi f C_1)^2 + 1}\right]$$

$$\tan S = \frac{1}{R_3 2\pi f C_1}$$

Fig. 4. 2e.



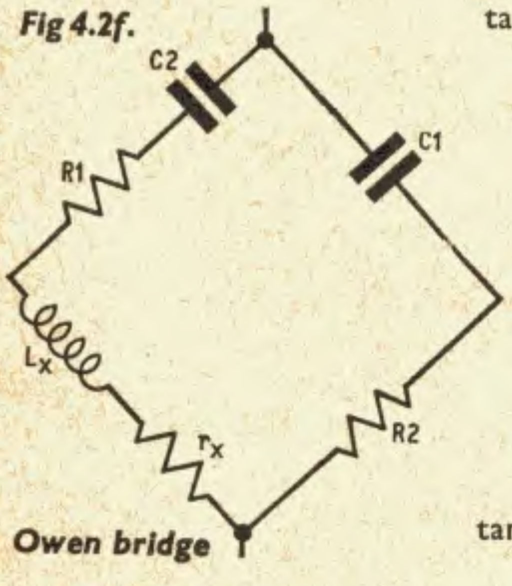
Maxwell bridge

$$L_x = R_1R_2C_1$$

$$r_x = \frac{R_1R_2}{R_3}$$

$$\tan S = \frac{1}{R_3 2\pi f C_1}$$

Fig 4.2f.



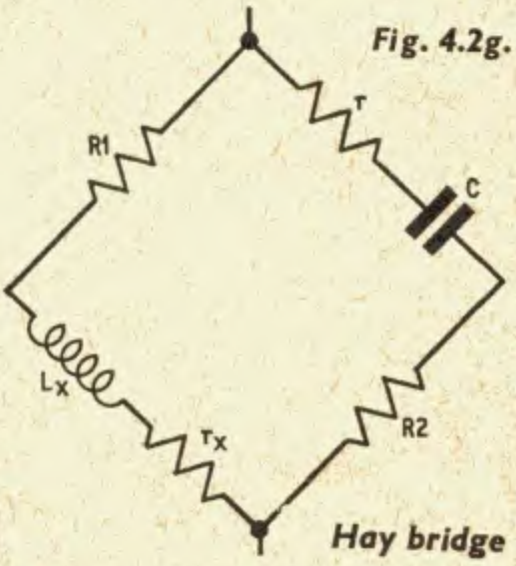
Owen bridge

$$r_x = R_2\frac{C_1}{C_2}$$

$$L_x = R_1R_2C_1$$

$$\tan S = \frac{1}{R_1 2\pi f C_2}$$

Fig. 4.2g.



Hay bridge

$$L_x = \frac{R_1R_2C}{1 + (r2\pi fC)^2}$$

$$r_x = \frac{R_1R_2r(2\pi fC)^2}{1 + (r2\pi fC)^2}$$

$$\tan S = r2\pi fC$$

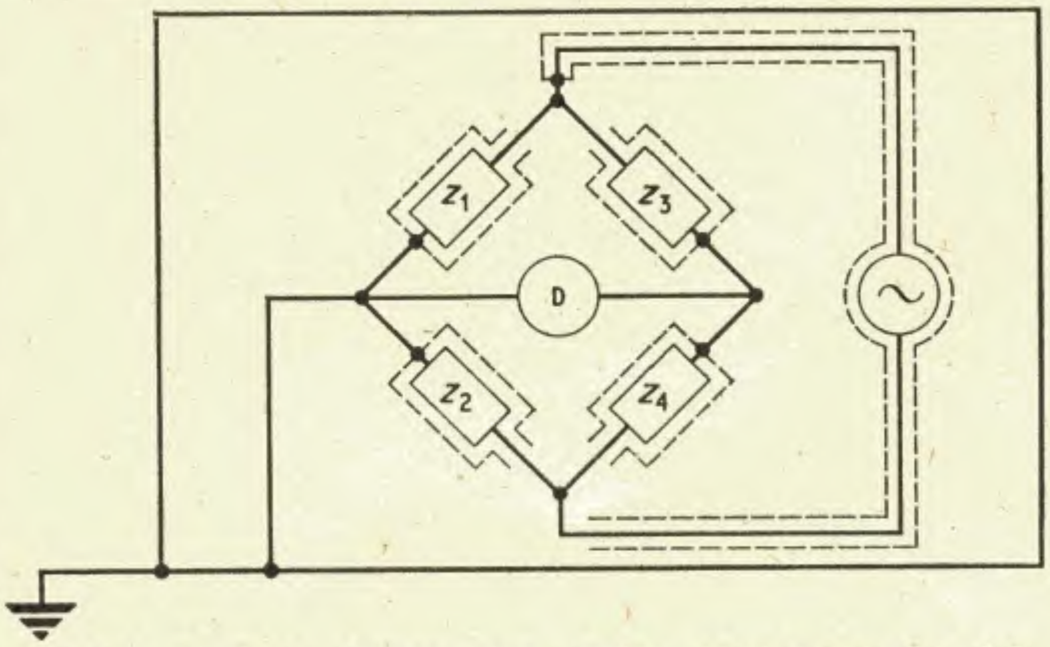


Fig. 4.3. Method of screening bridge components for h.f. measurements

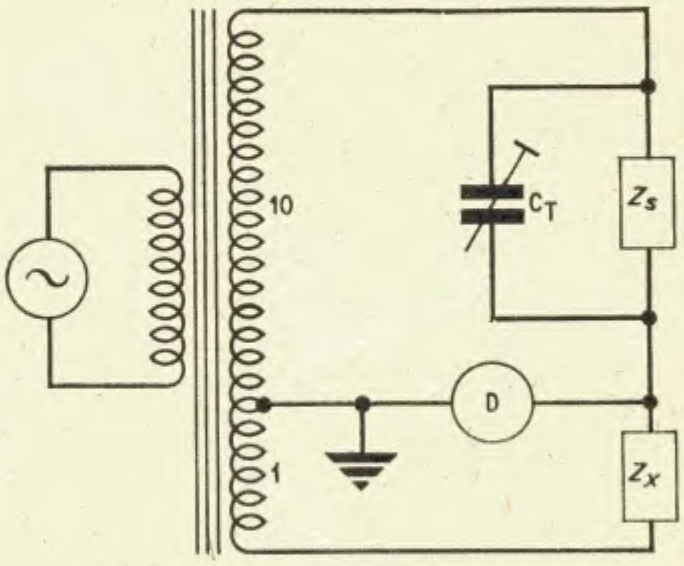


Fig. 4.5. Transformer ratio arm bridge using the same basic principles as other bridges

