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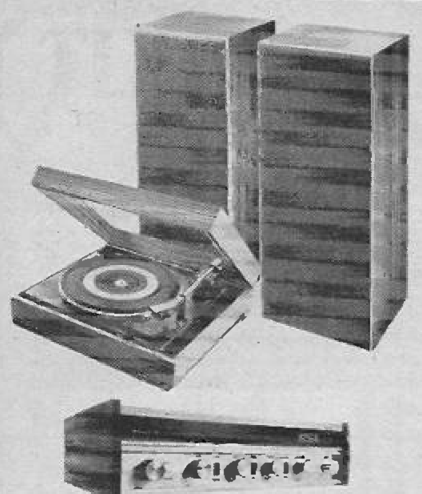

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Garrard SP25 with MAG. cartridge de luxe plinth and hinged cover *	£21.00 + £1.75 p & p.
total	£59.20

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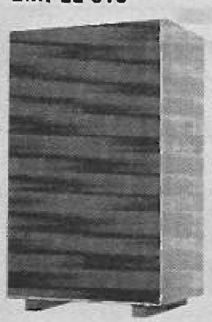

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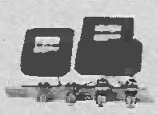

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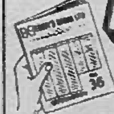

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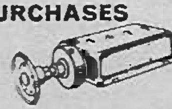

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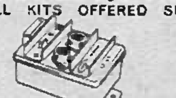

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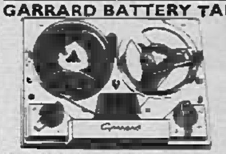

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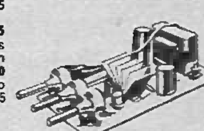

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The Cambridge kit is the world's largest-selling calculator kit.

It's not surprising – no other calculator matches the Sinclair Cambridge in functional value for money; and buying in kit form, you make a substantial saving.

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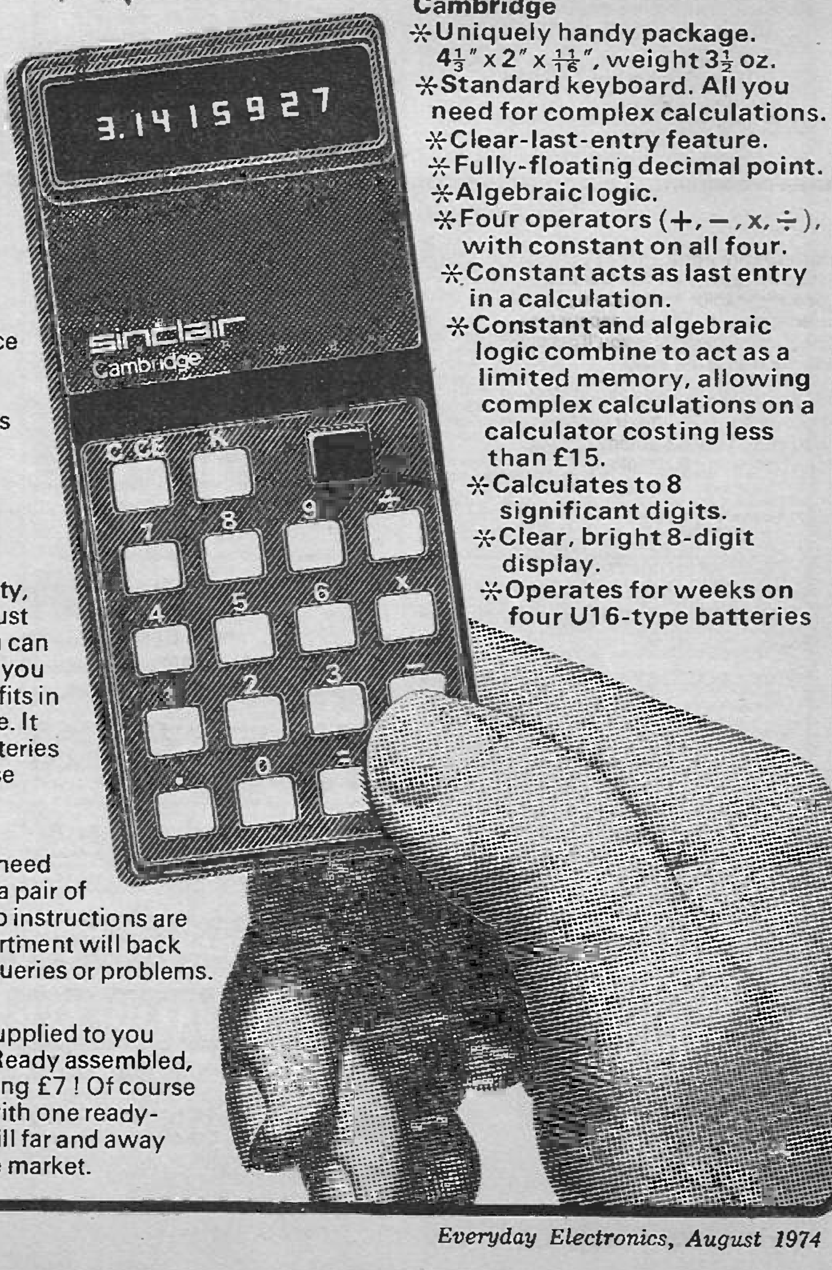
Easy to assemble
All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

Total cost? Just £14·95!
The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £21·95 – so you're saving £7! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.



Features of the Sinclair Cambridge

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- Clear, bright 8-digit display.
- Operates for weeks on four U16-type batteries

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PROJECTS....
THEORY......

CURRENT PROBLEMS

Conventions are not always soundly based on logic or fact. Despite this it is sometimes preferable and convenient to continue to accept certain traditional beliefs rather than to be entirely rational.

Take, for example, the direction of electric current flow. It is generally known that time-honoured ideas conflict with scientific fact substantiated long after the idea of "positive to negative" had become firmly established. So like it or not, we have the terms conventional current (positive to negative) *and* electron current flow (negative to positive) in common usage. All very confusing. Or is it really so?

In elementary instruction electricity is often depicted as something similar to water in a system of pipes, and flowing from a high level, or pressure, downwards. Thus "positive" or high pressure always seems perfectly natural at the top of a drawn circuit diagram, with negative at the bottom.

This custom helps to preserve in our minds the idea of current flowing from positive to negative. And this convention is perfectly acceptable when considering a circuit from a purely electrical point of view.

However when looking closely into the operation of the electronic devices such as diodes and transistors (and of course thermionic valves) we cannot evade scientific truth and so have to perform some mental gymnastics, and reason everything out in an *electron flow* sense; that is, from negative to positive.

But let newcomers be quickly reassured—it sounds much more difficult and confusing than it is in practice. This two-way approach to currents becomes second nature in a short while.

A FALSE REMEDY

Not surprisingly, the apparent absurdity of the situation has brought forth from time to time demands that everyone should think exclusively in terms of electron flow. This apparently simple remedy will not do however. The custom of thinking in terms of positive to negative is too firmly engrained.

Yet far more disturbing to our mind is the rumour that some "enlightened" educationalists have not merely abandoned conventional (positive to negative) current in their teachings but have actually purloined this term and misapplied it to mean electron flow. If this is actually so, it is to be greatly deplored.

The confusion caused by such independent defiance of widely accepted conventions must build up a store of problems for the future. We have indeed already encountered some of these problems through correspondence from a few readers, all of whom have presumably been brought up in the belief that in this electronic era conventional current is as dead as the dodo.

Those who are still perplexed should find this month's *Down to Earth* helpful in unravelling this conundrum of the currents.

Fred Bennett.

Because of prevailing production problems, no firm publishing date can be announced for the September issue. Readers are advised to check regularly with their local supplier from mid-August onwards.

Everyday Electronics Fleetway House, Farringdon Street, London, E.C.4. Phone: *Editorial* 01-634-4452; *Advertisements* 01-634-4202.

.EASY TO CONSTRUCT
.SIMPLY EXPLAINED

VOL. 3 NO. 8 AUGUST 1974

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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LIGHTS-ON ALERT

By E. J. BYATT

Produces an audible tone when the driver inadvertently leaves on the car side lights.

It is quite common, especially during the winter months, to see car headlights unintentionally left on while the owner is at work. When he returns he finds the car difficult to start because the battery has run down and become flat.

In the light of experience this unit has been devised so that if the sidelights of the car are on when the ignition switch has been turned off, an audible warning is sounded to bring the driver's attention to this fact.

CIRCUIT

The circuit diagram of the unit is shown in Fig. 1 and can be visualised in three parts, the oscillator, amplifier and control switch.

The oscillator is the common unijunction relaxation type and comprises TR1, R1, R2 and C1.

When the battery is connected to the circuit, capacitor C1 charges up at a rate controlled by the value of R2.

While the potential at the emitter of TR1 is below a certain value the resistance between emitter and base 1 is, to all intents and purposes, infinite, but when a threshold level is reached at the emitter this resistance becomes almost zero and the capacitor discharges through this path.

Once discharge has taken place the capacitor begins to charge again and the process is repeated, and continues for as long as the battery supply is connected.

Thus the voltage seen at the emitter is approximately a sawtooth waveform formed by the charge and discharge contours of the capacitor.

This sawtooth wave is coupled to the base of TR2 by C3, which blocks any d.c. content. Transistor TR2 is connected in the common emitter mode and is operated in an overdriven state. That is to say the output at the collector is a clipped sawtooth and becomes an approximate square wave.

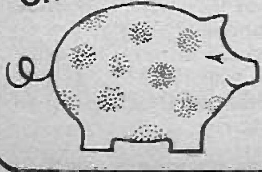
The output of TR2 is directly coupled to the base of TR3 which amplifies the signal to feed the loudspeaker, LS1. Resistor R2 determines the output volume by controlling the current through TR3.

The oscillator frequency may be changed by altering the value of R2 slightly. Resistor R6 is selected by using the *highest* value possible without sacrificing volume and will probably lie in the range 47 ohms to 1 kilohm. In the prototype a value of 470 ohms was found satisfactory. Components R3 and C2 form decoupling between the amplifier stages and the oscillator, values are not too critical but C2 must be at *least* 100 microfarads.

If the output tone is too harsh a capacitor can be inserted between TR3 collector and base. Too large a value will reduce the output volume, try experimenting with capacitor values about 0·01 microfarads.

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS including V.A.T.



£2.10 excluding case

*Based on prices prevailing at time of going to press

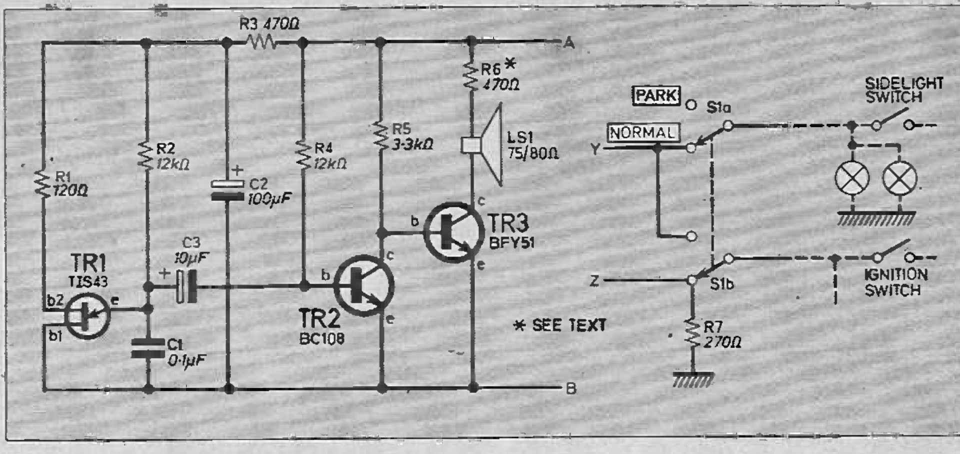


Fig. 1. Circuit diagram for the Lights-On Alert.

CONTROL SWITCH

The control switch, S1 determines the mode of operation by selecting the potentials to the supply rails of the circuit *A* and *B*.

This switch has two positions, "park" and "normal"; Table 1 gives a summary of events for the various positions of the three relevant switches.

It is seen that for S1 in the "normal" position the alarm is only sounded when the sidelights are on and the ignition switch is switched off as is the case when leaving the car parked after driving with the lights on, and forgetting to turn them off.

If it is required to park the car with the lights on, S1 should be set to "park" when the ignition is switched off.

CONSTRUCTION DETAILS

The prototype unit was constructed on a piece of 0·1in matrix Veroboard size 33 holes by 24 strips and was housed in a readily available Eddystone diecast box, size 115 x 90 x 55mm.

The layout of the components on the topside of the Veroboard is shown in Fig. 2; the layout is not critical and can be changed if desired. There are no breaks along the copper strips on the underside of the board.

Table 1: Possible switching arrangements

Ignition switch	Sidelight switch	Alarm	S1 position
On	Off	Off	Normal
On	On	Off	
Off	Off	Off	
Off	On	On	
On	Off	Off	Park
On	On	On	
Off	Off	Off	
Off	On	Off	

Begin construction by drilling the four fixing holes and then assembling the components on the board according to Fig. 2. The transistors should be soldered in place last of all and a heatshunt used to avoid thermal damage from the hot soldering iron.

Now prepare the diecast box to accept the components S1 and LS1, and the four fixing bolts. A hole drilled at one end of the box and plugged with a rubber grommet allows the three external wires to pass through.

Fix the case mounted components in position and wire up to the board as detailed in Fig. 2

Components....

Resistors
R1 120Ω
R2 12kΩ
R3 470Ω
R4 12kΩ
R5 3·3kΩ
R6 —see text
R7 270Ω 1W carbon
All ½W ±10% carbon

SEE SHOP TALK

Capacitors
C1 0·1µF
C2 10µF elect. 16V
C3 100µF elect. 16V

Transistors
TR1 TIS43
TR2 BC108 silicon *npn*
TR3 BFY51 silicon *npn*

Miscellaneous
S1 d.p.d.t. toggle or slide
LS1 miniature loudspeaker with coil impedance of 75–80 ohms
Veroboard: 0·1in matrix 24 strips x 33 holes ; Eddystone diecast box size 115 x 90 x 55mm ; 4BA nuts, bolts, washers and spacers (4 off each); rubber grommet

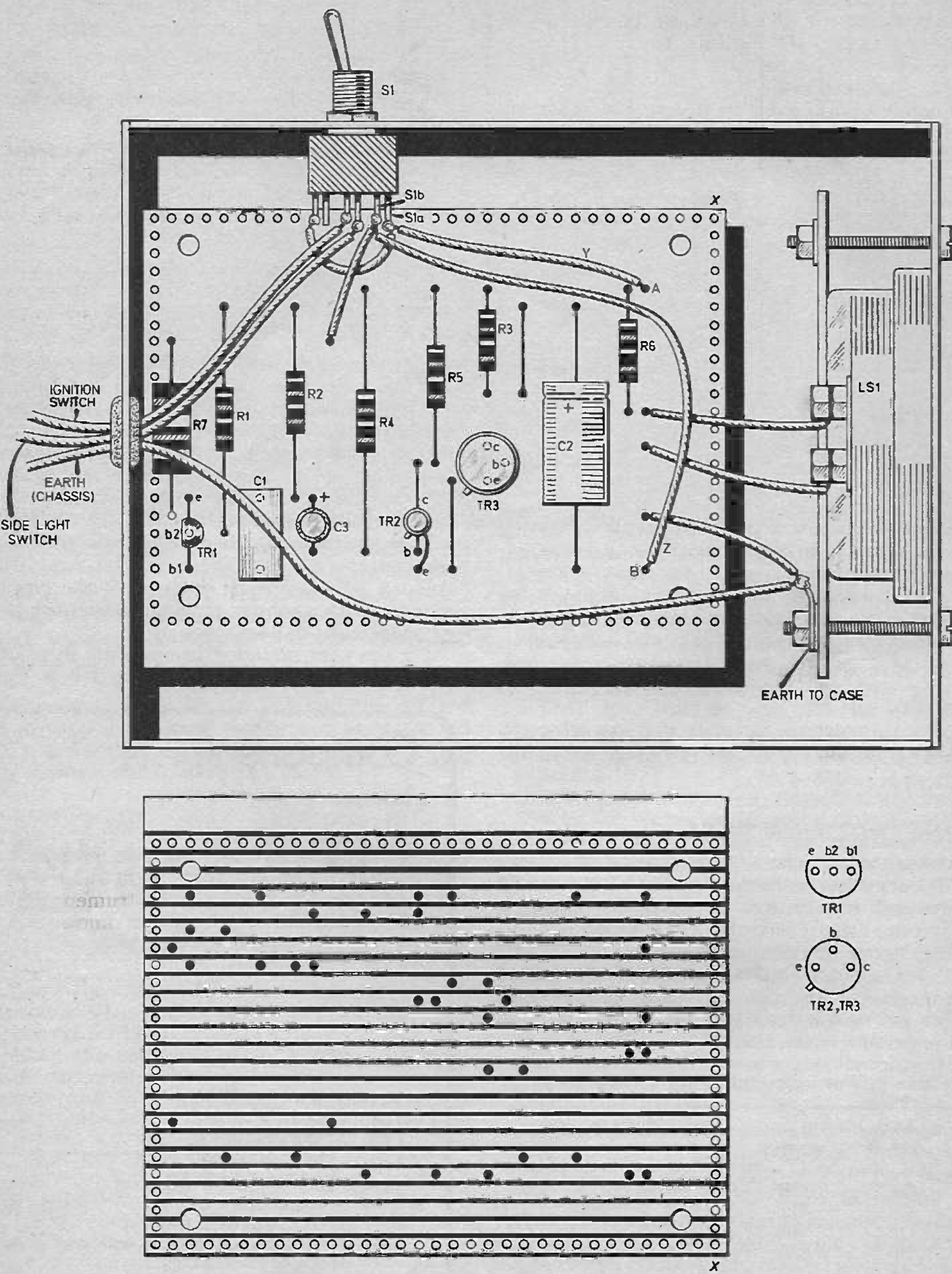


Fig. 2. Layout and wiring of the complete Lights-on Alert. Wiring is shown for negative earth, for positive earth move wire Y to point B and wire Z to point A.

according to the polarity of the car in which the unit is to be fitted.