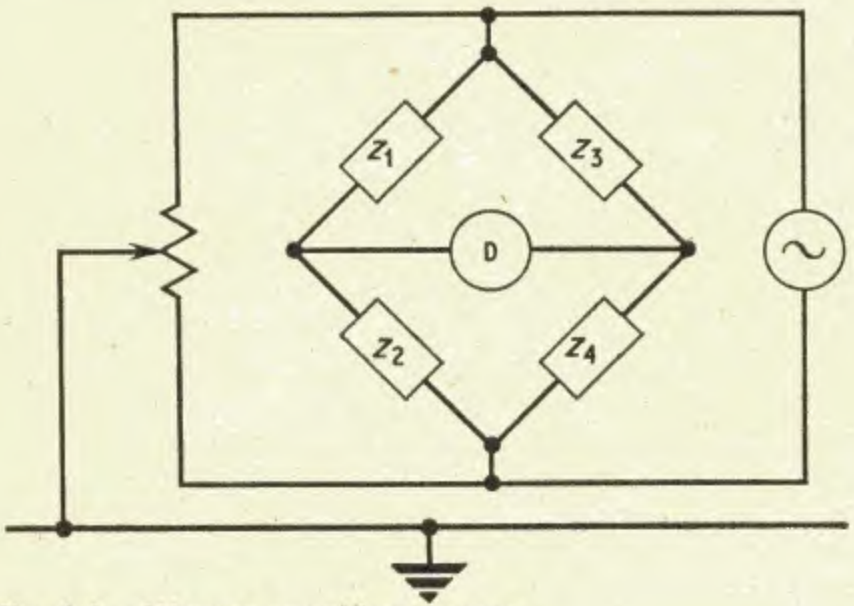


Fig. 4.4. Wagner earthing system

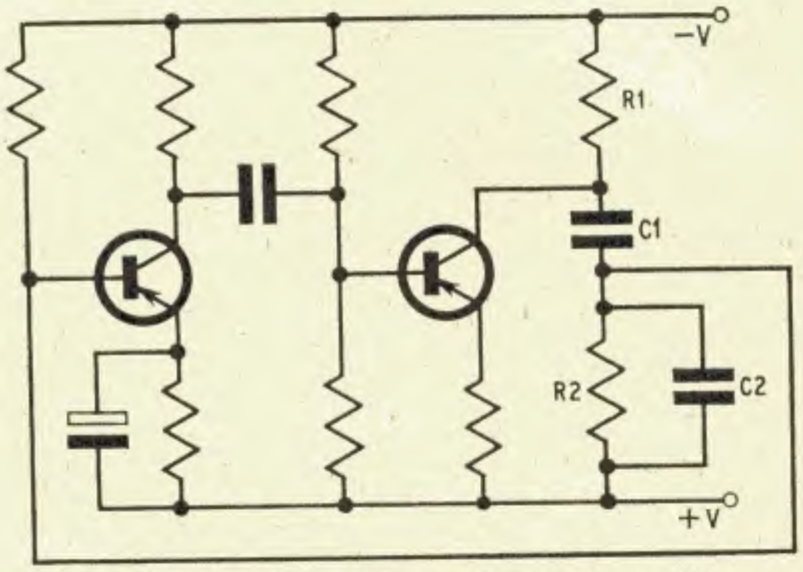


Fig. 4.6. Basic Wien bridge feedback oscillator. Frequency determined by balance of R1C1 : R2C2

THE TRANSFORMER RATIO ARM BRIDGE

There is no reason why one pair of ratio arms should not be provided by a tapped transformer winding, as shown in Fig. 4.5. By connecting the tap to earth, as shown, an automatic Wagner earth is obtained.

The voltage developed across a transformer winding depends on the current flowing through it and number of turns. As far as the secondary winding is conconcerned, it can be expected that 99·99 per cent or more of the flux will be shared by all turns. The possibility of errors in the voltage ratios between one part of the winding and another from this source can be ignored, even in a badly wound transformer. The voltage ratios thus rely on the number of turns in the winding, and these can be wound to an accuracy of 0·01 per cent with little difficulty. Once wound, the ratios do not alter.

If a transformer bridge is used with a 1 per cent standard in the remaining bridge arm, the overall accuracy of the bridge will be 1 per cent, compared with 3 per cent of the conventional bridge (see Fig. 4.1d).

The only other possible cause of error in the voltage ratios of the transformer is the voltage drop across the windings due to their inherent resistance. The resistance of the windings should therefore be kept low compared with the impedance of the load.

Stray capacitance across the winding will make no difference to the ratios, of course, but they will effect the remaining standard. Any stray capacitance across the "X" terminals can be balanced out by a trimmer capacitor, C_T, in the opposite arm.

A single winding can be wound with a number of tappings, the highest giving a ratio of 100 : 1 with little difficulty. Two such transformers can be coupled to give an overall bridge ratio of 10,000 : 1.

Using the transformer ratio arm bridge, capacitances as small as 0·0001pf can be measured quite easily. The bridge can also be used to measure inductance and resistance.

Reference to Fig. 4.2d shows that the balance of the Wien bridge depends on frequency, as well as component values. It follows, then, that given any particular combination of component values, the bridge will be selective to a particular frequency. The circuit can thus be used as a filter, and is most widely used as a frequency selective network in the well known Wien Bridge feedback oscillator, an example of which is shown in Fig. 4.6.

NOTE: The diagrams of Figs. 3.2b and 3.3g in last month's article should be interchanged.

Next month: Design criteria of simple transistor circuits.

SIMPLE INFRA-RED RAY DETECTORS

By E. V. KING

Fig. 1. Simple infra-red ray detector with probe attached. The extension lead with photocell probe is shown in the foreground

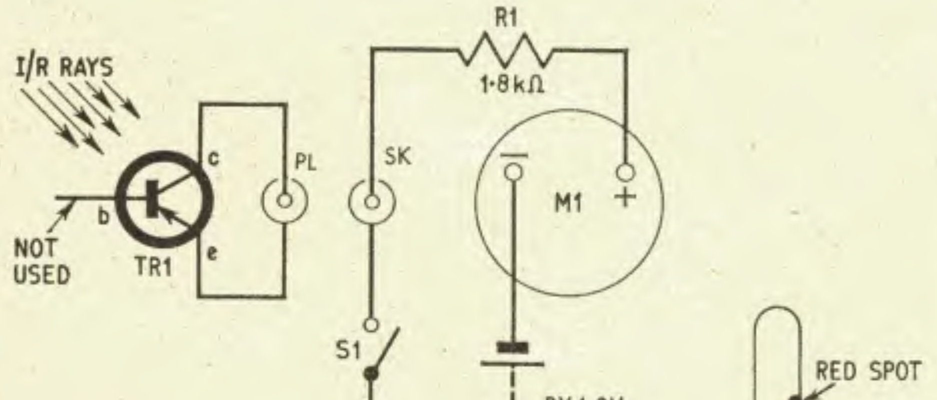


Fig. 2. Circuit diagram of the simple detector. Note the coaxial connections

IN THE past infra-red rays have usually been detected by delicate thermometers or thermopiles which operate as a result of a rise in temperature due to the incident rays.

The instruments to be described do actually detect the rays and do not rely on heating for the effect. Thus, they give a much quicker detection and some external heating can be tolerated without false readings. The detection of infra-red rays is useful when sighting overhead infra-red heaters in bathrooms and kitchens for they can be swung about with the detector in various positions and the effect noted quickly. The detector is particularly useful when setting up infra-red burglar alarms, infra-red photography, or in experiments with image converters.

BASIC CIRCUIT

A simple detector shown in Fig. 1 will be described first. The basic circuit, as shown in Fig. 2, comprises a photo-sensitive transistor, a moving coil meter (1mA f.s.d.), a series resistance, and a d.c. supply. A more sensitive arrangement using two transistors is described later. A photo-sensitive transistor such as an OCP71 is ideal but an OC71 can sometimes be used if the black paint is scraped off; this applies only to older production versions. The circuit is so simple that little need be said about it.

The photo-transistor is sensitised by the rays which fall upon the base-emitter junction, modulating the current flowing through it. Since the rays are basically an a.c. form of energy they need to be rectified to give an accurate reading on the meter. The transistor itself, being a semiconductor device, has its own built-in rectifying action. The base of the transistor acts as a conveyor of electrons and in this application does not need to be held to a specific potential.

SIMPLE DETECTOR UNIT

All that need be housed in the box of this simple version is the meter, battery, resistor and switch. The photo-transistor can be mounted in the end of a probe; a discarded ball pen case is suitable for this. The transistor could be mounted on a coaxial plug so that it can be used on the box or on an extension lead (see Fig. 1).

If the photo-transistor is fitted to a coaxial plug the collector lead (wire nearest the red spot) is fitted with some insulating sleeving and soldered to the centre pin of the plug. The emitter wire is gripped in the casing jaws and base is left unconnected. It is best to insulate the base wire completely so that it will not touch either of the other two connections.