When complete, the board should be secured in position by means of the four fixings; 10mm stand-off spacers must be used to prevent shorting of the board and case.

Thoroughly check out the wiring and when satisfied feed the three external wires (three different colours are recommended) out through the grommet and screw the lid in place. The switch positions should be labelled "park" and "normal" as shown. The unit is ready for installation in the car.

INSTALLATION AND USE

The unit should be fitted in a position within easy reach of the driver of the car. It is not necessary that the box makes contact with the car chassis as one of the flying leads provides this connection.

Connect the earth lead from the unit, to a good earth point on the car using a solder tag, nut, bolt and sprung washer.

Connect the lead from S1b pole to a tag on the ignition switch where power is supplied only when the ignition is switched on.

The lead from S1a pole should be connected to the sidelight switch on the same side as the connection to the sidelight lamps. The installation is complete.

TESTING AND USE

Set S1 in the "normal" position and switch on the sidelights. The audible tone should be heard. Switch on the ignition and the tone should cease. Switch off the ignition and the tone should be heard again and will stop when the sidelights are switched off.

Now set S1 to "park" and turn on the sidelights. No tone should be heard. Switching on the ignition will cause the alarm to sound and this then can only be muted by switching to the "normal" position.

If all the above results are observed the unit is functioning satisfactorily. Now the unit is fitted in the car, and it is not required to have the sidelights on, set S1 at "normal."

In the event of the lights being unintentionally left on once the ignition has been turned off, the alarm will sound and can only be stopped by either switching off the lights, or if parking lights are required, by putting the control switch to "park." When the driver next switches on the ignition the alarm will sound to tell him that the lights are on and the switch must be returned to "normal" before the alarm ceases.

This circuit is foolproof in that it cannot be "turned off" and will always give an indication of the lights being left on unintentionally. ■

...Counter Intelligence

BY PAUL YOUNG

A retailer discusses component supply matters.

WHEN there is a shortage of any commodity the person who is usually the last to be aware of it, is the ultimate consumer, in other words *you* the reader!

At least six months ago we were feeling the pinch and several months before that the manufacturers were crying out for raw materials. This was before the coal and oil problem, both of which have undoubtedly accentuated our difficulties, (many of the plastics are oil by-products).

Our old friends R. S. Components Ltd., who always made a point of keeping at least six months stock in reserve, were now running out of items much quicker. Firms whose production lines had ground to a halt, would come to us to buy three or four thousand capacitors at the full price. Only yesterday one firm wanted one hundred Bulgin knobs. We, as you all know, regard ourselves as strictly retail, and I have had to issue firm instructions to our staff, that they must not run our stocks down, to satisfy one "trade" customer, and by so doing, create one hundred disgruntled customers!

The point is, what can we, the retailer do, and you the customer do, to minimise this frustration? We certainly are trying very hard to help you. I personally have demanded to see every order where we cannot supply 100 per cent of the goods requested. I then advise the staff where I think a substitute will be acceptable.

For example, a customer will order ·15μF 10V capacitor; we are out of stock, but we have in stock 15μF at 25V. Unless physical size is of paramount importance this will obviously do. You may order a $\frac{1}{4}$ watt 5 per cent resistor and we lack the particular value you require; all right, we have one in $\frac{1}{2}$ watt, so we send that.

I am sure that 99 per cent of our customers would rather receive something that is usable rather than nothing at all! For your part I would advise the following, be patient and *don't* re-order an out-of-stock item until you have checked with the firm concerned *first* (by telephone if possible). Most mail order firms are probably handling upwards a thousand orders a week. If you have had one order returned, with certain goods out of stock, don't wait a couple of weeks and re-order regardless. Because if you do, when the firm receive it, they may well feel they cannot send the order straight back to you again, and whatever they do with it, it will be easily overlooked, and the goods you want may come in and be sold again, while your order gathers the dust! Remember too, that in the circumstances that prevail to-day *no-one* can give you an accurate forecast of delivery!

It will help us tremendously if on the goods you order, you give the *widest possible* specification. For example resistors $\frac{1}{8}$ to $\frac{1}{2}$ watt, tolerance 2-20 per cent. With capacitors choose the lowest voltage you can possibly use. You will see that this gives us far more scope for finding you something.

New products and component buying for constructional projects

SHOP TALK

By Mike Kenward

OUR brief note concerning the supply of transistors for the *Transistor Assisted Ignition* last month underlines the general component supply problems that face retailers at the present time. It is not unusual to find a supplier quoting a delivery date and two or three weeks after it has passed, quoting a new date a month or two in the future.

Unfortunately, it is not always possible to blame the manufacturer as he can easily be let down on supply of raw materials such as plastic, which—as we are constantly being told—there is a world shortage of. Although some delays are unnecessary, we must ask readers to be more patient than usual and for once spare a thought for the retailer who is the "man in the middle" in this situation. We all know he is in business to make a profit but we should also realise that it is not in his interest to delay the supply of components.

Radiation Monitor

The halogen quenched gamma counter tube (CV2247)—to give the Geiger tube its correct name—for the *Radiation Monitor* is available from Henry's Radio, for £1·25 plus V.A.T. plus 20p post and packing—we make that about £1·58.

A suitable transformer for this project should be available from most of the larger suppliers—the transformer and case must be compatible. We suggest you obtain the transformer and C4 and C5 before buying the case, since these components must be able to fit into the case side by side.

Heads or Tails

The components most likely to be difficult to get hold of for the *Heads or Tails* game are, surprisingly enough, the 6V 0·06A bulbs. However, these are supplied by R. S. Components, and can be ordered by any supplier from them.

The integrated circuit is generally available for around 20p and should not cause any problems. It is a good idea to order a holder for the i.c. when purchasing it.

Lights-On Alert

Almost all the components for the *Lights-On Alert* are readily available, only the 75 ohm loudspeaker may cause problems, and Henry's Radio can supply this for 60p plus V.A.T., plus 15p post and packing—81p!

The diecast box used for housing the prototype is eminently suitable for use in cars as it is very robust and quite easily machined. Most of the larger component suppliers provide these boxes.

Experiment in Headphone Stereo

In the final design described in the *Experiment In Headphone Stereo* article on 8μF non polarised capacitor is called for—the author utilised a paper type but since these are hard to find we have suggested the use of four 2·2μF Mullard C280 types, wired in parallel—this gives 8·8μF but is near enough to the required value.

The high voltage resistors and the low value potentiometers may prove difficult to get, but these should be available from the larger suppliers—it does seem that we use that term quite often, but we cannot quote a single supplier when we know that a number of suppliers can provide particular components. Although these particular components may not be readily available, when we know of more than two or three suppliers it is not fair to quote the name of only one, and not possible to quote them all with prices etc., so you must do some hunting.

The headphones mentioned in the text have not been recommended by us, they are quite simply those that the author purchased—any 8 ohm to 16 ohm stereo types will do.

HEADS or TAILS

A simple electronic game.

By M.G. ARGENT

THIS unit is an electronic version of a heads and tails game, which is simple and inexpensive to build. An integrated circuit is used to simplify the construction.

CIRCUIT

The circuit is shown in Fig. 1, TR1 and TR2 form an astable multivibrator which is the timing circuit of the unit. The output from either of the collectors is a square wave as shown in Fig. 2a. The waveform is a series of square pulses where the pulse, or mark as it is known, is the same width as the space between the pulses.

The diagram in Fig. 2a is correct, as the mark and the space are of equal width. Fig. 2b is incorrect as the mark is much shorter than the space. The reason for having a 1:1 mark/space ratio is that when the output from TR2 collector is a pulse (mark), one of the lamps will light up, and when the output is at 0V (space) the other lamp will light, so the mark/space ratio must be 1:1 otherwise one lamp will be on longer than the other.

The square wave output is taken from TR2 collector via the spin switch (S1) to the integrated circuit IC1. The IC consists of two NAND gates wired as a bistable or memory store. A NAND gate is an electronic switch with two or more inputs and one output. When all of the inputs to the gate are at +5V, the output is at 0V. In other words the output is the inverse of the input.

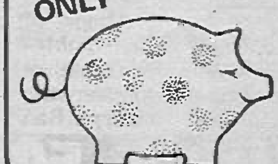
To change the state of the gate, only one of the inputs need be taken to 0V, regardless of the condition of the remaining inputs, and the output will then change to +5V. In "computer language" the +5V state is referred to as a logical "1" level, and 0V is referred to as logical "0" level.

IC OPERATION

The operation of IC1 is as follows. Referring to Fig. 3, if a logical 1 level is applied to pin 9, pin 8 will go to logical 0, taking with it pin 5, this turns on LP2 and changes pin 6 to logical 1

FOR GUIDANCE ONLY

ESTIMATED COST* OF COMPONENTS
including V.A.T.



£1.50

excluding case

*Based on prices prevailing at time of going to press

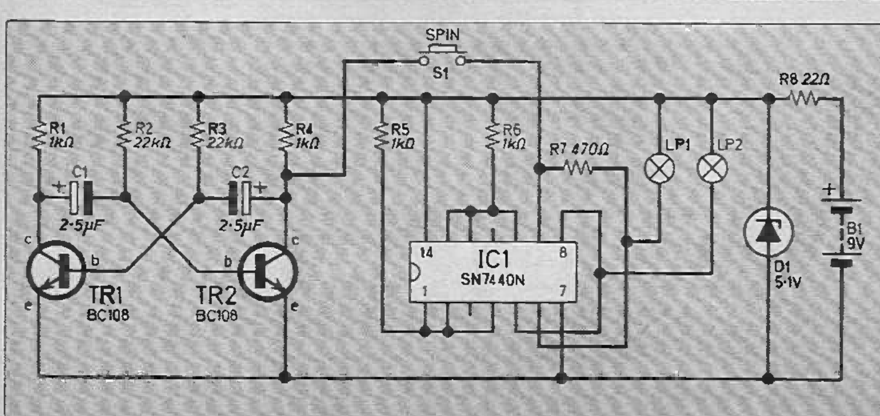


Fig. 1. Complete circuit diagram of the Heads or Tails game.

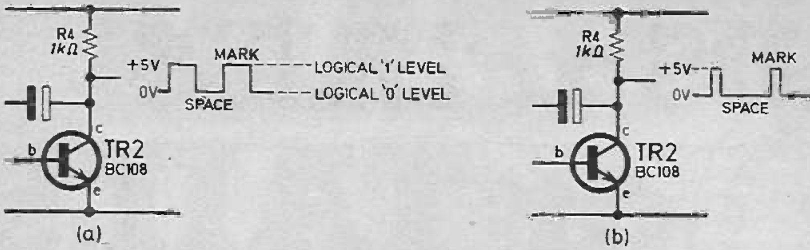


Fig. 2a. Equal mark to space ratio of a correctly balanced output (b) incorrect mark to space ratio.

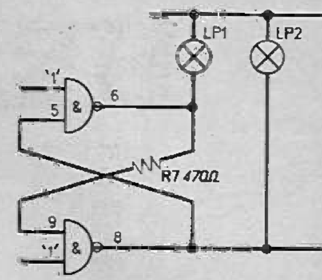


Fig. 3. Showing the wiring of the two NAND gates in IC1.

turning off LP1. IC1 will stay in this state as long as the input to pin 9 is not taken to 0V.

If pin 9 is now taken to logical 0, pin 8 will turn to logical 1, turning off LP2 and taking with it pin 5 which turns pin 6 to logical 0, turning on LP1. IC1 will now stay in this state until pin 9 is taken to logical 1.

When the spin switch is operated, the square wave output from TR2 collector, which alternates between logical 0 and logical 1 level makes the bulbs light alternately, when the spin switch is opened IC1 will stay in which ever state it was in immediately before the switch was opened.

As stated earlier, IC1 is used in this circuit as a bistable or memory store, which is a switch which will remain in whatever state (logical 1 or logical 0 level) it was left in, until it is triggered over by an input, which in this case is the output of TR2 collector via the spin switch.

The speed of the multivibrator is slow enough to appreciate the operation but too fast for anyone to follow the sequence, which would enable players to cheat. A frequency of 10 hertz was chosen to be best, and as the mark/space ratio is 1:1 there is no bias towards one lamp staying lit longer than the other.

The integrated circuit used is the SN7440N which is capable of driving low power bulbs directly, without the need for additional transistors. This IC requires a supply voltage of 5V and D1 and R8 are provided to limit the supply voltage to approximately this value.

CONSTRUCTION

All the components except the lamps and switch are mounted on a piece of 0·1 inch matrix Veroboard size 16 holes by 20 strips. The components are mounted as shown in Fig. 4, and the reverse with cutaways is also shown. The cutaways can be made with a small drill or the special spot face tool available. Care must be taken especially when soldering IC1, so as not to overheat it. If the board is clean and free from grease there should be no trouble in making a quick clean joint (an IC holder will eliminate this trouble).

The board, battery and bulbs are assembled into a small tin, in the prototype this was originally a throat pastille tin, there is no reason why any other container should not be used. The main idea is to keep the project simple and cheap to build.

As the tin used by the author was very small, no on/off switch was used, but this presented no problem as the lid can be lifted and the battery connected when required. If a larger tin is used, a switch can be incorporated in series with the battery lead. The spin switch is on a flying lead on the prototype, but again this can be built into a larger tin. The preference is up to the constructor.

Complete the unit by wiring up all the parts (S1, B1 and LP1 and 2) as shown in Fig. 4, and fitting inside the box. In operation, when S1 is pressed both lights will light rather dimly (they are only on half the time) and when S1 is released one lamp will stay lit while the other extinguishes. ▣

Components....

Resistors

R1 1kΩ
R2 22kΩ
R3 22kΩ
R4 1kΩ
R5 1kΩ
R6 1kΩ
R7 470Ω
R8 22Ω
All ¼ W ± 10% carbon

SEE **SHOP TALK**

Capacitors

C1 2·5μF elect. 6V
C2 2·5μF elect. 6V

Semiconductors

TR1 BC 108 silicon *npn*
TR2 BC 108 silicon *npn*
IC1 SN 7440N integrated circuit and holder to suit
D1 5·1V 300mW Zener diode

Miscellaneous

LP1,2 6V 0·06A bulbs (2 off)
S1 Push to make release to break push button
B1 9V PP9 battery and connecting clip
Veroboard 0·1 inch matrix 20 strips by 16 holes, 2 rubber grommets to hold bulbs, case (see text), connecting wire.

HEADS or TAILS

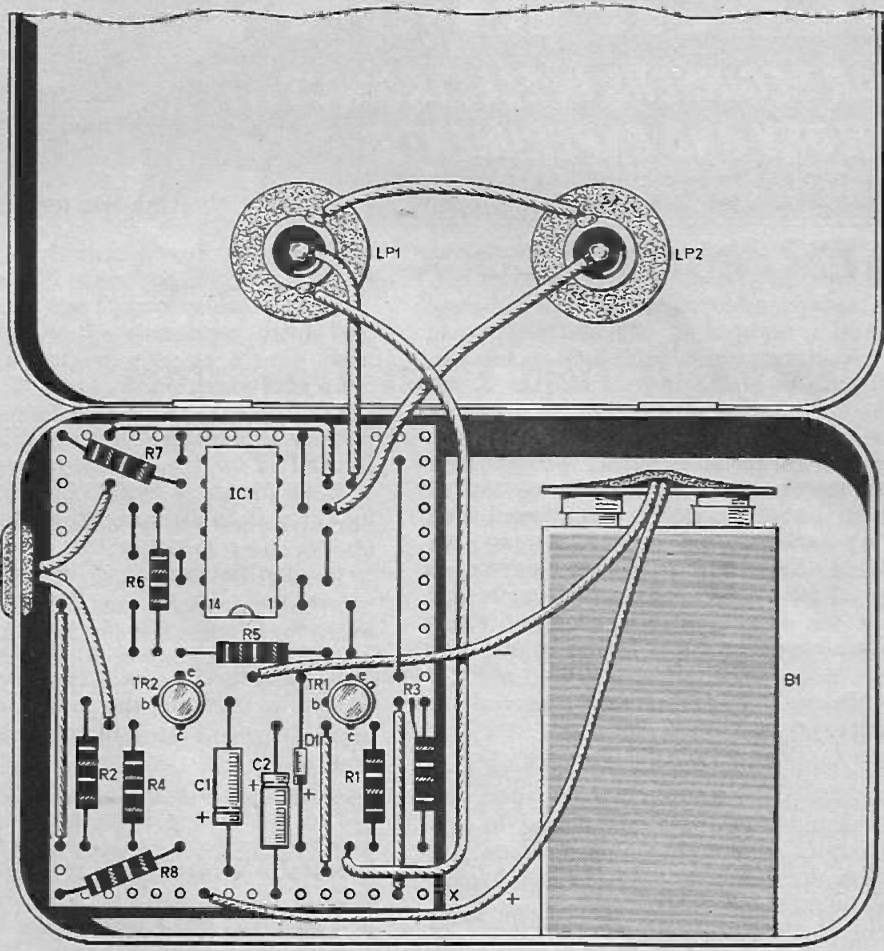
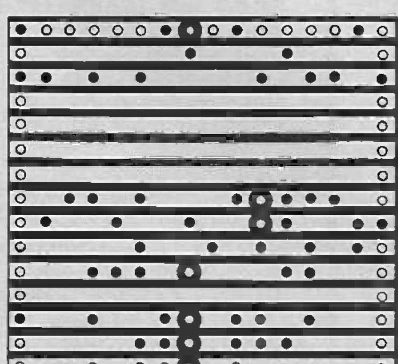
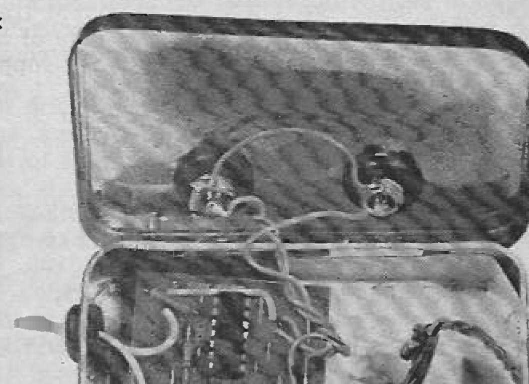


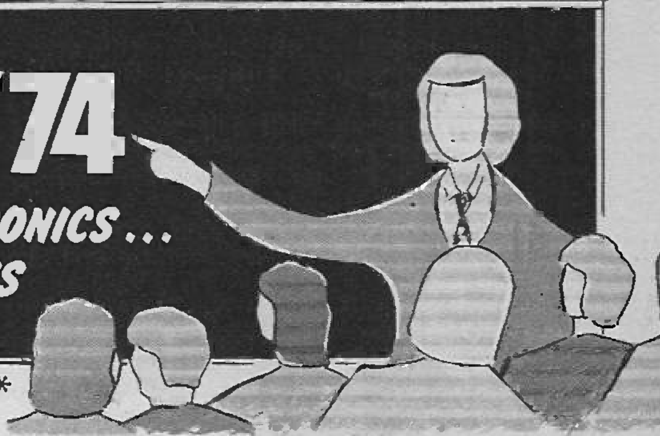
Fig. 4. Construction details of the Heads or Tails unit.