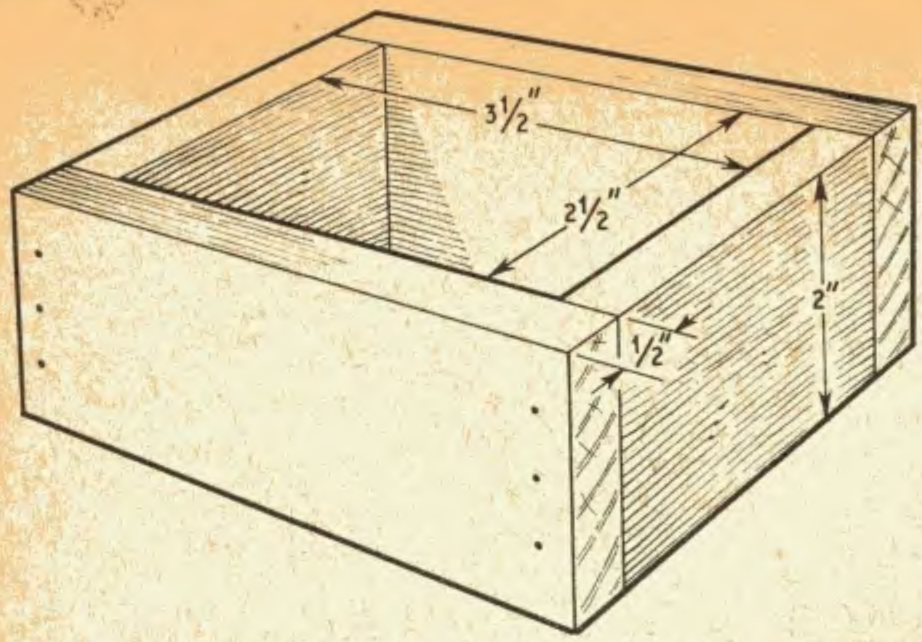


Fig. 3a. Box dimensions for the simple detectors

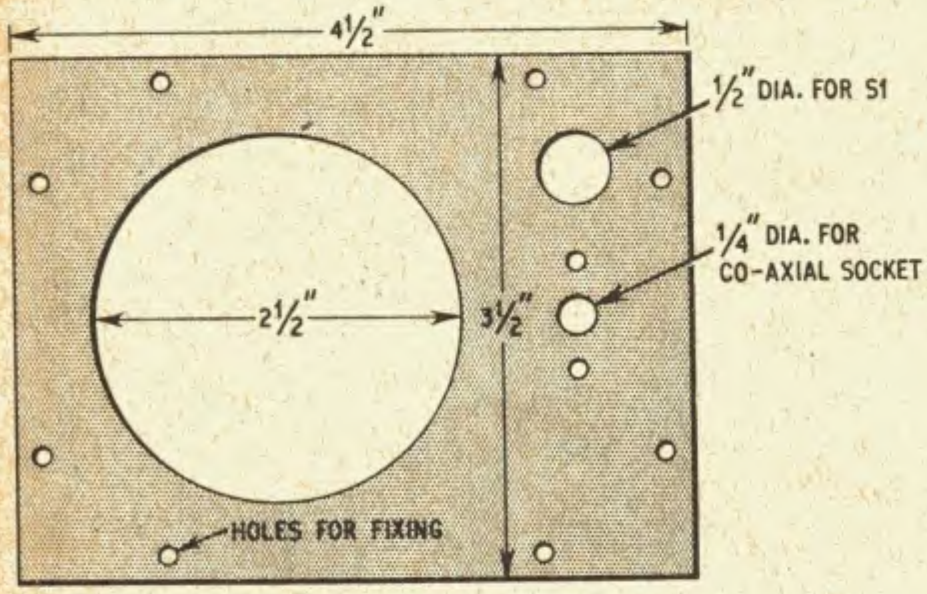


Fig. 3b. Front panel for the simple detector

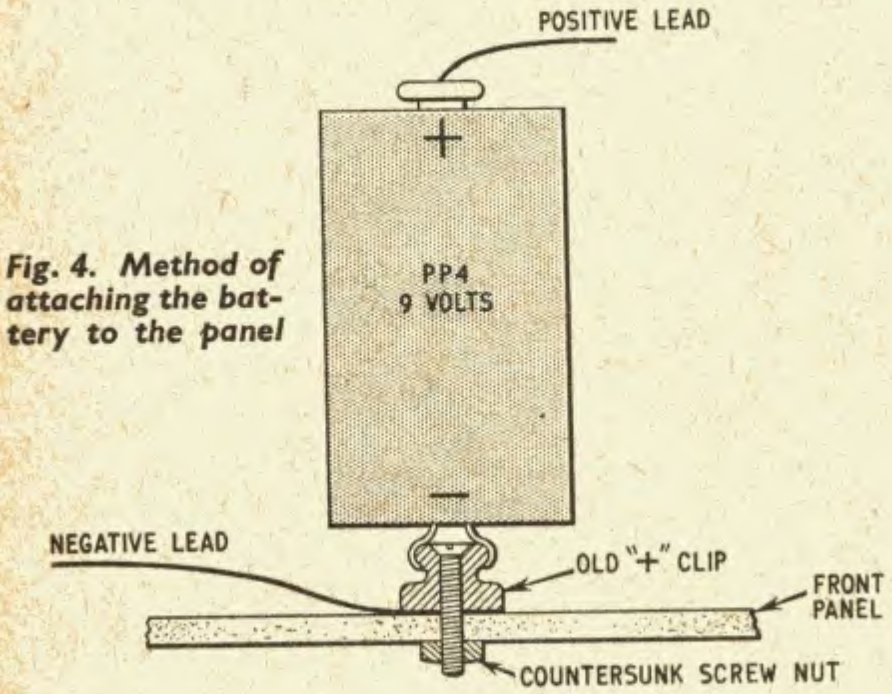


Fig. 4. Method of attaching the battery to the panel

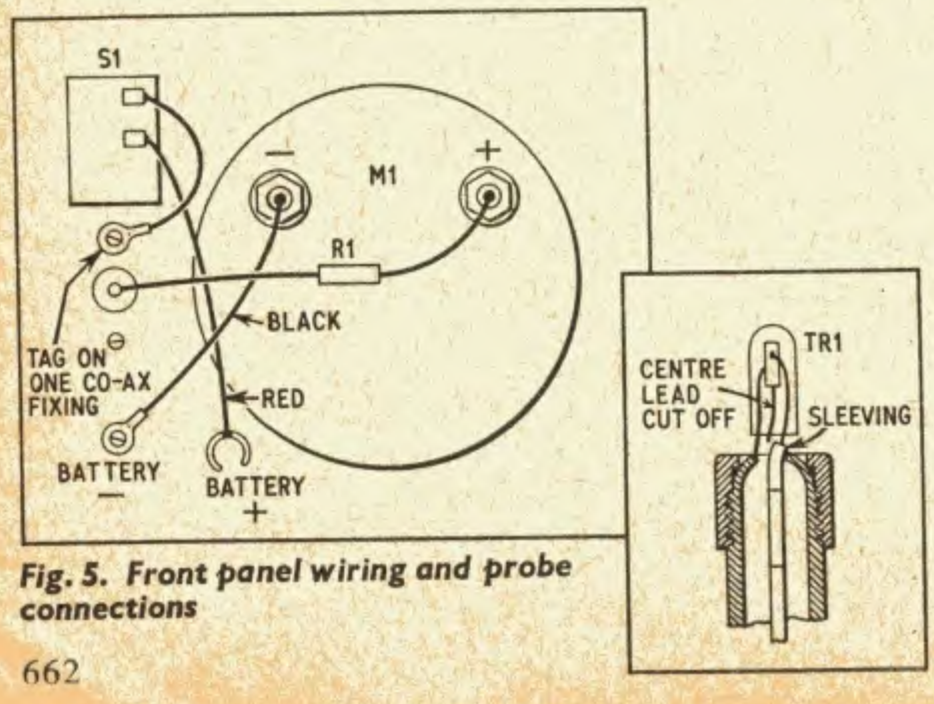


Fig. 5. Front panel wiring and probe connections

The prototype box was made from wood as shown in Fig. 3a. The drilling details of the front panel, which can be hardboard, plywood or laminated plastic, are shown in Fig. 3b. If the components used differ physically from those specified the holes should be modified accordingly.

A plug connector, which fits the negative terminal of the battery, is screwed to the inside of the front panel so that the battery can be fixed in position without an additional clamp (see Fig. 4). The internal wiring is shown in Fig. 5.

MORE SENSITIVE

A more sensitive instrument is shown in Fig. 6 with a circuit diagram in Fig. 7. The principle of operation is similar to that of the simple version except that an additional d.c. amplifier stage is incorporated. A variable resistance (VR1) is connected across the meter to prevent the higher readings overloading it.

Fig. 6. Sensitive infra-red ray detector with probe connected by a twisted pair of wires and wander plugs

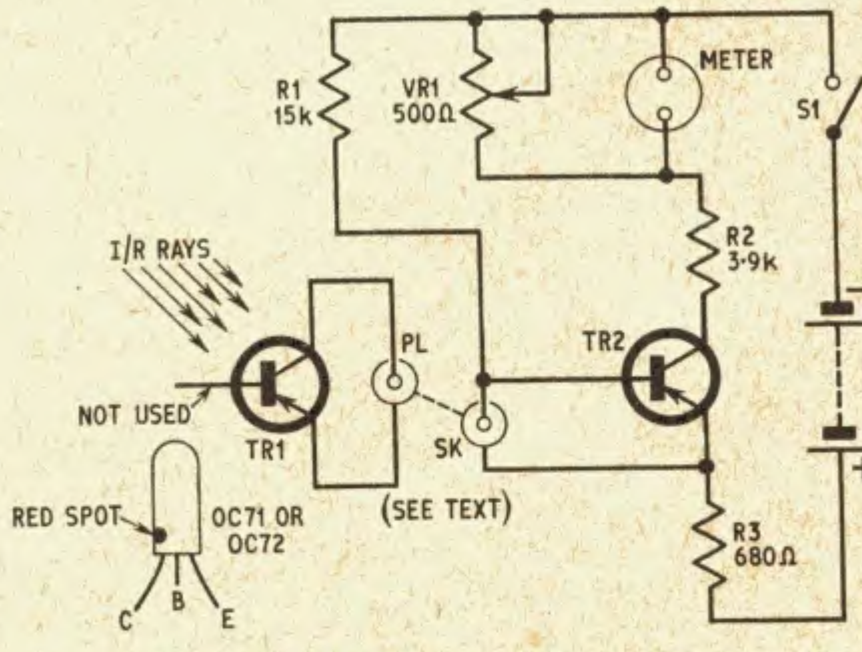


Fig. 7. Circuit diagram of the sensitive detector with probe connections shown in coaxial form