TEACH-IN '74

FOR BEGINNERS IN ELECTRONICS... THEORY AND EXPERIMENTS



TUTOR: PHIL ALLCOCK*

LESSON 11 Field Effect Transistors

So far in the Teach-In '74 series we have considered the operation of *npn* bipolar transistors in some detail and have mentioned that "opposite" polarity types, known as *pnp*, are also available. In addition to these devices a wide range of field effect transistors exists and this month we are going to examine these devices to see how they differ from the *npn*/*pnp* types.

TERMINOLOGY

Essentially a field effect transistor, abbreviated f.e.t., is controlled by voltage rather than current. A semiconductor material is used to provide a "channel" through which current can flow and the actual flow is controlled by the effect of an electric *field*.

This field is itself due to the presence of electric charge in a region close to the channel, known as the gate. The channel can be either *p*-type or *n*-type, depending on the semiconductor employed and in addition we have two distinct types of device known as **enhancement and depletion**.

An enhancement f.e.t. is one in which the channel is normally off, or non-conducting, and we must therefore apply a suitable bias to the gate to turn the transistor **on**.

The current flow in the channel is enhanced by the gate bias. In the other type the channel is normally conducting and current can be stopped by applying a suitable bias voltage.

The channel current flow is depleted by the applied bias voltage. As if this was not enough, we also find that new names are used for the connections to the ends of the channel, namely *drain* and *source*, and that there are two distinct f.e.t. families known as junction f.e.t's. and MOSFET's.

MOSFET

So much for the terminology—let us continue our investigation by looking at the MOSFET device in more detail.

The letters MOS refer to a field effect transistor that employs a metal gate insulated by an oxide layer from the semiconductor channel and a typical arrangement is shown in Fig. 11.1.

Starting with a piece of foundation material known as the substrate, which in this case is made of *n*-type semiconductor and therefore has free electrons, two *p*-type regions are diffused side by side into the surface.

The surface is then covered by a layer of insulating silicon oxide and two strips of metallisation are arranged to contact the *p*-type regions via windows in the oxide layer. A third metallisation strip lies on the top of the oxide, immediately over the gap between the two *p*-type regions, and forms the gate electrode.

With no bias voltage (or signal) connected to the gate, current cannot flow between the two *p*-regions, which are known as source and drain, due to the intervening *n* type region. This region effectively forms two *pn* junctions back to back, and is illustrated in Fig. 11.1.

The situation is similar to a *pnp* bipolar transistor with no connection at the base but the size of the intervening *n* region is different in the two cases.

BASIC OPERATION

If we connect the gate metallisation to a battery so that the gate is made negative (with respect to the source region) the gate will become negatively charged and the region of semiconductor immediately underneath the gate will acquire an opposite positive charge.

* North Staffordshire Polytechnic (*Any communications arising from the Teach-In '74 series must be addressed to Everyday Electronics, Fleetway House, Farringdon Street, London E.C.4*).

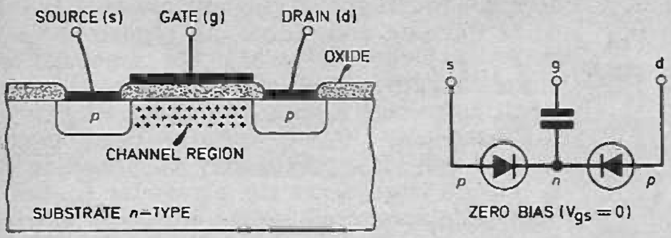


Fig. 11.1. A cross section of *p* channel MOSFET and an equivalent circuit.

In effect the electric field set up by gate repels the electrons and attracts the holes so that a "bridge" *p* type region is effectively formed which links the *p* type source and drain. Current can now flow in this *p* type channel if an external path is provided by the circuit in use.

The oxide insulates the gate from the p type channel and in effect behaves as a very small value capacitor. The gate current will be negligible if the oxide is free from leakage effects and the transistor therefore exhibits a very high resistance at the gate terminal.

From the description given it should be clear that the transistor considered in Fig 11.1 has the following features:

(a) Normally off with zero gate voltage.

(b) MOS construction.

(c) Channel is formed by a *p*-type region.

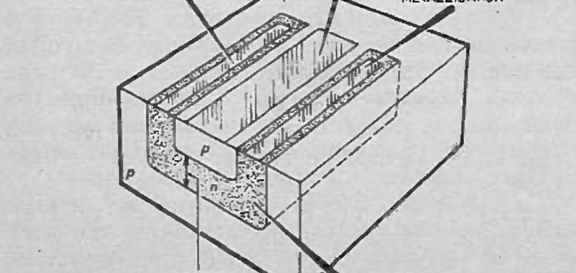
The device would therefore be described as a *p*-channel enhancement MOSFET and this type of transistor has been widely used in certain types of integrated circuits.

JUNCTION F.E.T.

An alternative method of construction for the gate region employs a "diode", which is normally kept under reverse bias and is formed by the junction between the gate region material and the channel. Such a device is illustrated in Fig. 11.2 and would be known as a junction f.e.t. or JUGFET.

All junction f.e.t's. are normally conducting at zero gate bias and are thus classed as depletion type transistors. The gate voltage must always be chosen to maintain the gate-channel diode in the reverse bias condition if correct f.e.t. operation is required.

Fig. 11.2. Typical *n* channel JUGFET. Note that the *n* type channel is surrounded by *p* type "gate" region.



The transistor used for the Tutor Board experiments is a junction type employing an *n*-type channel and the device symbol and typical bias polarities are illustrated in Fig 11.3. The current in the drain/source channel is usually called I_{ds} and varies with the gate voltage V_{gs} as shown in Fig. 11.4.

Note that the curves are similar in shape to those given earlier for the *npn* transistor, in which the base current was used for control. Two of the parameters normally listed by the manufacturer are I_{dss}, the channel current with $V_{gs}=0$, and V_{gs}(off) which is the bias voltage required to cut-off the channel (or reduce the current to some specified low value).

As might be expected the manufacturer usually quotes a range for each parameter and in the case of the 2N3819 the values are:

$$I_{dss} = 2 \text{ to } 20\text{mA}$$
$$V_{gs}(\text{off}) = 8\text{V (maximum)}$$

The alternative names, pinch-off or threshold voltage are sometimes used instead of V_{gs}(off) but it is more usual nowadays to reserve the term threshold voltage for the voltage level at which enhancement MOS devices start to turn-on.

Fig. 11.3. (left) Symbol for *n* channel JUGFET. All polarities and "arrow" on gate lead are reversed for *p* channel device.

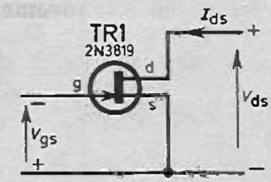
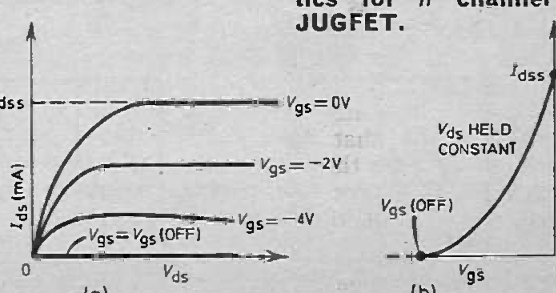


Fig. 11.4. Characteristics for *n* channel JUGFET.



DIFFERENCES

The most obvious difference between the BC107 *npn* bipolar transistor and the 2N3819 *n*-channel JUGFET is the very high input resistance of the latter device which can be of the order of 1,000 megohms. Thus if we require a circuit having a very high input resistance it would be wise to consider a field effect transistor for the intended application.

The Tutor Board experiments this month include one circuit which utilises the high input resistance feature of the 2N3819. Whilst on the subject of high input resistance it is worth mentioning that MOS devices can be damaged if the gate electrode acquires a static charge which causes the gate breakdown voltage rating to be exceeded.

The gate capacitance is usually very small, typically a few pF, and since V=Q/C, a small charge can easily give rise to excessive voltage.

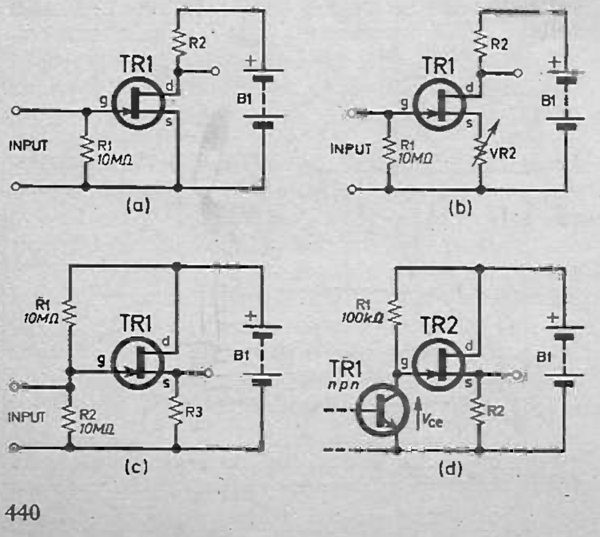
MOS transistors are often fitted with a small wire clip or spring which shorts all connections together. These clips should only be removed *after* the transistor has been connected to the external circuit. Since a thin oxide layer is not used for making the gate of a JUGFET these problems do not occur but the manufacturers ratings should not be exceeded.

JUGFET BIAS CIRCUITS

To become more familiar with field effect transistors let us look at some of the circuits that can be employed. Fig. 11.5 shows several ways of arranging the necessary gate and drain supplies for the 2N3819 *n*-channel JUGFET.

Notice that in each case the drain is connected to the positive supply terminal and I_{ds} will flow into the drain terminal and out at the source terminal (conventional current assumed). In Fig. 11.5a the gate and source are connected via a relatively high value resistor (10 megohms) but since the gate leakage current is normally very small no voltage drop occurs across R1.

Fig. 11.5. Some "bias circuits" for an *n* channel JUGFET (a) Common source circuit with $V_{gs}=0$. (b) Common source circuit with self bias (V_{gs} negative). (c) Source follower circuit. (d) Source follower fed from *npn* transistor stage.



Consequently $V_{gs}=0$ and the drain circuit current will be approximately I_{dss} providing R2 is not too large. Since the parameter I_{dss} has a very wide spread of 2-20mA the drain current is not very well defined by this circuit and will vary from one transistor sample to another.

In Fig. 11.5b a resistance (VR2) is included in series with the source lead and gives rise to a voltage drop of magnitude:

$$\text{Voltage across VR2} = (\text{VR2}) \times I_{ds} = -V_{gs}$$

Since I_{ds} depends on V_{gs} as shown in Fig. 11.4b the circuit tends to compensate partly for variation of I_{ds} between transistor samples. For example, if I_{ds} "tries" to increase by say 1mA and we assume that VR2 was set at one kilohm this would give an increase in the magnitude of V_{gs} of one volt. Since this V_{gs} change will tend to *reduce* the current I_{ds}, the final change in current is less than it would be with VR2 not fitted.

To calculate the actual working current is slightly complicated by this feedback action and in practice we can make VR2 variable and adjust the resistance to give the required working current which must of course be less than the transistor I_{dss} value for the sample used. (If the manufacturer's curve of I_{ds} against V_{gs} is available it can be used to work out the bias point.)

The circuit shown in Fig. 11.5c gives the field effect transistor equivalent of the usual emitter follower circuit and in this example the voltage at the gate will be one half the power supply. The circuit requires R3 to be greater than $\frac{V_{ds}}{2\ I_{dss}}$ if correct operation is to be achieved. Fig. 11.5d is similar to (c) except that the gate voltage is determined by the bias arrangements for the *npn* stage. In this circuit R2 must be greater than $\frac{V_{ce}}{I_{dss}}$ for correct operation.

VOLTAGE CONTROLLED RESISTANCE

By operating a field effect transistor at low V_{ds} voltages, typically less than 500mV, the transistor can be used as a voltage controlled resistance. The effective resistance of the channel depends only on V_{gs}, providing the drain/source voltage is kept small, and actually corresponds to operation at (or near) the origin of the characteristics shown in Fig. 11.4a.

This principle can be employed as an electronic "volume control" by arranging the transistor as one part of a potential divider system. The principle is illustrated in Fig. 11.6 which is

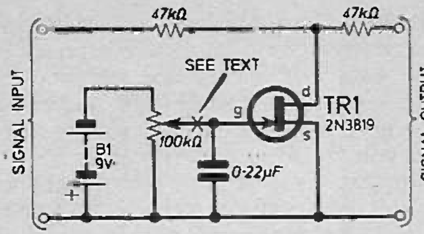


Fig. 11.6. Experimental electronic volume control.

suitable for experimental purposes providing input signals of less than a few 100mV are used.

The transistor is effectively open circuit when $V_{gs} = -9V$ and the input signal can then pass directly from input to output. The signal will suffer some attenuation depending on the load resistance connected at the output.

For a load of 100 kilohms the maximum output signal will be about 50 per cent of the input. If this circuit is used in place of a conventional carbon track volume control a noise free control is achieved.

The 0·22μF capacitor acts as a filter to remove any noise produced by the adustable 100 kilohm bias-voltage control. Additional filtering can be provided if necessary, by including an extra 100 kilohm fixed resistor at point X.

Next month we shall examine the action of the thyristor and give some simple tests based on the type BTX 30-25. (The components list April '74 issue gave the BTX 30-25 as a triac—it should have read thyristor).

TUTOR BOARD EXPERIMENTS

Test No. 22. Measurement of f.e.t. parameters.

Low cost field-effect transistors are usually wide tolerance devices and in this test we illustrate some simple measurements that can be made to determine the I_{dss} parameters of a typical sample.

Set up the circuit shown in Fig. 11.5a on the Tutor-Board, but make R1 zero by shorting the gate and source connections with a wire link. (The 2N3819 transistor should be mounted in the same manner as that used for the BC107. The connections are shown in Fig. 11.7.)

Use a fixed 100 ohm resistor for R2 and 9V for the supply. Set up the standard 0-10 volt voltmeter circuit and measure the voltage across R2. From this reading it is possible to calculate I_{dss} since:

$$\text{Voltmeter reading (in volts)} = \frac{I_{dss}(\text{mA}) \times 100}{1000}$$

$$= \frac{I_{dss}(\text{mA})}{10}$$

For example, a reading of 1·5 volts would correspond to $I_{dss} = 15$ mA. If the voltmeter reading is too small to observe accurately, the range of the voltmeter can be reduced to 0-1 volt by using a 10 kilohm ±5 per cent resistor in *parallel* with the normal 100 kilohm ±2 per cent meter resistor. With this modification it is only possible to cater for I_{dss} values up to 10 mA.

Test No. 23.

This test demonstrates the very high input resistance at the gate terminal of the 2N3819. The circuit is shown in Fig. 11.8 and should not present any layout problems on the Tutor-Board.

The potentiometer VR2 is set to mid-position (approximately) and the switch is closed after setting VR3 for maximum resistance. Except for the capacitor the circuit is now similar to Fig. 11.5c.

The capacitor will rapidly charge up to the voltage level determined by the setting of VR2 and a reading should be apparent on the meter. The meter can be set to full scale deflection by adjustment of VR3.

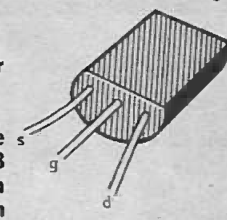
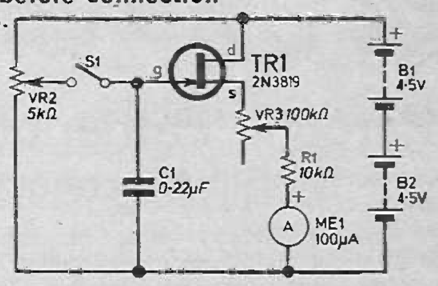


Fig. 11.7. Connections for 2N3819.