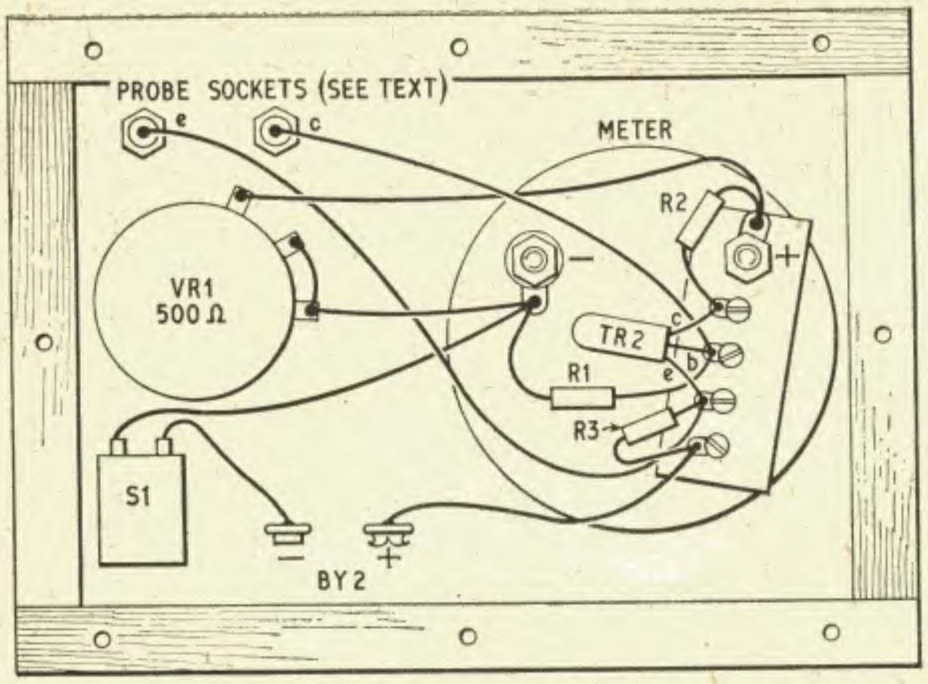


Fig. 8. Wiring diagram of the sensitive detector. The box is similar to that for the simple detector except that the layout on the front panel is adjusted to accommodate the potentiometer

Construction of this model can be on similar lines as in the previous one, but allowance should be made for the additional potentiometer on the front panel. As shown in the photographs the coaxial socket on the simple version is replaced by a pair of wander plug sockets, but there is no reason why the coaxial socket should not be used in this model. Wiring details are shown in Fig. 8.

INFRA-RED PROBE

The probe was made with a ball-point pen case, but here again the same probe as in the simple version can be used.

Where a probe is required to detect infra-red light only, where other forms of light are present, the probe should be fitted with a filter such as an Everine tile. This can be heated and moulded to form a "glove" which completely encloses the photo-transistor. A fairly high temperature will be required to do this and it is best to wear asbestos or leather gloves. A gas ring or bunsen burner can be used to heat the tile, but do not let it get so hot that it is unmanageable. The important point to remember is to mould the shape very quickly and do not allow any pin pricks to appear. A probe made in this way is shown in Fig. 9a and fitted over a ball pen case shown in Fig. 6.

A more simple form of filter housing (shown in Fig. 9b) comprises a small box covered with a similar material.

TESTING THE SIMPLE INSTRUMENT

After all the wiring has been checked and is correct the panel can be fitted to the case. Switch on and see that there is no deflection of the meter needle apart from a small kick caused by the initial surge of current. This should die quickly to zero. Cover the probe completely with a blackened can or box; plug the probe leads into the front panel socket. There should still be no deflection on the meter. Now uncover the probe and a deflection should be produced in ordinary daylight. The infra-red component of the light spectrum should produce a very large deflection on the meter. Reflected ambient daylight in a room should cause a deflection of about 0·4 of full scale. Full scale deflection should be achieved by placing an energised 100 watt tungsten filament lamp about two feet away from the probe.

Invisible rays may be picked up from an electric fire element immediately after switching it off. Although it is still hot and does not apparently glow, infra-red light rays will still be picked up. With the fire switched on and the probe held within a few feet of it, the meter should show full scale deflection.

TESTING THE SENSITIVE INSTRUMENT

After checking that the wiring is correct switch on and adjust VR1 to give a deflection of between 0·5 and 1·0mA. Cover the probe completely and plug in the leads. Now readjust VR1 so that the meter reads 1mA.

The smallest amount of incident light or infra-red will now cause the meter needle to be deflected backwards towards zero. The light from a match may be detected several yards away and an infra-red torch beam many scores of yards away.

This instrument is so sensitive that spurious infra-red light sources from toasters, fires, lamps, and even soldering irons can interfere with intended measurements.

If desired VR1 can be calibrated as a sensitivity control. The detector is not a linear measuring device but radiation intensity can be measured by comparative photometer methods.

INVISIBLE LIGHT

Infra-red is mostly present with visible light such as in an incandescent lamp, but invisible infra-red can be detected by using a suitable filter which may be obtained from a few high class photographic dealers. Since the author had some difficulty in obtaining one he found that a black plastic tile (such as "Everine" used in bathroom tiling) was quite suitable. This type of filter passes infra-red and stops visible light.

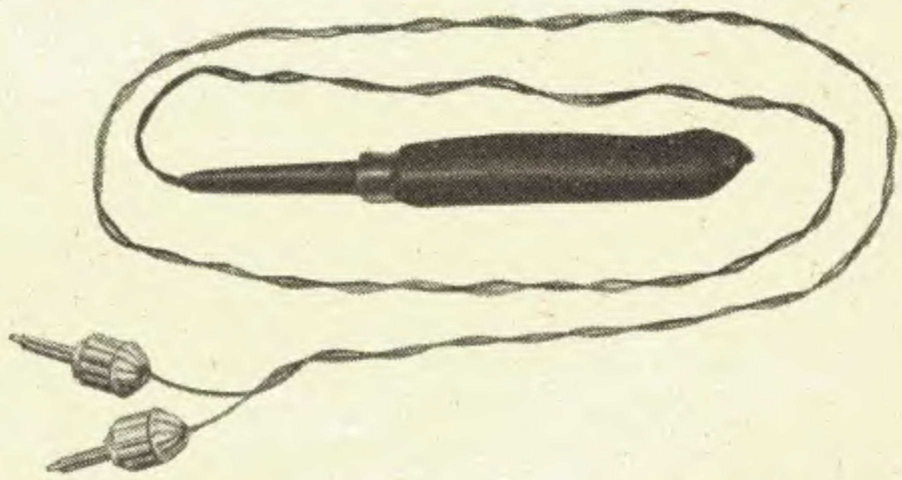


Fig. 9a. Probe made from a ball-pen case with an infra-red filter "glove" moulded round it

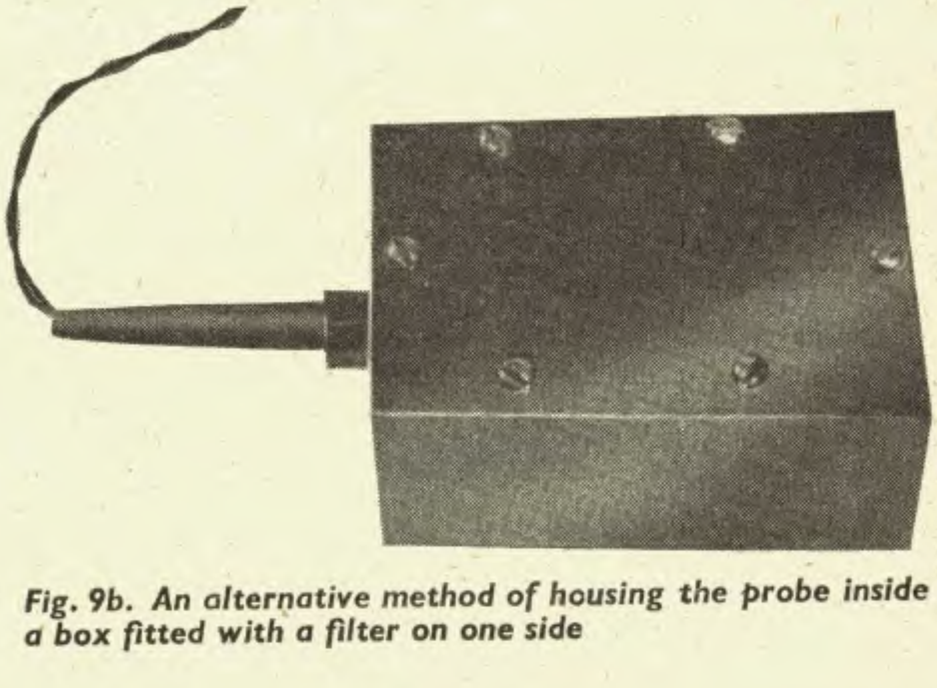


Fig. 9b. An alternative method of housing the probe inside a box fitted with a filter on one side

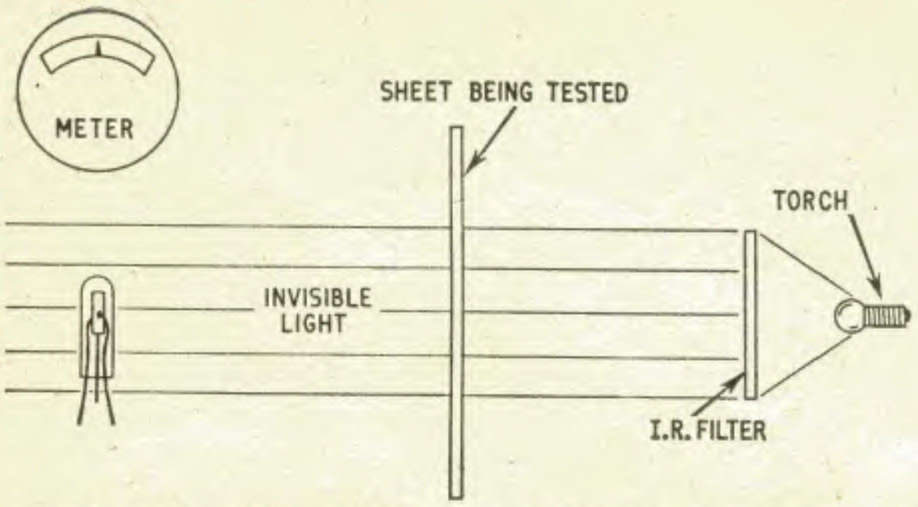


Fig. 10. Experimental set-up to determine the absorption properties of various materials

COMPONENTS . . .

SIMPLE DETECTOR

Resistor
R1 1·8kΩ ½ watt carbon ±10%

Transistor
TR1 OCP71 (see text)

Meter
M1 1mA f.s.d. moving coil

Switch
S1 Single pole on-off toggle

Battery
BY1 9 volts (Ever Ready type PP4 or similar)

Miscellaneous
Battery connectors, soft wood 2in × 0·5in × 18in long, two pieces of plastic laminate or aluminium 4·5in × 3·5in, two coaxial plugs and sockets, wire (see text)

SENSITIVE DETECTOR

Resistors
R1 15kΩ
R2 3·9Ω } ½ watt carbon ±10%
R3 680Ω

Transistors
TR1 OCP71 (see text)
TR2 OC72 *or* OC81

Meter
M1 1mA f.s.d. moving coil

Switch
S1 single pole on-off toggle

Potentiometer
VR1 500Ω carbon or wirewound, 2 watts or higher

Battery
BY1 9 volts (Ever Ready type PP4 or similar)

Miscellaneous
Battery connectors, soft wood 2in × 0·5in × 18in long, two pieces of plastic laminate or aluminium 4·5in × 3·5in, wander plugs and sockets or coaxial plugs and sockets (see text)

TEST SAMPLES

For probe, filters, etc., the following are suggested in the text: "Polytile S & S" or "Everine" black plastic tiles. Polytile ceramic tiles are not suitable

Some substances pass infra-red without much absorption; others absorb the rays. A simple experiment may be performed to illustrate this. Fig. 10 shows a set-up to find which materials will absorb infra-red rays. Before inserting the test piece in the light beam make sure that everything functions and a reading is obtained on the meter. Note that there will be a slight deflection of the needle due to ambient light before switching the torch on. Switch on the supply to the torch bulb and note the amount of increase in meter reading. For the purpose of this test an infra-red filter should be inserted in front of the torch bulb. Place a piece of material, such as plastic Polytile, Everine, Formica, thin sheet rubber, or Bakelite between the lamp and probe. You will notice that the meter needle will rise indicating that these substances pass most of the rays. Now insert some other materials one at a time. Try a lino tile, vinyl floor tile, half-inch thick wood; you will notice that these do not pass infra-red rays. Further experiments can be carried out with bottles of copper sulphate solution, iodine solution, methylated spirits, and coloured salts, often with startling results.