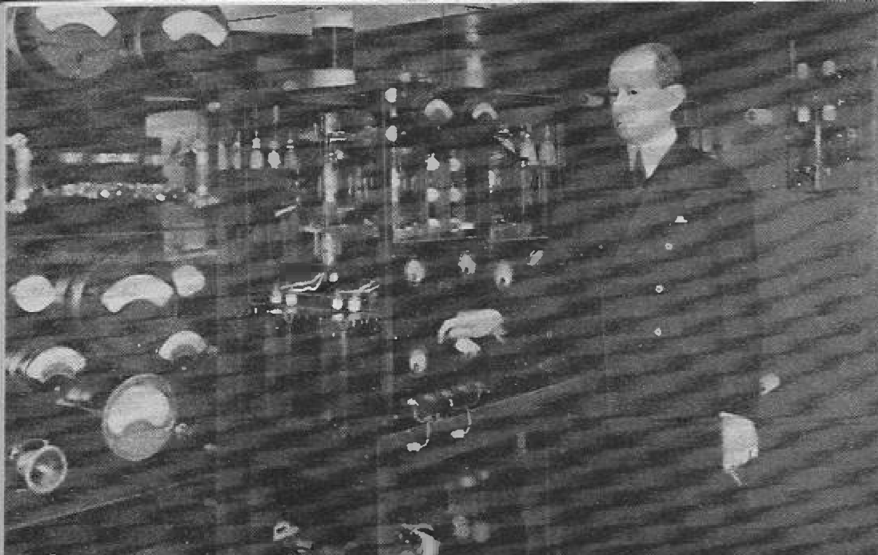
Fig. 11.8. Capacitor discharge observation circuit, VR3 should be set for maximum resistance before connection of batteries.



If the switch is now opened the capacitor can only discharge via the high input resistance of the f.e.t. and the capacitor leakage paths. The very slow discharge will be apparent by the slow fall in meter reading.

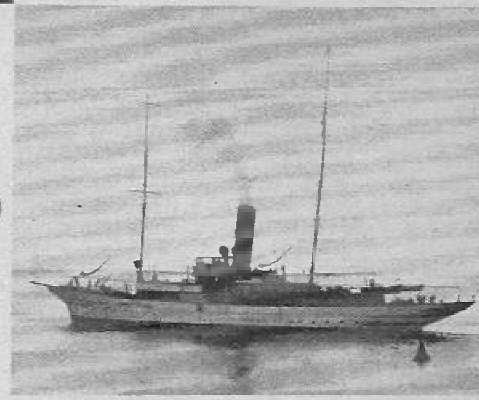
The circuit is a source-follower with the meter reading the current flowing in the source resistance. As the gate voltage falls due to the capacitor discharge the transistor current also falls.

"Stan's still having trouble with the practical side of his electronic devices."



Left. Marconi in the laboratory of his yacht *Elettra*, pictured beside a high power short wave transmitter. (*Marconi*)

Marconi's steam yacht *Elettra*, fitted with extra topmasts for aerial height. (*Marconi*)



Centenary of an Amateur

Marconi 'Father of Wireless'

By Bill Maconachie

In this centenary year of the birth of Guglielmo Marconi a great deal has already been written about his inventive genius, portraying him—rightly enough—as the founder of a great industry and of great companies. But there was a side to his personality about which little has been said, and this is perhaps best illustrated by a remark he made in 1933 when he visited the World Fair in Chicago.

One of the features of the exhibition was an amateur radio shack. Marconi called in, introduced himself, and was shown over the station with, one can imagine, a mixture of pride and embarrassment on the part of the man who had built it. Marconi congratulated him on his workmanship and he modestly replied that of course he was only an amateur. "Yes," said Marconi. "But then I am only an amateur myself".

That remark was in all probability not prompted by false modesty, for Marconi's character indicates that while in no way a boaster he nevertheless always had a proper sense of his own achievements. To say that he was an amateur was no more than a simple statement of fact. He began as an amateur, and an amateur he always remained until his death in 1937.

His first attempt at communication was in the Villa Grifone at Pontecchio, near Bologna, shortly after ten in the morning on Saturday, 25th April, 1874. There was nothing special about it, for it was no more than the wail common to all newborn babies and no doubt it didn't carry very far, anyway. Far enough, though, to delight his Irish mother Annie, the daughter of Andrew Jameson of County Wexford and whiskey fame, and to stop the pacing of his father Giuseppe.

EARLIEST EXPERIMENTS

There was nothing special about his early boyhood either, but very soon he developed a fascination for electricity, and before he was ten he had started reading about it and experimenting with its effects.

Precocious, you might think, but then he had no formal schooling and, except for his brother Alfonso who was nine years older, lacked the company of other boys and their interests. His mother had taught him to read and write, and he found books on electricity of absorbing interest. For his crude experiments he used whatever materials he could lay his hands on, and among his domestic acquisitions was a set of dinner plates which he decided would come in handy as insulators for a high-voltage line across a stream near the house. The result was disaster.

The plates were smashed. To Marconi's father Giuseppe, a man in the old Victorian *paterfamilias* mould, mean almost to the point of miserliness, this was senseless destruction of valuable property, and from that day on he systematically demolished any bits of the boy's apparatus he found around the house. Annie, however, stood up for her son and eventually a sort of armistice was reached and young Marconi was given the run of the attic floor of the house where his grandfather Domenico kept trays of silkworms. In their silent company he was allowed to dabble undisturbed.

STATIC ELECTRICITY

When he was thirteen the family took an apartment in Leghorn for the winter and young Marconi attended the Technical Institute there, for the first time receiving some real education in electrophysics. He rigged up a zinc contraption on the apartment roof and succeeded in using the charge of static electricity it built up during a thunderstorm to ring a bell downstairs. And he met an old telegraphist named Nello Marchetti who taught him the Morse code.

There were distractions, two of them deliberately arranged by his father who opened his purse to buy the boy a small sailboat and to pay for piano lessons. Young Marconi learned to sail and to play the piano rather well, and developed a passion for music, but he kept returning to his electrical experiments though for some time these seemed to have no definite aim more than the satisfying of his curiosity.

Then in January, 1894, Heinrich Rudolf Hertz died and shortly afterwards Marconi read an article by Augusto Righi on the work of Hertz. He was fascinated by the account of the "Hertzian rays" and from that point on his hitherto rather aimless dabbling had a firm goal, the transmission of electrical signals without connecting wires.

FIRST WIRE-LESS SUCCESS

Back home in the attic of the Villa Grifone he worked ceaselessly, far into the night, and his mother's reward for the earlier encouragement of her son came one night when she was asleep. It was almost midnight when her twenty-year-old son woke her and asked her to come up to the attic. There she watched while he pressed a Morse key and at the far end of the attic a bell rang. There was no wire, no thread, connecting the key and the bell. Twenty-year-old Guglielmo Marconi had sent electrical impulses through the air.

That was his big breakthrough, though only domestically at first. Father Giuseppe at last, if somewhat grudgingly, admitted that there might just be some practical use for his son's dabbling, and even handed over a little cash to buy more materials. Marconi improved his apparatus and was able to send signals to the other side of a little hill close to the house. Details of the invention were then sent to the Italian Ministry of Posts and Telegraphs, but Signor Sineo, the Minister, turned down the offer without even asking for a demonstration.

OFF TO LONDON

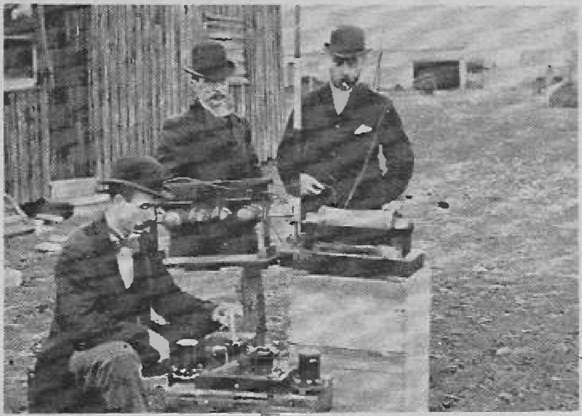
It must have been a big disappointment, not only to young Marconi but doubtless also to his father who had viewed his cash contribution as an investment and was looking for a return on it. However, Annie Marconi was not to be beaten. Believing that Britain, in those days the world's foremost maritime nation, might see the value of the invention for communicating with ships at sea, she obtained a letter of introduction to W. H. Preece, engineer in chief of the British Post Office, and armed with this set off with her son for London in February, 1896.

Preece was himself an experimenter in new methods of telegraphy transmission but had had little success with his attempts at using inductive techniques, and he gave the young Italian his support, introducing him as a "surprise guest" at the end of a lecture he gave at Toynbee Hall in December, 1896.

You can perhaps picture this shy, reserved young man walking on to the platform to face his first scientific audience, carrying his home-made apparatus that the Press was soon to call "the mysterious black box", and giving a demonstration of its capabilities while almost certainly praying inwardly that nothing would go wrong. But it worked, even though Marconi carried his black box about the hall to show that there was no deception, and next day the papers carried headline stories about the Italian inventor.

Of course there were sceptics in plenty. Even Lord Kelvin said that so far as sending a message by wireless was concerned he would sooner trust a boy on a pony. And there were others who, while admitting the truth of what

Marconi in London in 1896 with the original apparatus he brought from Italy including the "mysterious black box." (*Marconi*)



A group of Post Office officials keenly interested in Marconi's hook-up for the first successful transmission across water from Lavernock to Brean Down in 1897. *(Marconi)*

they had seen in Toynbee Hall, would not believe that signals could ever be sent over any substantial distances. As for sending them across water—well, everybody knew that water absorbed electricity from the air, so that was a non-starter.

TRANSMISSION ACROSS WATER

But Marconi proved that he could send signals for considerable distances out of doors, and in May, 1897, confounded those who thought that water would be a barrier by transmitting across nearly nine miles of the Bristol Channel between Brean Down and Lavernock.

That was proof enough for everybody, including even Lord Kelvin who became an enthusiastic convert. Willing financial backers took up the young inventor and the ardent amateur found himself swept into commercialism with the formation of the world's first wireless firm, the Wireless Telegraph and Signal Co., Ltd.

Orders came in from Lloyd's to equip their signal stations for the reporting of passing ships soon after the company was formed on 20th July, 1897—a day, incidentally, when, however important it must have been in Marconi's life, he had actually returned to Italy to demonstrate his apparatus to the Italian Navy which proved much more receptive than that country's postal authorities had been three years earlier and immediately decided to adopt wireless for its ships.

In fact, Marconi's absence from London on the day the company was formed is a pointer to his character. He was always happier at a laboratory bench than behind a desk—always the devoted dabbler with bits of wire rather than the complete business man, an amateur in the truest sense of the word. But he was, too, always a shrewd user of publicity.

ROYAL PATRONAGE

An opportunity for this came his way in 1898 when the then Prince of Wales—later to become King Edward VII—was convalescing on board the Royal yacht *Osborne* off Cowes after an injury, while Queen Victoria was in residence at Osborne House. Since intervening hills made visual signalling between the yacht and Osborne House impracticable, the Queen decided to give the new wireless a trial and have sets installed on board the *Osborne* and at Osborne House. During the next fortnight or so 150 messages were exchanged, with full reporting of the Prince's progress in the newspapers.

Incidentally, there is a story—possibly apocryphal—told about this, in which Marconi, summoned by the Queen, arrived at the front door of Osborne House and sent in his name, but was told to report at the tradesmen's entrance. He refused, and the Queen is said to have commanded "Send for another electrician." No other electrician of his calibre, however, was available, and no doubt the incident ended amicably.

BUSINESS DEVELOPMENTS

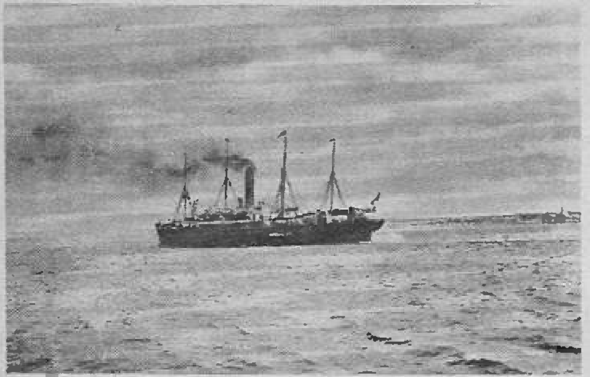
In the meantime the new company's affairs were progressing, but slowly, most of its business being with the British government, Army, and Navy, all of which showed great interest but did not come forward with much in the way of firm orders. Marconi himself seemed to care deplorably little for the interests of the shareholders—as long as the company could provide money for further experiments he was happy.

The other directors, however, did not share this attitude and a decision was taken—Marconi's being the only dissenting vote—to reconstitute the company as Marconi's Wireless Telegraph Co., Ltd., in order to capitalise on his name. That was in February, 1900, and two months later Marconi took out his patent No. 7777 for the first method of tuning transmitters and receivers. This was a great step forward since until then transmissions had been untuned over a very broad frequency band and selection of stations to be received had been impossible.

Although Marconi's original idea had been to use wireless to end the isolation of ships at sea, no commercial orders for installing it on ships had been received in the first three years of the company's existence. The breakthrough came with the fitting—not of a British ship—but of the Norddeutscher Lloyd lines *Kaiser Wilhelm* in February 1900.

That April a second company, the Marconi International Marine Communication Co., Ltd., was formed to hire equipment to ships since, under the terms of the Telegraph Acts of 1868 and 1869, the Post Office had a virtual monopoly of all telegraph traffic and if shipping companies had bought their installations each would have had to set up its own coast station.

In May of the following year, 1901, the *Lake Champlain* became the first British ship to be



The liner *Lake Champlain*, in 1901, was the first British merchant ship to be commercially fitted with wireless. (*Marconi*)

commercially fitted, and soon after Cunard, with their *Campania* and *Luciana* followed suit. Marconi had built a powerful transmitting station at Poldhu, in Cornwall, to handle Transatlantic traffic to ships, and once this was in operation other passenger-carrying ships began to install apparatus. Then Marconi was off again, this time to St. John's in Newfoundland to put up a station there and prove that communication right across the width of the Atlantic was possible. He did it, and in 1902 a permanent station was established at Glace Bay.

OTHER GREAT INVENTIONS

During the period up to the first World War Marconi and the team of like-minded men he had gathered around him—inquisitive engineers as distinct from the office staff—were busy indeed. Marconi himself devised and patented the magnetic detector to replace the inefficient coherer; Dr. J. A. Fleming, scientific adviser to the company, developed the diode (later improved by Lee de Forrest by the addition of the grid) and the directional aerial, another Marconi idea, was brought into use at Clifden in Ireland where a new station had been erected to replace Poldhu.

This period also saw the first use of wireless in the air, first in communication with a captive balloon and then, in 1910, with an aeroplane. In 1910, too, its use in the capture of the murderer Crippen captured the public imagination, and its value in bringing help to a ship in distress was demonstrated to the world in 1912 when the *Titanic* sank, even though on that occasion assistance arrived too late to save all on board.

Marconi's fertile mind, too, was demonstrated in the course of his evidence at the enquiry into the loss of the *Titanic* when he said that he was considering the feasibility of an instrument that would ring a bell on ships within range of a vessel in distress—the germ of an idea that he was later to develop into the auto-alarm receiver which is compulsory equipment on most single-operator ships today.

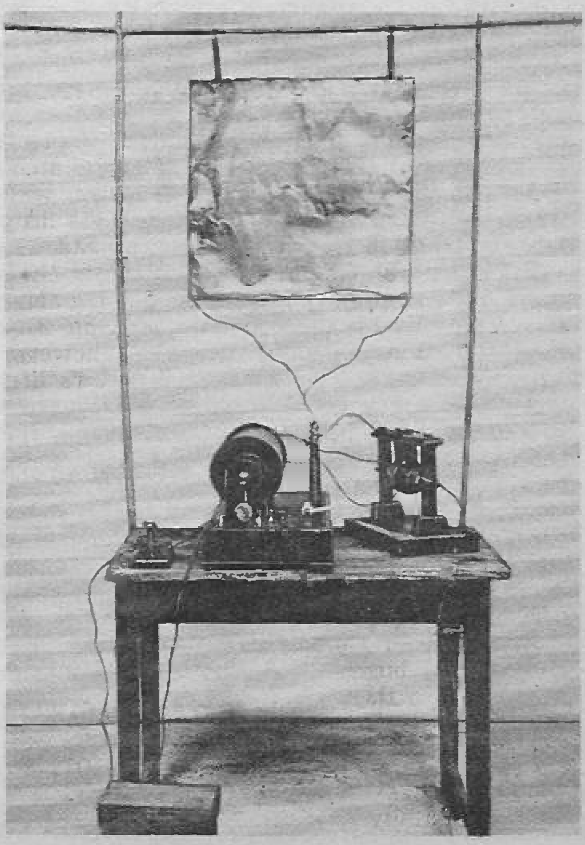
AIR TO GROUND RADIOTELEPHONY

He had also been intrigued by what he called "the directional effect of wireless emissions" and acting on his observations another of his team, Captain H. J. Round, did a great deal of work in developing the direction-finding receiver which in the 1914-18 war enabled Britain to monitor the movements of German warships and led to the Battle of Jutland. Round and two other colleagues, Prince and Furnival, also overcame the problems of air-to-ground radiotelephony and plane-to-plane telephony, the latter being achieved in 1917.

Radiotelephony became broadcasting in 1920 with two events.

One was when the delegates to the Imperial Press Conference, travelling to Canada on the liner *Victorian*, heard a concert of gramophone records broadcast from Chelmsford, 1,000 miles away—Marconi's flair for publicity again. The other was the first advertised broadcast, a song recital by Nellie Melba in an improvised studio at Marconi's Chelmsford works.

A simulation of Marconi's early experimental transmitter using a copper sheet aerial, induction coil and spark gap. The coil seen in this replica assembly is, however, of much later date and is in fact a production model of a type used for a number of years after 1900. (*Marconi*)



The handiwork of an amateur. Marconi used a cigar box as a case in which to build his first magnetic detector while experimenting on board the Italian warship *Carlo Alberto* in 1902. *(Marconi)*

A little over a year later the Marconi company was licensed for regular broadcasting and opened the 2MT station in an ex-army hut at Writtle, and a licence was also granted for the original 2LO London station at Marconi House in the Strand. Later still, in 1922, the Marconi company was one of six which formed the British Broadcasting Company, superseded in 1926 by the British Broadcasting Corporation.

SHORT-WAVE EXPERIMENTS

Marconi himself, though, took little interest in the development of broadcasting. It presented no real technical challenge to him, and as he once said when tackled on the subject, "Can you compare entertainment with the saving of men's lives?" In 1920 he had bought a steam yacht which he named *Elettra* and fitted out as a floating laboratory, principally to work on investigations into short-wave transmissions in pursuit of one of his greatest personal ambitions, the linking of all the countries of the British Empire by directional short-wave.

In the course of his experiments with short-wave techniques he noticed, as he said in a speech he gave in New York in 1922, "that short-wave transmissions were subject to reflection by metallic objects many miles away." He went on to say "It seems to me that it should be possible to design apparatus by means of which a ship could project a beam which would be reflected back and reveal the presence and bearing of another ship in fog."

Evidently the principle of radar at least existed in Marconi's mind at that time, but being preoccupied with his grand project of the Imperial Wireless Chain he did not pursue the idea and it was left to Sir Robert Watson Watt to give Britain the invaluable lead in radar for World War II, though Marconi did return to thoughts of it shortly before his death.

The Imperial Wireless Chain project almost came to fruition and in fact Marconi had a contract for the setting up of the necessary stations practically within his grasp in 1924. But cable companies throughout the British Empire, seeing their business threatened, brought influence to bear with their respective governments with the effect that their interests were merged with the Marconi scheme and control was vested in a new organisation, Cable and Wireless, Ltd.

WITHDRAWAL FROM BUSINESS LIFE

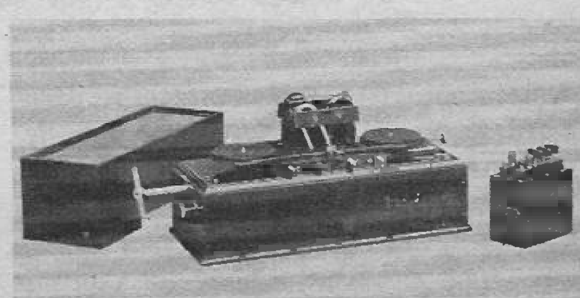
Sorely disappointed and plagued by increasing ill-health, Marconi withdrew more and more to his home in Italy and to life at sea on board the *Elettra*. Business life, that had never really meant much to him, was put aside pretty well completely, and most of his time was spent as it had been in his youth, experimenting and trying out new techniques.

He did a great deal of work on microwave transmission, leading up to the creation of the first microwave radiotelephone link in 1932. Then in 1935 he took up his radar idea again and was able to construct a working model and demonstrate it in principle. His health, however, was failing rapidly and in the early months of 1937 he suffered three minor heart attacks. He had a fourth and major attack on 19th July that year and died early the following morning at the age of 63.

THE FINAL TRIBUTE

All his life Guglielmo Marconi had had honours and distinctions bestowed upon him, but none could have been matched by the world's tribute on the day of his funeral in Rome when radio and broadcasting stations all over the world closed down for two minutes from 6 p.m. and the "ether" was for a brief period again as silent as it had been before that midnight in the attic of the Villa Grifone at Pontecchio. ▣

When the magnetic detector went into production it was a much more elaborate affair with a clockwork motor to drive pulleys causing a band of soft iron to rotate through the magnetic field. In a handsome mahogany case, it had a glass-topped lid to keep out dust. *(Marconi)*



We would like to thank The Marconi Company Ltd., for the photographs used in this article.

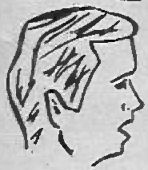
NEXT MONTH!!

for you to construct

...A METAL LOCATOR

A straightforward design that is inexpensive and easily constructed, this metal locator will provide hours of entertainment and could provide some valuable finds.

A 2WAY IN-HOUSE COMMUNICATOR



A communication system for your home—no more shouting at father in the garage, simply call him up and request the pleasure of his company.

AND...A SIMPLE CRYSTAL SET

A very simple m.w. crystal set, with improved selectivity, that can also be used as a simple tuner. This neat unit has been designed for ease of construction.

PLUS ALL THE REGULAR FEATURES

Because of prevailing production problems, no firm publishing date can be announced for the September issue. Readers are advised to check regularly with their local supplier from mid-August onwards.

everyday electronics

KNOW YOUR COMPONENTS...

Hints & Tips for the Novice Constuctor

By Ron Adams

The Capacitor

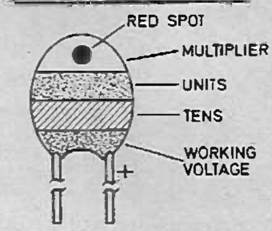
This device normally has its value printed on its body, but many lower value capacitors are colour coded like resistors, see below. Remember, if in doubt—check it out. Remember also that electrolytic and solid tantalum capacitors are polarised—make sure that they are inserted in circuit the right way round.

If the electrolytic body is not marked with polarity, a good tip to bear in mind is that the negative lead is usually connected to the case.

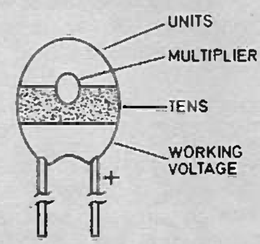
Tantalum bead capacitors can be tricky. They are those capacitors that look like frogs eyes on wires. The way to identify the positive lead on this component is to hold the capacitor with the dot facing you with its wires facing down; the positive lead is on your right hand.

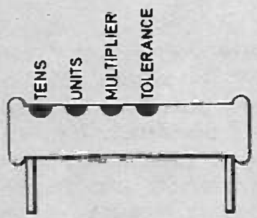
Remember that voltage ratings are important, but obviously a 50V capacitor can be put in place of a 25V capacitor. Again the rule is "up, not down".

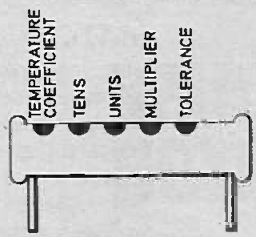
SOLID TANTALUM TYPES



WHEN VIEWED WITH SPOT SHOWING POSITIVE LEAD IS AS MARKED

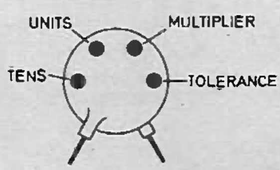






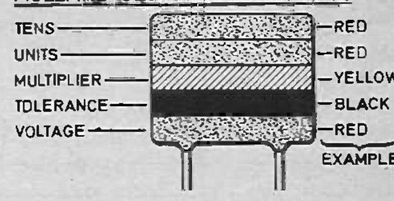
5 DOT COLOUR CODE

CERAMIC TYPES



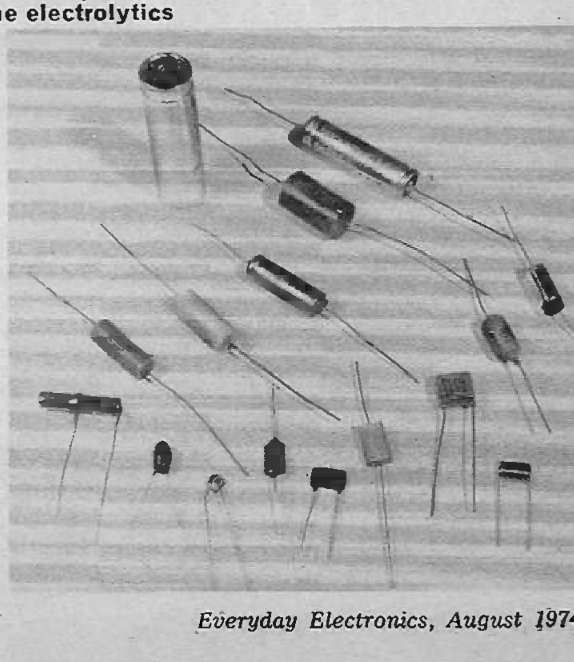
4 DOT COLOUR CODE HAS THE SAME SIGNIFICANCE AS FOR C280 TYPE

MULLARD C280 POLYESTER TYPE



EXAMPLE:—
CAPACITANCE = 22 x 10 000pF
= 220 000pF OR 0·22μF
TOLERANCE = ± 20%
VOLTAGE = 250V

Below right. Photograph of a selection of most of the common types of capacitors including some electrolytics



CAPACITOR COLOUR CODE
As Used For Mullard C280 Series and Ceramics

Colour	Tens & Units	Multiplier	Tolerance	Voltage
Black	0	x 1pF	±20%	—
Brown	1	x 10pF	±1%	—
Red	2	x 100pF	±2%	250V
Orange	3	x 1,000pF	±2·5%	—
Yellow	4	x 10,000pF	—	400V
Green	5	x 100,000pF	±5%	—
Blue	6	—	—	—
Violet	7	—	—	—
Grey	8	—	—	—
White	9	—	±10%	—

CAPACITOR COLOUR CODE
As Used For Tantalum Capacitors

Colour	Voltage	Tens & Units	Multiplier
Brown	—	1	x 10μF
Red	—	2	x 100μF
Orange	35V	3	—
Yellow	6·3V	4	—
Green	16V	5	—
Blue	20V	6	—
Violet	—	7	—
Grey	25V	8	x 0·01μF
White	3V	9	x 0·1μF
Black	10V	0	x 1μF
Pink	35V	—	—

EXPERIMENT IN HEADPHONE STEREO

An experimental circuit designed to improve the stereo effect when using headphones.

By H.T. KITCHEN

For many people, stereo listening via headphones is the norm, either because of circumstances or because of personal preference. Others, like myself, may have a single large lounge which houses both the stereo and the family television set, and here the conflicting demands of both services requires careful and skilful manoeuvring by the head of the house if chaos is not to reign unchecked. However, as the saying sayeth, there is many a slip!

Both wife and seven-year-old daughter failed to recognise the advantages of listening to TV via "phones"; stalemate! Realising that "A Family at War" and "Top of the Pops" had won the day, and that there was a danger of dad's classics suffering from instant silence, I withdrew from the fray and started investigating headphones, dad for the use of.

Not knowing if I would like headphone stereo, I decided to invest in a modestly priced pair, and a short "demo" on mono f.m. radio ended in my purchasing a pair of Eagle SE40's, together with the appropriate shorting socket and a 5 metre extension. (I like conducting Beethoven whilst walking about.) The problem of attaching the 'phones to the Quad II's was on.

Early experiments were encouraging, the sound level and quality from the SE40's being higher than expected.

MATCHING

A straight changeover from 'speakers to 'phones wasn't liked, the apparent volume levels being too dissimilar, plus the difference in the "central" positions. I decided to try and equalise things. Fig. 1 shows the first attempt at equalising the apparent sound levels, and at providing a balance control that was operative on 'phones only, permitting the Quad pre-amp balance control to be used as a master balance control.

A switch, S1a and S1b was added, this being mounted on the front panel to select 'speakers or 'phones. A rotary 6 pole 2 way switch was used, three pairs of poles being connected in parallel to reduce contact resistance. At low

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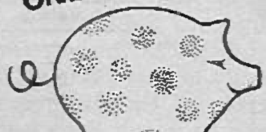
ESTIMATED COST* OF COMPONENTS including V.A.T.

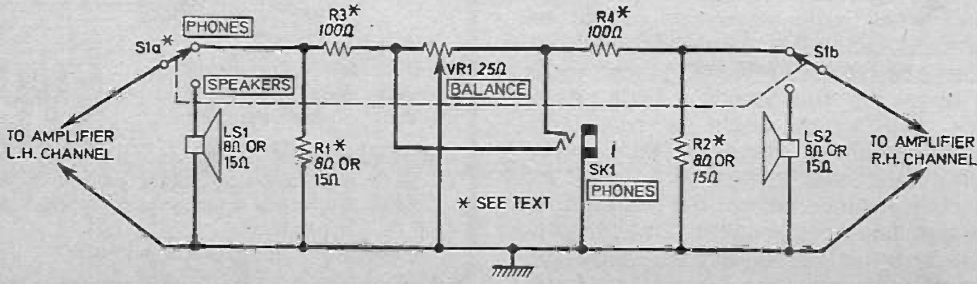


£3.50

excluding case

*Based on prices prevailing at time of going to press

Fig. 1. Basic equalisation and balance circuit.



levels, the oxide layer that inevitably builds up, can act as a rectifier, setting up distortion. Three pairs of switch contacts should assist in reducing contact resistance.

Resistors R1 and R2 are 15 ohm 10 watt components, and substitute for the 'speakers when 'phones only are required. The Quad power amplifiers are tolerant of varying loads, but this should not be taken as an excuse for haphazard "matching". Also, other amplifiers may not be so tolerant, and may suffer consequential damage.

Resistors R3 and R4 are series resistors, subjectively selected to provide approximately equal sound levels when the 'phones are substituted for the 'speakers. The variable resistor VR1 is the balance control. Various resistance values were tried; the 25 ohm resistor gave the best subjective results. Its operation will be obvious.

We now have a circuit which allows one to change from 'speakers to 'phones without a drastic change in the apparent volume levels, and which allows one to set the central image independently.

So far, so good. The family at war is now, domestically speaking, a family at peace. Dad can enjoy his stereo again, albeit his head feels as if it had been firmly clamped in a vice after an hour or so! The sound quality is astonishingly good for such an inexpensive pair of 'phones, even after the initial enthusiasm has worn off.

But wait, and listen, all is not well! The sound quality hasn't altered, but something is amiss. Ahah! I have it! Half the orchestra are on my left, and the other half are on my right. There is very little in front.

SOUND STAGE

The "fault" does not lie in the equipment. Rather it is the way in which we hear that is the cause. Normally, a sound source directly in front can be identified as being in front, even if the eyes are closed, if both ears have similar characteristics. A sound to the right or to the left can similarly be identified, simply because the brain translates direction in terms of the difference in time taken by the sound to reach each ear.

If a sound takes a millisecond or so less to reach the right ear, than it does the left, then that sound is identified as being to the right of centre; the reverse also applies.

The sound stage, with 'speakers, cannot be wider than the spacing between the 'speakers, though reflections from suitably (!) placed walls sometimes opens up the image a little. As a consequence, the sound angle is restricted, 90 degrees being about average. The experts' recommendations cannot always be adhered to, because of circumstance, or are not adhered to, because of personal preferences. One demonstration I recently attended (I shall spare the agent's blushes) had the 'speakers at an angle approaching 160 degrees for the front row. Talk about a hole in the middle!

With 'phones, the ears are completely isolated from one another, and since they are set on apposite sides of the head, a stereo signal will apparently originate on opposite sides of the head, whilst a correctly phased, centralised, signal will apparently originate in the centre of the head. Subjectively, the results can be amusing, bewildering, or irritating. The end result is almost always listening fatigue, and it is worth trying to find even a partial cure, if not a complete cure.

Narrowing of the sound stage can be effected by feeding part of one signal into the other, i.e. part of the right hand 'phone signal to the left hand 'phone, and vice versa. Quite elaborate circuits exist for this purpose, but it was decided to try and see if something simpler would not provide reasonable results. Fig.2 shows the second attempt at improving headphone stereo, ignoring VR3 and C1 for the moment, VR2 is connected across VR1 and functions as the sound width control. At maximum resistance, its effect upon the apparent sound width is negligible.

As the resistance in circuit decreases so the sound stage narrows, until its resistance is zero, when the sound, being fed to two 'phones in parallel, produces a mono image. All other factors being equal, this will provide a central image within, apparently, the listener's head. Although somewhat crude, this method works reasonably well, and is worth experimenting with.

FREQUENCY SELECTIVE SYSTEM

The drawback to the simple circuit of Fig. 2 is that it compresses the sound stage willy nilly. An extension of this scheme is to introduce frequency selective sound stage narrowing, and this is effected by VR3 and C1.

Components....

Resistors

- R1 15Ω 10W } (or to suit amplifier output
- R2 15Ω 10W } resistance e.g. 8Ω 10W)
- R3 100Ω 1W } (selected on test—see text)
- R4 100Ω 1W }

Capacitor

- C1 8μF metalised polyester (4 × 2·2μF)

Potentiometers

- VR1 25Ω wirewound
- VR2 50Ω wirewound
- VR3 50Ω wirewound

SEE SHOP TALK

Miscellaneous

- S1 6-pole 2-way rotary switch (see text)
- SK1 Standard stereo jack socket to suit phones
- Case, connecting wire, 4 knobs

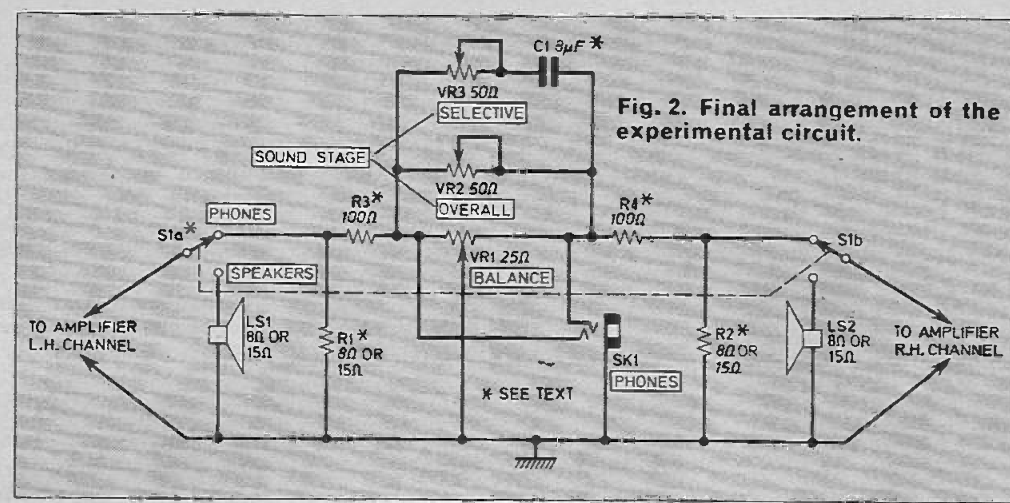


Fig. 2. Final arrangement of the experimental circuit.