APPLICATIONS

Many uses can be found for these detectors. In the home they come in extremely useful where infra-red heaters are required to be concentrated with maximum benefit on one particular place. The meter can be placed where the operator can see the needle. The heater is then adjusted to a position whereby maximum light from it falls on the probe. ★

DETACHED PARTICLES

By John Valence

IT ALL DEPENDS . . .

Is it electronic, or is it not? This particular query is often posed and arguments then ensue for and against the use of this word in connection with some piece of apparatus. I am sure we can all think of many borderline cases where the distinction between electrical and electronic cannot be clearly seen. For example, does the presence of a solitary diode warrant the description "electronic" being applied to a piece of apparatus that would otherwise be unhesitatingly called just plain straight forward electrical?

RING OFF

THERE is no doubt at any rate that the new de luxe telephone now being introduced by the G.P.O. is a legitimate electronic device, for this instrument incorporates a transistorised oscillator and small loudspeaker in place of the conventional bell. The "Trimphone" as it is called, emits a warbling note as a calling signal. From reports I have read it seems that the so-called warble is quite unlike that of any of the known species of bird, but use of this word suggests some nostalgia for the countryside on the part of a laboratory imprisoned engineer.

If the G.P.O. wants to be really enterprising it could spend some further time on research and development and then offer a choice of the lesser whitethroat, goldcrest, or the alpine warbler for a small additional charge.

I've never known the white-vented bulbul so far north as Hampstead

The entry of electronics into this particular field provides the Trimphone with a very definite advantage over its long established predecessor, for the subscriber can set the level of the calling signal from soft to loud by a volume control. But I wonder why they didn't think of providing a couple of terminals for wiring up to an external indicating device. Many people, I imagine, could make use of a remote indication when the telephone rings (sorry—"warbles"), and this might well be visual rather than audible. The connection of any such circuit would be against the existing regulations of course—however this might well be a reasonable case for modifying them.

ELETTRA III

IT seems that I have been guilty, albeit unwittingly, of slighting a lady. Permit me to offer here and now my apologies to *Elettra III* for referring to her as *a launch* a little while ago. No disrespect was intended. The use of this diminutive term was just an unfortunate lapse into slipshod writing I'm afraid. Also, further evidence of my lack of nautical knowledge. (I was in deep waters a few months before this you may remember.)

To make matters worse, I was at fault on two further counts: in misspelling the name of the vessel, and in transferring ownership (and without reference to Lloyd's Register), although I did at least keep her in the same family! Don't know what the Greeks might or might not have said, but indeed it seems as though trouble becomes Valence!

The Editor has passed on to me an interesting account of *Elettra III* received from her rightful owners, The Marconi International Marine Co. To help restitution of *Elettra's* true status as a sea going yacht, I will quote a few particulars from this official description. To start with, some vital statistics: length 82ft; breadth 20ft; depth 11ft; displacement 134·3 tons; cruising range 3,000 miles at 10 knots. Finally, I don't think it's an indiscretion to mention her age—3 years.

To landlubbers such as myself a better appreciation of the size of *Elettra III* is perhaps conveyed by the wide variety of electronic equipment installed in the special demonstration saloon on the main deck. This apparatus changes according to requirements and as new equipment is brought into production. Typically we might find on board the following: a couple of radar installations, a communications console, an emergency transmitter, auto-alarms, recording echometer, radiotelephone station, automatic direction finder, and v.h.f. control unit; all in order and capable of demonstration under seagoing conditions.

Apart from this impressive selection of marine electronics, there is a comprehensive work-a-day installation in the wheelhouse including depth indicator, rudder indicator, directional finding radiotelephone, automatic helmsman and radar.

BOY MEETS GIRL

AMONG the varied tasks given to a computer at the New York World's Fair was the choosing of compatible pen-friends for a hundred schoolboys from Trowbridge here in England. Forms giving the interests and hobbies of the boys were fed to the computer and matched up with similar data provided by American schoolchildren.

The computer set to work in its usual cool, calm and impersonal way. In due course (some microseconds later) it produced the required selection of suitable pen-pals. Lo and behold, all the English boys were paired with American girls. Reading this, thoughts came into my mind; of a new breakthrough in technology resulting in some electronic automaton with Freudian-like understanding of human weaknesses and an awareness of what makes the world go round. These thoughts were almost immediately shattered I regret to say. The true explanation for this mating was—wait for it—simply that most of the boys *asked* for girl pen-friends.

Readout—
A SELECTION FROM OUR POSTBAG

Tapespond anyone?

Sir—I would like to tapespond with a boy of my own age (14 years). My tape-recorder is a Phillips four-track model. It has a speed of 3¾in per second and all tapes will be answered. I am also a keen short-wave listener.

Colin Coker,
6 Lower Collins Road,
Totnes, Devon.

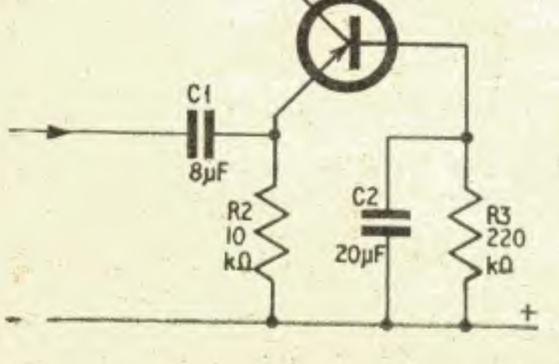
Configurative speech

Sir—When I wrote the fourth article in my series on *Semiconductors*, I said that, in the grounded base amplifier, all the transistor current flows through the base. This is, in fact, incorrect because the emitter current is the *sum* of the base and collector currents whatever the amplifier configuration. The circuit diagram is also incorrect.

In the correct circuit shown below the emitter current is divided between collector and base in the ratio of fifty to one.

In the same article I said that a valve cathode follower inverted the phase of a signal. Since the phase on the grid is the same as the phase on the cathode this also is incorrect. Please accept my apologies for these errors.

Charles Norman.



DX breakthrough

Sir—I would like to add my congratulations to the many you must have received concerning Practical Electronics. After the first three issues I had no hesitation in placing a standing order with my newsagent, and now look forward to each issue with great impatience to see what new projects you have lined up for us.

I find working with transistors most interesting and it is this feature of your magazine which is most attractive from my point of view.