The reactance of a capacitor is, as is well known, $1/2\pi fC$, C being in Farads, and f in Hz. The reactance of a capacitor is inversely proportional to frequency, i.e. it is halved for every doubling of frequency. As far as this particular application is concerned, all this means is that C1 will offer a reduced resistance to the higher frequencies, so reducing the apparent sound stage for the increasing frequencies.

Assuming VR2 is out of circuit, the low frequency instruments of an orchestra will occupy the extremities of the sound stage, with the higher frequency instruments progressively occupying the central portions of the sound stage.

A theoretical objection to this scheme is the shrinking/expanding piano. Theoretically, this will "move" as the pianist's fingers move across the scales. So too will other wide range instruments or vocalists. This theoretically undesirable effect does not, in practice, appear to obtrude excessively. This is probably due to the fact that the full range is only rarely used at any one time.

The circuits given should, perhaps, be best regarded as being of an experimental nature, to be varied and expanded upon by the individual. The cost, in terms of coin of the realm, is low. Time is the major ingredient, and should, at the very least, lead to a greater understanding and appreciation of stereo via headphones.

Capacitor C1 can be made up of four 2·2μF polyester types in parallel—variation of the overall value for experiment is then possible.

A constructional diagram for the circuit of Fig. 2 is shown in Fig. 3. Mount S1 and VR1 to VR3 in a suitable case and wire up as shown. ▣

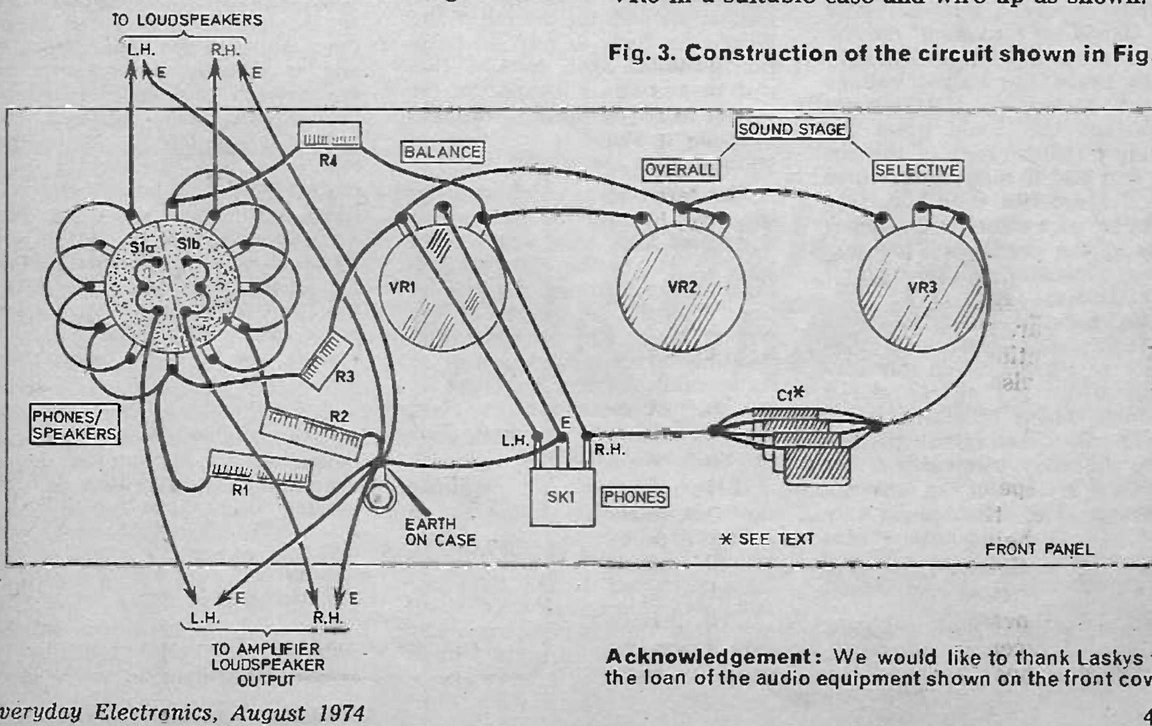


Fig. 3. Construction of the circuit shown in Fig. 2.

Acknowledgement: We would like to thank Laskys for the loan of the audio equipment shown on the front cover.

Decoupling

Can you tell me why one often sees a high value capacitor connected across the power lines of a circuit—even though the circuit is run from batteries and there is no smoothing problem?

These capacitors come into the general category of *decoupling capacitors* and they are usually included for one of two reasons. Some circuits draw modest current from a battery under normal circumstances but may occasionally require a brief surge. If this surge is too great the internal resistance of the battery might cause the output voltage of the battery to fall momentarily and this could upset the biasing of other parts of the circuit and lead to distortion—worse still the drop in supply voltage might act as a signal to an earlier stage of the circuit and low frequency oscillation (instability) might ensure.

The capacitor—straight across the supply rails—acts as an extra source of current when this condition arises; the charge stored within it, during normal running, is withdrawn during the current surge and this compensates for the limiting effect of the battery's resistance. This technique is only valid for short duration surges because time has to elapse for the capacitor to regain its charge between them.

Many amplifiers have a capacitor connected between the supply rail and ground near the pre-amplifier stage—usually on the pre-amp side of a resistor in the power rail. This has a similar function. When the output stage of the amplifier is drawing peak current there is always a slight drop in supply voltage (it may only be a few millivolts) and this could act as a signal into the input stage—by reducing the collector current of an early transistor. The capacitor and series resistor in effect filter out the slight supply variation.

A.C. and D.C. Coupling

I am a bit confused by the terms a.c. coupling and d.c. coupling. Can you help?

If one applies a constant current (from a d.c. voltage source) into the base of a transistor the collector voltage will take up a fixed level and will stay there as long as the base current is maintained. If the collector voltage of this stage is directly coupled to the base of a following stage (either through a resistor or by direct connection) then the output of the second stage will follow suit and will stay in the new condition for as long as the original input current is maintained. This is d.c. coupling.

If, however, the voltage at the collector of the first stage is incompatible with the biasing of the second we have to provide isolation from the fixed voltage. This is done by putting a capacitor (or transformer) between the stages and then we have to provide suitable bias for the second stage.

The base current (provided by the input signal) for the second stage will vary only when there are changes in the collector voltage of the first; at the end of the "change" the output of the second stage will always revert (possibly after a bit of time) to its normal quiescent level (set by the bias) irrespective of the fixed base current into the first. This is called a.c. coupling.

If one considers an amplifier there is obviously going to be a lower frequency limit below which the second stage will not respond. Hence to get good low frequency response in a.c. coupled amplifiers the coupling capacitor usually has to be of quite a large value.

Potentiometers

There seems to be an unlimited range of potentiometer types to choose from—carbon wirewound, log, linear, precision, ganged etc. Would it be possible for you to summarize the differences and give any hints as to what applications the different types have?

Carbon and wirewound simply describe the material used as the resistive element inside the device. On the whole wirewound devices are of better quality and are less likely to fail in use. After a lot of use the carbon tracks of composition potentiometers tend to wear away and the device becomes "noisy"; this is less likely to happen with wirewound devices.

Because there is more bulk in wirewound pots they usually have a greater power dissipation. Because they would require many turns of extremely fine wire high value wirewounds are rare (values greater than a few hundred kilohms are not common). Because they—in effect—form a coil of wire wirewound potentiometers have a significant self inductance and this precludes their use in very high frequency circuits otherwise you can always use a wirewound device to replace a carbon potentiometer.

Linear law (lin.) potentiometers are so called because the resistance between the wiper and one end is directly proportional to the amount of spindle rotation; i.e. with the spindle turned one half of a complete revolution the resistance will be exactly half the total value; a logarithmic law (log.) device does not have this proportionality—the degree of rotation is proportional to the log of the resistance. The latter are used as volume controls because the ear's sensitivity to volume also follows a logarithmic law.

Certain types of log pots are used in analogue computers (as indeed are anti-log pots) but these are usually very expensive devices because there must be an accurate relationship between the rotation and resistive value obtained; these are called precision potentiometers. They are not often used by amateurs—unless you are making a good quality signal generator or such like.

They can come as linear, log, or anti-log devices.

As the name implies, ganged potentiometers are simply two or more potentiometers coupled together on the same spindle so that they all change in value by the rotation of a single knob—most frequently come across in stereo amplifiers and Wein bridge oscillators. These can be of any law depending on the application.

Capacitor Measurement

Is there any way one can use a multimeter to measure the value of capacitors?

Unfortunately this is not possible with any degree of accuracy. The technique is to apply a known frequency signal to the capacitor and then measure its reactance with a special circuit known as a bridge. We published a capacitance bridge in our September 1972 issue (back numbers or reprints are not available).

Rectification

I would like to know what value rectifier to use to produce 9V d.c. from the mains?

To produce the voltage you require you must first reduce the value of the mains voltage with a transformer. This also gives you protection from the live mains. You then use a rectifier which must have a reverse breadown voltage in excess of the d.c. voltage you require and it must have a current rating higher than the maximum current you expect to draw.

In some instances you might need good smoothing and a capacitor might be necessary. We recommend that you watch these pages for suitable designs; we have published several in the past and there are sure to be more in the future.

Aerial and Earth

Why was it that old valve radio sets required an aerial and an earth while modern transistor radios need no earth connection?

One could write a book on the theory of radio propagation and reception so our answer will be an oversimplification of the reason. First, there is no distinction on the grounds of valves versus transistors. When a radio signal is transmitted it is made up of two components; an electrostatic signal and an electromagnetic signal. These two signals each carry the information we want to receive and we can arrange to pick up either at the front end of our radio set.

When picking up the electrostatic signal we need a long aerial which acts rather like a single plate of a capacitor—the other plate of this mythical capacitor is ground. The electrostatic signal induces charges in the aerial which flow through the tuning circuit of the radio down to the earth connection giving rise to the input signal. In many instances it is not necessary to connect the other end of the tuning circuit to a real ground because there is usually quite a high capacitative coupling anyway—nevertheless a good earth connection can make all the difference to the signal pick-up.

Before the days of ferrite aerial rods a number of portable radios used frame aerials which picked up the electromagnetic radiation from the transmitter—in just the same way that a current can be induced in a coil when a magnet is moved nearby. As technology developed we began to get magnetic materials which were efficient at the high frequencies involved and these enhanced the efficiency of the frame aerials giving rise to the ferrite aerial which is no more than a coil affected by the radiated electromagnetic energy.

No earth connection is required because the signal is totally induced within the coil, however, the orientation of the ferrite rod is important as it has to lie along the direction of the radiated lines of force for maximum signal. This occurs when the rod is horizontal and its axis is at right angles to the direction of the transmitting station.

I have recently discovered a quick and easy way of cutting Veroboard, s.r.b.p. board and almost any other type of circuit mounting board.

First rest the board you wish to cut on a hard flat surface and with a straight edge as a guide, score a deep "V" groove with a sharp glass cutter. Now rest the board on the edge of, say, a table, and give it a sharp downward blow; the board should break along the line leaving a neat sharp edge.

This method works for any type of Veroboard, tagboard or printed circuit board always giving a professional finish and doing away with the need for a hacksaw which can sometimes give a far from straight edge.

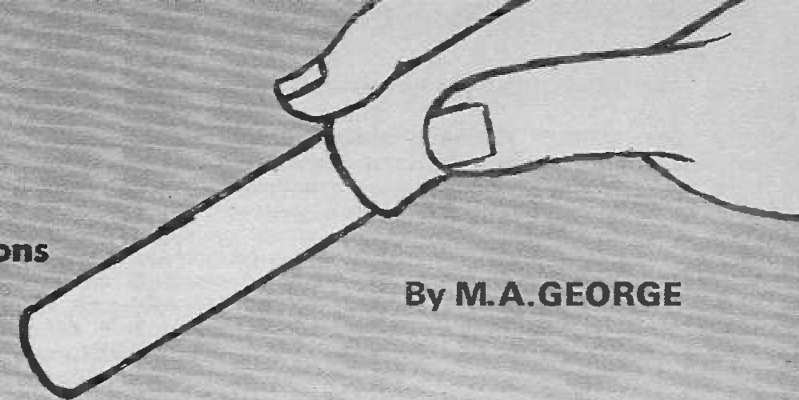
T. Holden
Northampton.

In building my *Tutor Board* for the *Teach-in '74* series I fixed the terminal blocks to the baseboard with medium size pop-rivets. These are easily removed when necessary and are, I think, an improvement on the nail method.

If the rivet shank is loose, it can easily be hammered oval.

D. Blades,
Salford, Lancs.

Readers' Bright Ideas; any idea that is published will be awarded payment according to its merit. The ideas have not been proved by us.



For simple investigations into radioactivity.

By M.A.GEORGE

RADIATION MONITOR

THIS article describes the construction and use of a portable Radiation Monitor for investigations into radioactivity in the laboratory and out of doors.

It can be used as a simple means of demonstrating the principles of radioactivity in schools (e.g. measuring penetration of β-radiation), radiation pollution monitoring and source checking.

There are also other applications for the basic circuit outside radioactivity such as testing neon lamps, and as a power supply for a battery operated oscilloscope.

The output can be fed via a Schmitt trigger to a ratemeter or decade scaler unit to form a true Geiger counter.

Despite the simplicity of the circuit, the unit is just as sensitive as any commercial one, since sensitivity depends only on the tube used, and having the correct operating voltage.

CIRCUIT

The complete circuit diagram of the unit is shown in Fig. 1 and is seen to be a Hartley Oscillator (see *Demo Circuits* Dec. '73) followed by a voltage-doubler rectification stage.

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ESTIMATED COST* OF COMPONENTS including V.A.T.

£5.50

excluding case

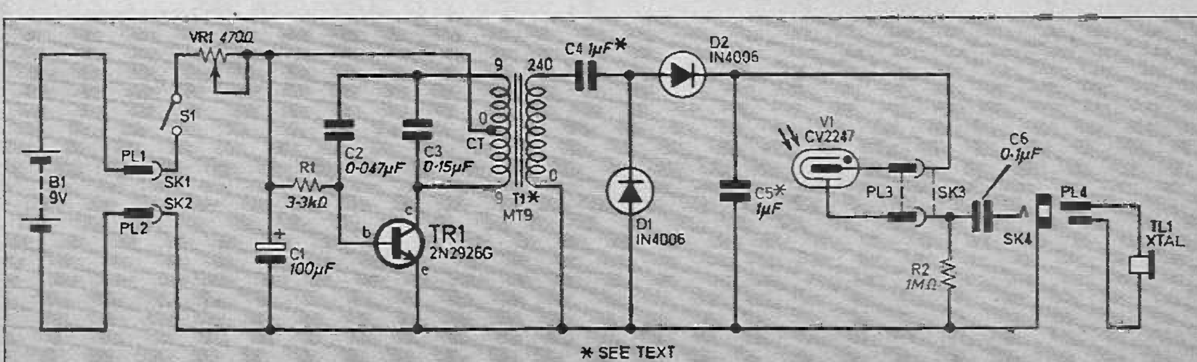
*Based on prices prevailing at time of going to press

The oscillator load is the secondary of a low voltage, low current miniature mains transformer, the secondary should not be rated at more than 100mA. The frequency of the oscillator is controlled by the choice of C3.

The bias for the oscillator is set by VR1 and positive feedback is obtained via C2 and is sufficient to overdrive TR1 to produce a clean, fast rising edge waveform for the "inverter" section of the circuit.

Due to transformer action, a voltage is induced across the primary of T1 of about 250 volts. Components D1, D2, C4 and C5 are connected to act as a voltage doubler, rectifier and smoothing stage to produce a steady d.c. level

Fig. 1. The complete circuit diagram of the Radiation Monitor.



of about 500 volts required for satisfactory operation of the Geiger tube.

The current through the tube is limited by R2 and the signal across the latter is taken via blocking capacitor C6 to the monitoring device, which in the prototype was a high impedance crystal earpiece, TL1.

Capacitors C4 and C5 must be high quality mixed dielectric types with a minimum voltage rating of 600V d.c. and diodes D1 and D2 should be rated at least 800 p.i.v.

CONSTRUCTION

The prototype unit was constructed in an aluminium box size 100 x 65 x 55mm and most of the components were mounted on the removable lid; the three bulky components, T1, C4 and C5 were secured to the base of the box. The size, shape and material (metal) of the case are not important and can be modified to suit individual requirements.

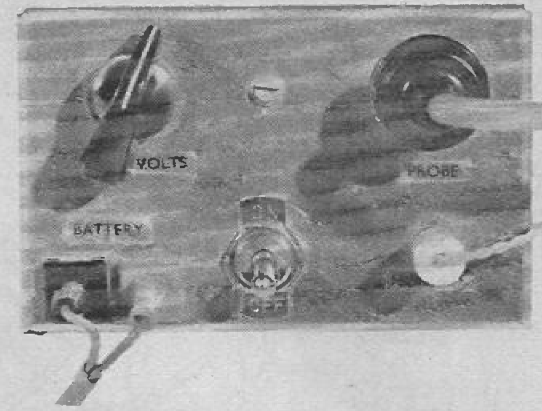
Begin construction by soldering the components to the Veroboard as detailed in Fig. 2. There are no breaks along the copper strips on the underside.

The lid should now be prepared to accept all the lid mounted components as indicated in Fig. 2. Secure these components in position and wire up to the component board as shown.

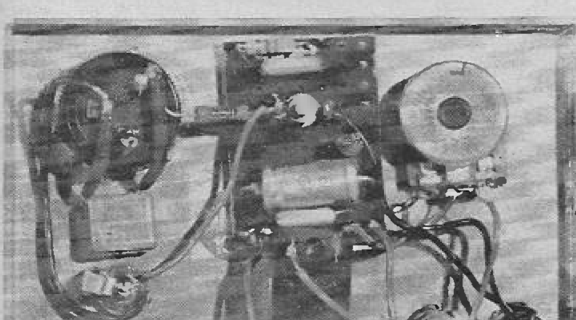
When screwing the board to the lid, a piece of foam rubber between board and lid will prevent any contact between board and case.

Two capacitor clips (or Terry clips as used in the prototype) should next be screwed to the inside base of the box to hold C4 and C5. The transformer should now be bolted or glued to the base and solder tags fitted to one of the case sides. Place C4 and C5 in position and wire up as detailed in Fig. 2.

A piece of foam rubber should be placed over the base mounted components and held in place with insulation tape before securing the lid in position. This will avoid any contact between lid and base mounted components. The controls and sockets should now be labelled as shown in the photograph.



Details of the component positioning and labelling on the top panel of the prototype.



The layout of the components and wiring on the underside of the top panel in the prototype.

Components....

SEE
SHOP TALK

Resistors
R1 3·3kΩ
R2 1MΩ
¼W ± 10% carbon

Capacitors
C1 100μF elect. 16V
C2 0·047μF
C3 0·15μF
C4 1μF mixed dielectric 600V d.c.
C5 1μF mixed dielectric 600V d.c.

Miscellaneous
VR1 470Ω carbon lin.
TR1 2N2926 green silicon *npn*
D1, 2 1N4006 or similar rated 800 p.i.v. minimum (2 off)
T1 MT9 (Osmor) or similar mains/9-0-9 80mA secondary transformer—see text
S1 s.p.s.t. toggle
VI Geiger tube type CV2247—see text
PL1 4mm wander plug, red
PL2 4mm wander plug, black
PL3 three-pin or two-pin non-reversible plug
PL4 2·5mm jack plug
SK1, 2 4mm insulated sockets, one red, one black (2 off)
SK3 socket to suit PL1
SK4 2·5mm jack socket
TL1 crystal earpiece
Veroboard 0·15in. matrix 7 strips × 10 holes; 4BA solder tags (4 off); capacitor clips (2 off); metal case

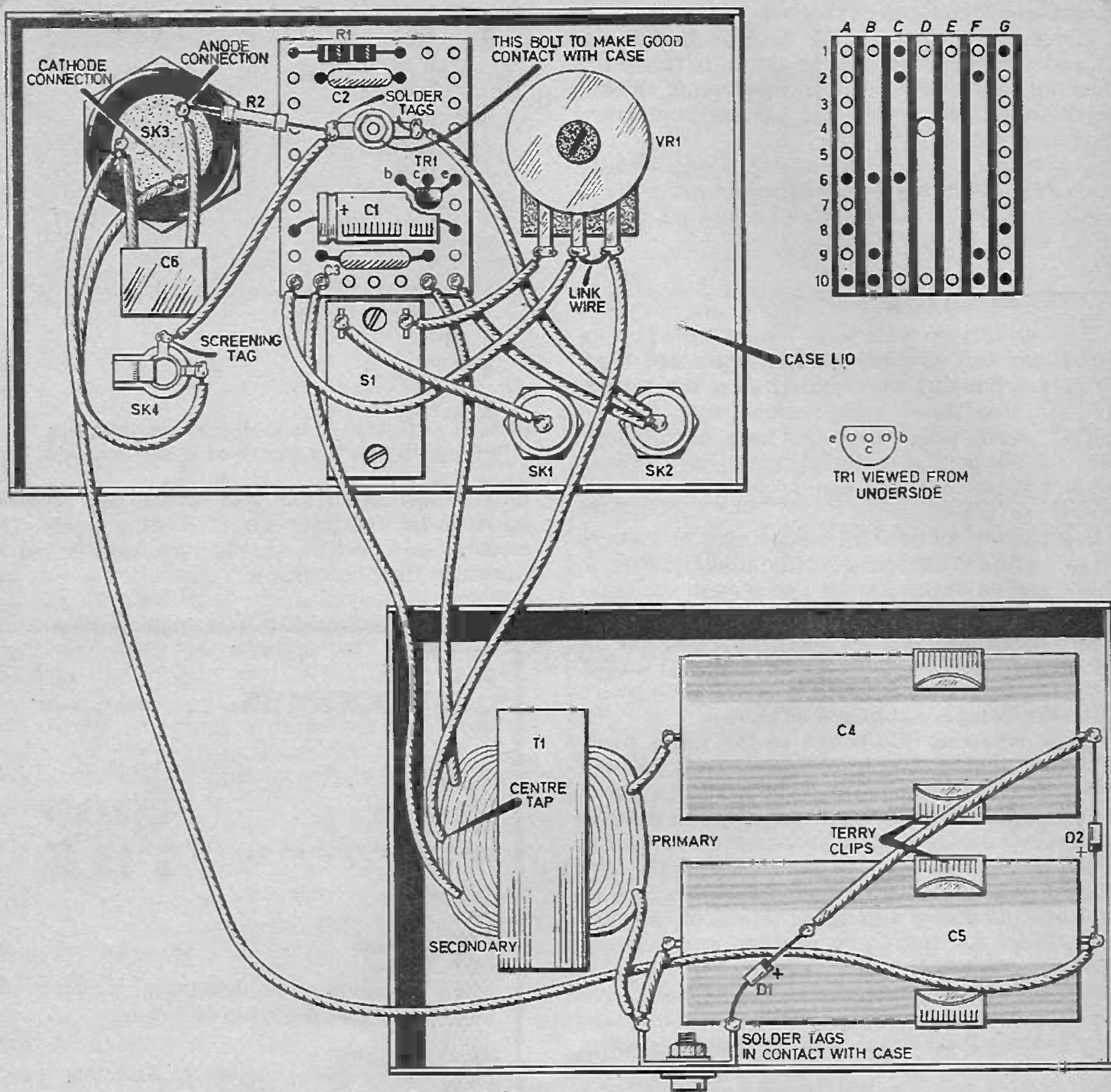
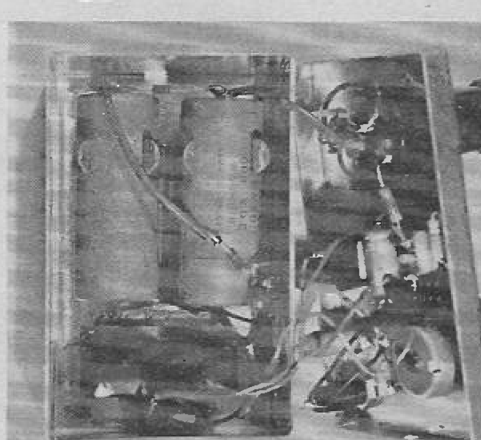


Fig. 2 (above). Assembly and wiring details within the aluminium case.

RADIATION MONITOR

Photograph (right) of the completed prototype with lid removed.



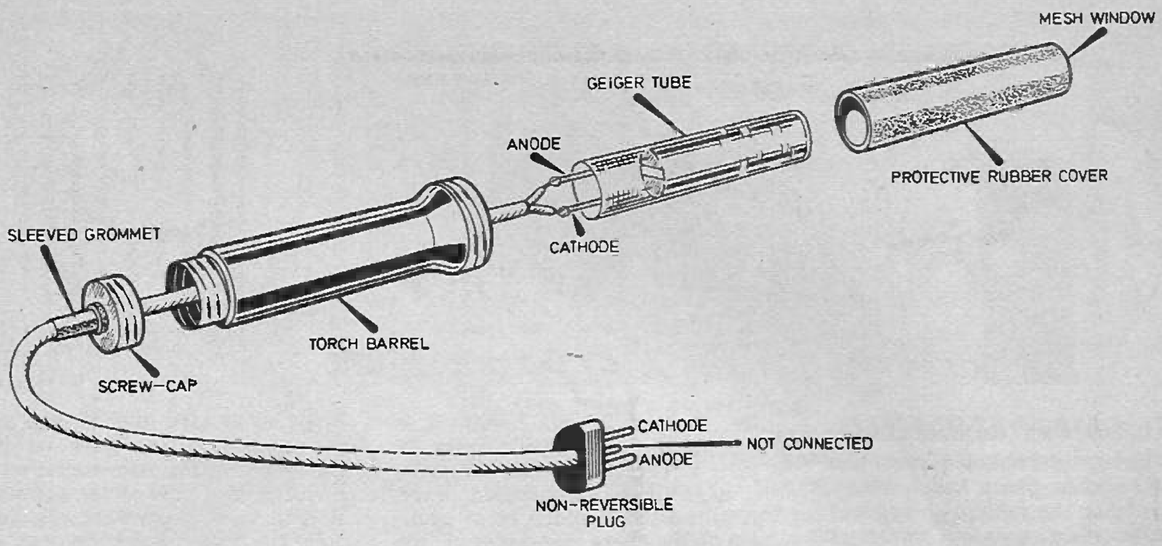


Fig. 3. Construction details for the probe.

PROBE

The probe in the prototype used a government surplus Geiger tube type CV2247 and was housed in the barrel of a torch. The tube comes complete with a sturdy rubber cover with a wire mesh window at one end for protection.

A length of twin-core mains cable should be soldered to the two terminals of the tube (brown to the anode, blue to the cathode) and fed through the torch barrel and secured there by an adhesive such as Araldite. The cable should be passed through a sleeved grommet in a hole drilled in the screw on the bottom cap, see Fig. 2.

Ensure that the wires from the tube terminals are not in contact with the inside of the torch barrel. It is a good idea to paint the torch barrel for insulation purposes.

The cable should be terminated in a two-pin non-reversible plug. In the prototype a three-pin plug and socket was used since this was at hand and the spare connector pin proved useful.

TESTING

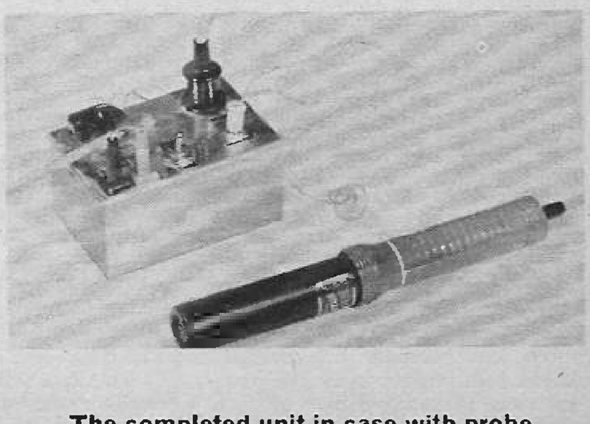
When completely satisfied with construction the unit may be tested. With S1 in the off position and VR1 set fully anticlockwise, connect the battery leads from a PP9 battery into the appropriate sockets, SK1, 2 on the lid. Insert the crystal earpiece at SK4 and plug in the probe at SK3. Switch on at S1.

A tone should be heard in the earpiece, building up after a while to a steady high pitched note. Now rotate VR1 control slowly in a clockwise direction, the pitch of the tone should gradually increase. A point will be reached where "clicks" will be heard. The number of clicks will be about 40 per minute this being due to background radiation, however these are very random—there may be periods of silence followed by bursts of clicks. This will indicate that the unit is functioning correctly.

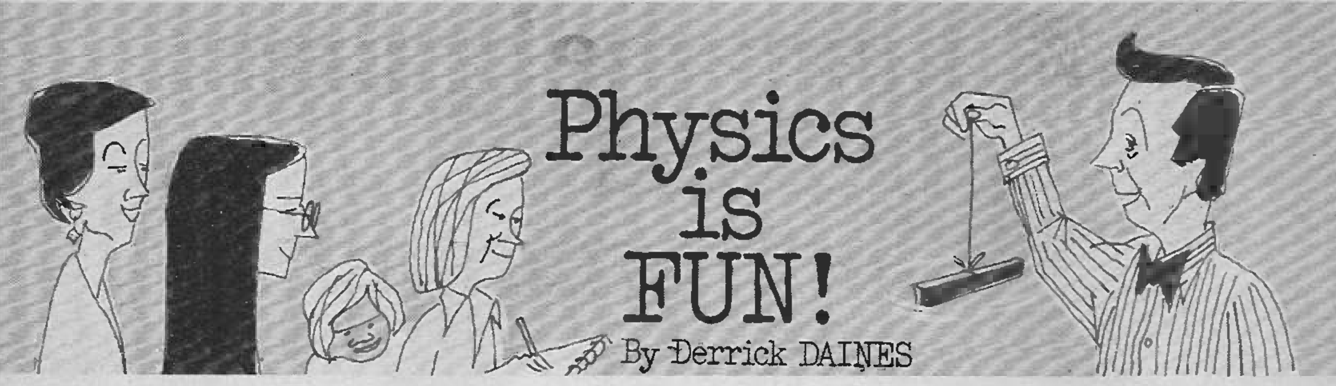
IN USE

An increase in the number of clicks or "counts" will result if the probe is placed near a source of α or β radiation (such as the face of a luminous watch or near a TV tube) and can thus be used to compare intensity of radiation, the intensity being directly proportional to the count rate.

The monitoring system can take several forms, audibly via the earpiece as in the prototype, display on an oscilloscope, or via a Schmitt trigger to an analogue or digital ratemeter or decade scaler. The latter two instruments should be well known to those with a knowledge of atomic/nuclear physics. ▣



The completed unit in case with probe.



Physics is FUN!

By Derrick DAINES

THE MAGNETIC FIELD

Obtain a discarded razor-blade or hacksaw blade and holding it firmly on the table with one hand, stroke it down its full length with one pole of your magnet, see Fig. 1. At the end of the stroke, lift the magnet clear and make a wide arc to the beginning again.

Continue until either your patience or the magnet wears out. The razor-blade will now be found to be magnetised. Mark one end and suspend it by a thread. As before, the razor-blade will make an effective compass, having a north-seeking pole.

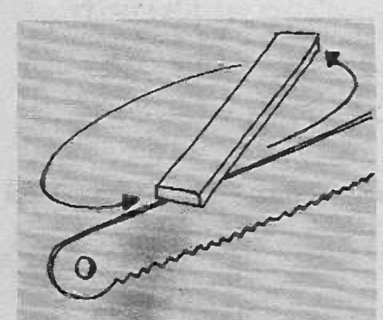


Fig. 1. Making a compass from a razor blade or hacksaw blade using a magnet.

Bring the North pole of your permanent magnet up to the North pole of the blade; the blade will spin away. Bring the North pole of the magnet up to the South pole of the blade; they will be attracted to each other.

Like poles repel—opposite poles attract.

We can compare the magnet/blade relationship with the compass/earth relationship of last month's question. When we hold the magnet in our hands, it is difficult for an outside force to turn it. Therefore, when we bring it near to the magnetised blade, it is the blade which spins away, but both have experienced the same force. Similarly with the earth; when we suspend the magnet by a thread, it reacts to the Earth's magnetic field shown in Fig. 2. Both the Earth and the magnet have experienced the same force, but it is the tiny mass of the magnet that spins, not the great mass of the Earth.

The earth is a gigantic magnet, whose magnetic field stretches many thousands of miles out into space, (Fig. 2).

The correct answer to last month's question therefore is that both the earth and the compass are active; they react to each other's magnetic field. A similar experiment to that with the iron-filings will model this more clearly.

Fig. 2. The magnetic field of the earth. The lines of force are similar all the way around the equator.

Obtain a child's compass—the smaller the better. Place your magnet on the table and a sheet of paper or card over it. Now put your compass anywhere on the paper and make two marks on it opposite the ends of the compass needle. Remove the compass and join the two marks. Repeat all over the paper until the lines begin to join up into longer and longer lines, Fig. 3.

There are two things to notice: (1) The compass needle always points North/South with respect to the magnet; (2) The lines form precisely the same patterns as did the iron filings in last month's experiment. The pattern is of course two-dimensional, but if you turn your magnet over through 90 degrees of arc and repeat the experiment you will easily see that the magnetic field itself extends in all directions through space, i.e. it is three dimensional.

Magnetic fields are three-dimensional

One more experiment for this month; put your small compass in a tin—the deeper the better—and bring the magnet near to it. The compass does not respond. Why? And why did we say that the deeper the tin, the better?

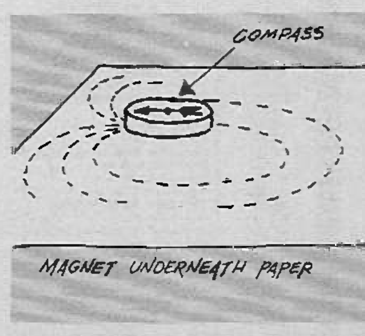


Fig. 3. Plotting the magnetic field of a magnet. This method plots the field on one plane only.

SEMICONDUCTOR PRIMER

By A. P. STEPHENSON

18 ■ EXPERIMENTAL TRANSISTOR CIRCUIT

An experimental circuit to demonstrate the behaviour of a typical low-power *pnp* transistor is shown in Fig. 18.1. Component values and suitable meter ranges are given below.

Battery voltage
12 volts is suitable since nearly all transistors can withstand 12 volts between collector and emitter.

Meters
0-20mA for measurement of I_C and I_E
0-1mA for measurement of I_B

0-12V for measurement of V_C } meter sensitivity should be at least 20,000 ohms per volt
0-1V for measurement of V_B

Resistors
VR1 1 megohm
VR2 As low as possible, e.g. 100 ohms 2 watt. This will draw 120mA from the battery.
R1 5 kilohm, this will limit the base current to a safe level if VR1 is set to zero.

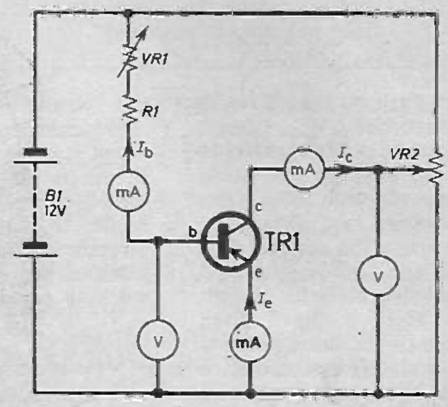


Fig. 18.2. Experimental circuit diagram used for determining some basic characteristics of a low-power *pnp* transistor.

19 ■ SIGNAL GROUND

In Fig. 19.1 point *A* is obviously 5 volts positive as far as d.c. is concerned, but as an alternating signal is concerned this point is virtually at ground because the capacitor is behaving as a short circuit to the a.c. signal.