One of the difficulties of living in New Zealand is in having to wait an extra six weeks for things to get here from the Old Country, so if ever you run any competitions or special offers you might spare a thought for your many readers overseas when planning closing dates.

G. H. Wilson,
Wellington,
New Zealand.

Sir—A wonderful discovery has been made here in Australia. It is your latest magazine, Practical Electronics.

At this time I would like to say thank you and congratulations on behalf of all Australians for such a splendid book. We have waited a long time for such a complete and comprehensive book in the field of electronics.

I left England in 1960 after spending 5 years with Pye of Cambridge. It is amazing the progress that has been made in electronics since then. Your magazine is progressive too, and very up to date.

It is such a terrific source of information that it is bought up immediately it comes on the newstands. The copies are jealously guarded by the customers and this makes it somewhat difficult to obtain.

Lawrence J. Regan,
Queensland,
Australia.

Protest from a G

Sir—I was sorry to note that the now tiresome subject of a novice licence had been introduced to the pages of Practical Electronics (see page 528 of the May issue). This tired whine—and it can be described by no other words—has disgraced the pages of most other technical periodicals for some time now, but I am glad to say does not appear to be gaining any ground from the authorities that matter.

Now we have a "Novice Society" —and petitions. How far ahead I wonder are the "novice marchers", the sit down protests and all the other peculiar actions that go with the easy-way-out mentality?

Surely the only satisfactory way of obtaining a transmitting licence is to approach it from the correct angle—a little study plus a desire to work for something you really want. Lets face the issue, to agitate for a novice licence is to admit your inability to master the simple requirements set by the G.P.O.—why camouflage the point at all?

I note too that some support is being obtained from commercial selling organisations. Would it be too cynical to suggest that this action is motivated by a stock room full of Japanese 27 Mc/s transceivers?

Incidentally, the new "G8" v.h.f. licence conditions have unwittingly provided an "easy way out"—or should it be "easy way in"—for many would-be amateurs. Obtaining such a licence appears to be a ridiculously simple thing to do, and once the G8 call has been obtained, you have the P.M.G.'s blessing to operate another amateur's h.f. station, on A3, provided the owner is present, and of course agrees to let you do so.

It still seems to be a long way round a very small obstacle and to me most unacceptable. My advice to Mr. Wadsworth and Co. is to earn that covetted "G" call by the only worthwhile way. Re-organise your Society for the study of radio theory and the Morse code—there's plenty of space left for you from topband downwards, and you'll be very welcome—provided you're equipped with a genuine G3 call! Why not think again?

H. N. Kirk G3JDK,
Rotherham,
Yorks.

Readout—
A SELECTION FROM OUR POSTBAG

continued

Distress call

Sir—Having read the item, under the heading "Electra's The Name", on page 427 of your April issue, I am a little reluctant to cast any shadow of mourning over your link-up between the new title of the Electrical Trades Union and the name of our demonstration and research vessel but feel sure that you would like to have your records accurate, so far as the latter is concerned.

Her name is not, I am afraid, *Electra* but *Elettra III* since she is the second successor to Marconi's original yacht *Elettra*, on board which many of his famous experiments were conducted and which, therefore, became part of the Marconi story.

Marconi also gave the name *Elettra* to his daughter and it was natural that when, in 1950, we decided to commission a vessel specifically for research and demonstration on marine electronics she should have been christened *Elettra II*. Later, as techniques advanced, she was found to be inadequate for the duties required of her and we accordingly had the present vessel *Elettra III*, built to succeed her in 1962.

I enclose a photograph of *Elettra III* from which I think you will see that she might feel hurt to see herself described as a launch.

She is, by the way, owned by us and not by our associates The Marconi Company, Limited.

W. Maconachie,
Publicity Manager,
The Marconi International Marine
Co. Ltd.

Landlubber Valence replies on page 668.

Elettra III, *the modern successor to Marconi's original* **Elettra**, *is a twin-screw motor yacht used by The Marconi Marine Company for research and demonstration purposes.*

3FP7 to the rescue

Sir—I have built the Inexpensive Oscilloscope (March issue) using a 3BP1 tube with favourable results.

Some constructors with limited funds (haven't we all) or bad luck might not be able to obtain this tube. I know for a fact that the 3BP1 tube is hard to obtain around the Croydon area. A tube type 3FP7 obtainable for about 15s each works very well in the circuit without any modifications even to the base connections. The main differences of this tube are:

(1) A blue trace with a yellow afterglow.

(2) A post deflection anode which is not connected into the circuit.

I would like to point out that some 3FP7 tubes work slightly better than others. This is probably due to manufacturers' tolerances which is fairly wide in commercial tubes and in this case is not a point to worry about.

C. M. Holt,
West Wickham,
Kent.

The fact that no modifications to the e.h.t. circuit were necessary appears to make it an extremely useful alternative. The much longer persistence of this tube should cause little or no inconvenience to the average constructor though such tubes are usually used for the display of transistory phenomenon.

As this tube has a post deflection anode which is not connected, the focus will not be quite so sharp as would be obtained using the tubes listed, particularly the 3BP1. The astigmatism control may also be less effective.

Due to the different deflection sensitivities and internal capacitances of this tube, the amplifier deflection and bandwidth specifications will be slightly different from those specified in the article. Such changes being taken into account when the instrument is calibrated.

A further point that may be of interest is that the circuit shown may be used with the majority of tubes under about 3½in diameter. The only differences will be in deflection sensitivity and possibly in bandwidth due to the differences in plate sensitivity and capacitance between tube types. This can vary considerably and is dependent principally upon the final anode voltage whcih in this case is approximately 1kV (voltage between cathode and A3). The only modifications necessary would be in the e.h.t. circuit which would have to be altered to suit the differences in electrode voltage of the particular type of tube used.—P. Cairns.

Electrolytics

Sir—In the *Beginners Start Here* series No. 6 it states that electrolytic capacitors are not suitable for a.c., but as an industrial maintenance electrician I have often come across capacitors of this type used as starting capacitors in small a.c. 1 h.p. motors.

Surely, in view of the large rating shown, these must be electrolytic?

Perhaps you could explain this point to me.

Patrick J. Cass,
Ferrybank, Waterford,
Ireland.

We can assure you that the facts given in Beginners Start Here concerning electrolytic capacitors are perfectly correct. The normal type of electrolytic capacitor should NOT be used on raw a.c. If this is done, excessive heat will be generated inside the component and an explosion will probably occur.

It is true that a special form of electrolytic capacitor is manufactured for use in motor circuits. These capacitors are in circuit only for a very short time, and switches are usually provided to disconnect the capacitor from circuit once the motor has reached its normal running speed.