The point *A* is said to be at SIGNAL GROUND.

As far as the value of the capacitor is concerned, its reactance X_c should be much smaller (say ten times smaller) than the resistor it bypasses.

This calculation must be carried out on the assumption that the LOWEST possible frequency is present.

If it is a reasonable "short", to say 50Hz, it will be even better at 500Hz.

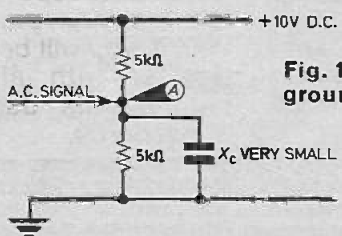


Fig. 19.1. Point A is at ground for a.c.

Examples
(a) The d.c. supply rail in any transistor circuitry is always at signal ground (because of the large electrolytic capacitors used to smooth the supply).
(b) The emitter of Fig. 19.2 is 5 volts positive to ground as far as d.c. is concerned but is at signal ground due to the capacitor.
(c) The common-base amplifier shown in Fig. 19.3 must have the normal d.c. bias on the base but it must be held at signal ground. The capacitor takes care of this.

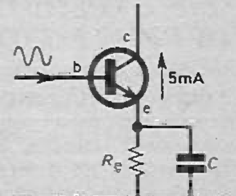


Fig. 19.2. For a.c. signals the emitter is held at ground by the capacitor.

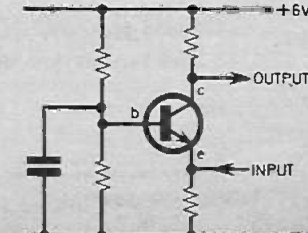


Fig. 19.3. Single-stage common-base amplifier.

DOWN TO EARTH

By GEORGE HYLTON

"Why does everybody persist in saying that current flows from positive to negative when the electrons, which make up the current, flow from negative to positive?"

The short answer, I suppose, is that not everybody does adopt the convention of positive-to-negative current flow. Some teachers use electron flow. The result is needless confusion.

In one respect the argument is absurd. This can be demonstrated by the simplest electric circuit, see Fig. 1. Here a "box" gives out a voltage (or as some pedants would say, an electromotive force). The box may contain a battery or a dynamo or a solar cell or any other kind of d.c. generator. It doesn't matter which. Let's suppose it's a battery.

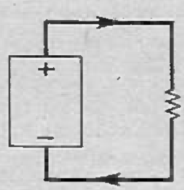


Fig. 1. Direction of arrows shows conventional current flow through R.

TWO-WAY FLOW

Conventional current flows in the direction shown, from positive to negative. Or does it? Take a closer look. The current goes round and round, through the resistance *R*, back through the battery, through the resistance . . . . and so on. Concentrate on the battery.

Conventional current in the battery does not go from positive to negative, does it? It goes from negative to positive!

So in one part of the circuit we have current going from positive to negative while in another part it goes from negative to positive. If the current consists of a stream of electrons, then it goes the "right" way inside the battery and the "wrong" way outside it.

Whichever convention you adopt it gives the wrong direction in one part of the circuit. The idea that the direction of electron flow ought to be the same as the direction of current flow must be violated in some part of any working circuit.

CURRENT CARRIERS

If the battery happens to be a lead-acid accumulator, two kinds of current carrier are at work inside it at the same time. Positive hydrogen ions move to the positive plate, while negative sulphate ions carry their charges to the negative plate. There are no free electrons involved. So the simple idea that current ought to flow the way the charges flow is, in an electrolyte, meaningless.

It's true, of course, that in electronics we are usually concerned only with the external circuit, and not with what's going on inside the power supply. It's also true that the commonest ingredient of electronic circuits, namely bits of wire or their printed or integrated circuit equivalents conduct current through the movement of electrons and only electrons. True also is that these have negative charges and so move towards the positive side of the supply line. True that this movement of electrons is in the opposite direction to conventional current.

CONTRADICTION

The reason for this contradiction lies in history. Long before the discovery of the electron, physicists were faced with the need to adopt some sort of convention for the direction of flow of the weightless, invisible substance which they called "the electric fluid". They needed a convention so as to be able to talk to one another about it. Too bad that they guessed wrong, in terms of electron movement.

By the time J. J. Thompson discovered the electron at the end of the 19th century, generations of electrical engineers had grown up and a vast amount of technology and hardware had been produced all in the convention of positive to negative flow. The price of changing the convention would have been enormous, and anyway, the motors still went round the right way, error or no error, so what difference did it make? So they did nothing.

RADIO VALVE

Things got a little tougher when the radio valve came along. Here was a device in which an electric current passed through a vacuum and there was no doubt at all—after J. J. Thompson's discovery—that the charge carriers in the valve were electrons.

Electrons certainly moved from the negative cathode to the positive anode, the opposite direction to conventional current as indicated on a meter.

Difficult. Yet despite this glaring contradiction generations of radio engineers have managed to ply their trade without coming to grief. With the introduction of the transistor life became easier.

HOLES

In the transistor, as in the valve or the piece of wire, electrons carry the current. But for reasons of mathematical convenience transistor physicists invented a new, imaginary carrier, the positive "hole". Now, a positive hole is the space left where a negative electron has moved out. It has no real existence; it just happens to be easier, in certain circumstances, to think of positive holes moving one way than negative electrons moving the opposite way.

Never mind. If you apply the "hole" concept to an ordinary circuit like Fig. 1 then the holes move in the same direction as the conventional current—in the external circuit, of course—so there's no need to alter the convention after all. Particle motion —imaginary though the particles may be—and current direction are at one, God's in his heaven and all's right with the world.

Ignoramuses?

I write because I take strong exception to the comments of your columnist, Mr. Paul Young in *Counter Intelligence* in your April issue.

He (or the supplier of his material) seems to have the attitude that those who live beyond the English Channel or the Irish Sea are a bunch of ignoramuses who know nothing about the realities of life outside the jungle clearing.

Mr. Young's article is intended to give the idea that overseas customers wish to be subsidized. No wonder that this firm only gets £1,000 in overseas business a year. Has this firm ever conceived it likely that if they said to customers "You owe us £1·10" or "Please send a remittance of £2·50 to cover costs" that the customer would refuse.

Thankfully, the attitude of this firm in the home country is not shared by some others. I have dealt with a number of them that advertise in your excellent magazine and in those published by IPC Magazines and I can commend to your overseas readers Electrovalue Ltd., Arrow Electronics and Antex Ltd. to name three who are prompt in their despatch of items, are courteous and charge fair prices.

The position is not as one-sided as Mr. Young would have your readers think. There are a number of export mail-order firms that charge outrageous amounts for packaging, and no matter what quantity is added for postage etc., it is kept and no credit given.

Recently two meters that arrived in a light cardboard box surrounded by shredded newspaper cost £1 to package. Couple this with the attitude of Mr. Young's firm and can you wonder why overseas customers have now switched to other countries for their supplies?

I am afraid that besides the unguaranteed and uncertain delivery date of British products another serious casualty of world competition has been the traditional British reputation for courtesy and impeccable trade practices. But I guess that these do not balance books.

W. C. Trotman
Barbados,
West Indies.

The difficulty in answering Mr. Trotman's letter, is that he accuses me of saying or implying things I neither said nor implied. "Please re-read my article Mr. Trotman". I did not state nor imply that overseas customers were ignoramuses (or is it ignorami?), in fact I commiserated with them on their plight!!

Mr. Trotman also misses the point, which is that a small mail-order firm like ourselves cannot cope with export orders. The three firms he mentions, one is a manufacturer and two are wholesalers. They would be geared up to export anyway, so that an extra small order would not throw them and they know there is always the chance it will be followed by a big order.

Several years ago we tried very hard to build up our export side, but our turnover never exceeded £2,000 a year and it became obvious that we should never receive any orders other than the small "one off" orders.

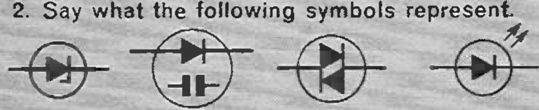
I do not think I would be exaggerating, if I said that even with U.K. orders we probably lose money on any order under one pound, but we regard that as part of our service because that customer returns again and again; the overseas customer rarely does!

Paul Young.

What do you know?

DIODES

1. A circuit you are constructing calls for a bridge rectifier of 50 p.i.v. at 1 amp. State what these ratings mean and indicate which of the following bridge rectifiers would be suitable (a) 50V, 1·5A (b) 75V 1A (c) 100V ½A.
2. Say what the following symbols represent.



(a) (b) (c) (d)

3. Indicate the anode and cathode on diagram 2a and state which end would be marked with a red band or dot or a + sign.

ANSWERS

1. The 50 p.i.v. means that the diode can stand a peak inverse voltage of 50V, i.e. the voltage is applied so that the diode is reverse biased. Both (a) and (b) would be suitable—the current rating is a maximum thus (c) would not be suitable.
2. (a) Zener diode (b) diode used as a capacitive device, e.g. varactor (c) bi-directional diode, e.g. diac (d) light emitting diode (l.e.d.).
3. The cathode is the end to which the arrow points and is normally marked with a red band or dot or a + sign.

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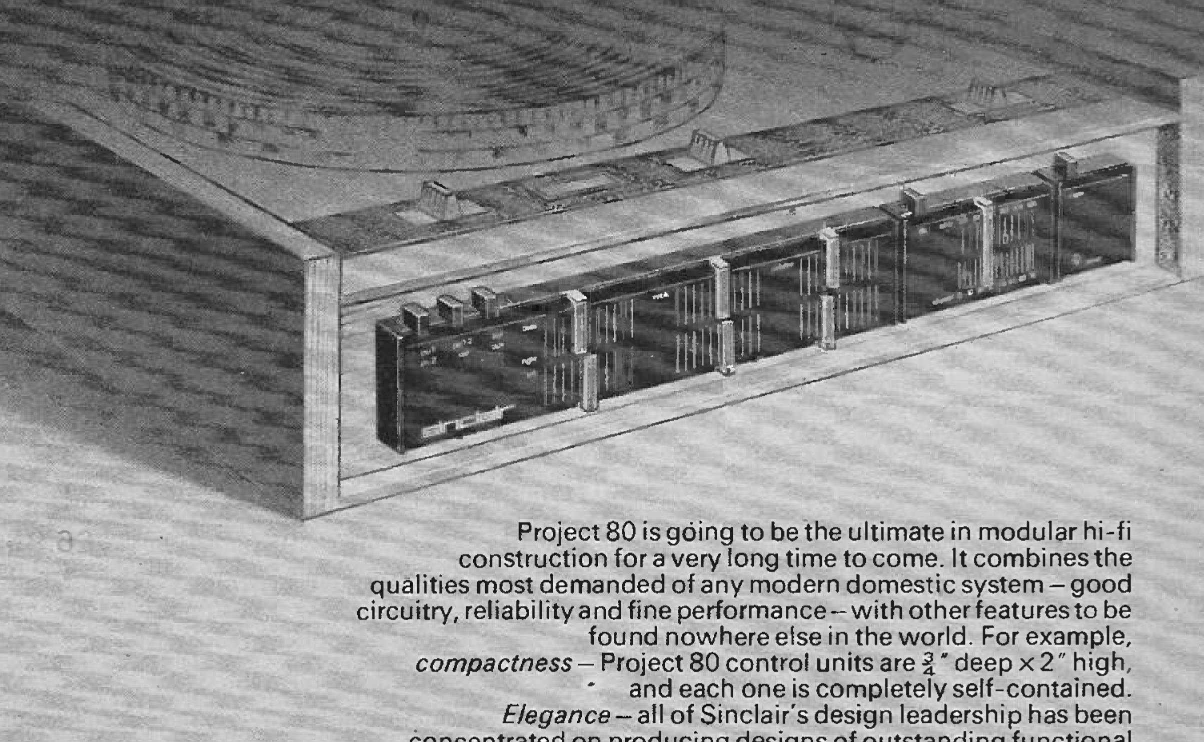

Project 80 is going to be the ultimate in modular hi-fi construction for a very long time to come. It combines the qualities most demanded of any modern domestic system – good circuitry, reliability and fine performance – with other features to be found nowhere else in the world. For example, *compactness* – Project 80 control units are $\frac{3}{4}$" deep × 2" high, and each one is completely self-contained. *Elegance* – all of Sinclair's design leadership has been concentrated on producing designs of outstanding functional elegance unsurpassed for styling and simplicity. *Flexibility* – the size and styling of Project 80 modules makes them the most versatile units ever. Combine them how you will, where you will, the Project 80 System of your choice gives you the best.

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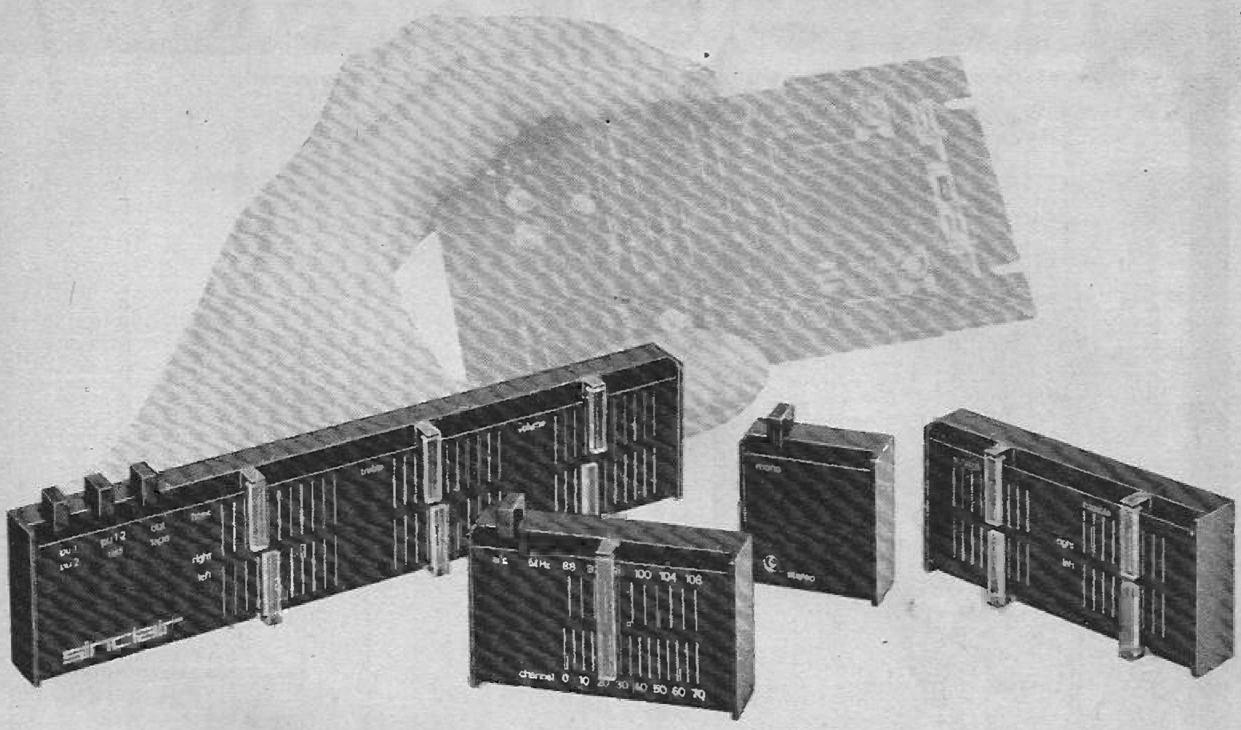
Sinclair Project 80



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Stereo 80 Control Unit Size – 260 × 50 × 20mm ($10\frac{1}{4} \times 2 \times \frac{3}{4}$ins) Finish – Black with white indicators and transparent sliders Inputs – Magnetic pick up 3mV RIAA corrected; Ceramic pick-up 350mV Radio 100mV; Tape 30mV Signal/noise ratio – 60db Frequency range – 20Hz to 15KHz ±1dB; 10Hz to 25KHz ±3dB Power requirements – 20 to 35 volts Outputs – 100mV – AB monitoring for tape Controls – Press button tape radio and P.U. Sliders on each channel for volume bass treble R.R.P. (add £1·19 V.A.T.) **£11.95**

Project 80 FM Tuner Size – 85 × 50 × 20mm ($3\frac{1}{3} \times 2 \times \frac{3}{4}$ins) Tuning range Dual varicap – 87·5 to 108MHz Detector – I.C. balanced coincidence One I.C. equal to 26 transistors Distortion – 0·2% at 1KHz for 30% modulation 4 pole ceramic filter in I.F. section Aerial impedance – 75 Ω or 240 300 Ω Sensitivity – 5 microvolts for 30dB S/N ratio Output – 300mV for 30% modulation Power requirements – 25 to 35 volts (R.R.P. add £1·19 V.A.T.) **£11.95**

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Z.40 Power Amplifier Size – 55 × 80 × 20mm ($2\frac{1}{8} \times 3\frac{1}{8} \times \frac{3}{4}$ins) 9 transistors Input sensitivity – 100mV Output 18 watts RMS continuous into 4 Ω (35V) Frequency response – 30Hz-100KHz ±3dB S/N ratio – 64dB Distortion – at 10 watts into 8 Ω less than 0·1% Power requirements – 12 to 35 volts. built-in protection against overload R.R.P. (add 54p V.A.T.) **£5.40**

Z.60 Power Amplifier Size – 55 × 98 × 15mm ($2\frac{1}{8} \times 3\frac{1}{2} \times \frac{3}{4}$ins) 12 transistors Input sensitivity – 100-250mV Output – 25 watts RMS continuous into 8 Ω (50V) Distortion – typically 0·03% Frequency response – 15Hz to more than 200KHz ±3dB S/N ratio – better than 70dB Built-in protection against transient overload and short circuiting Load impedance – 4 Ω min. safe on open circuit R.R.P. (add 69p V.A.T.) **£6.95**

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AC117K	32	AF114	27	BC153	31	BD135	44	BF185	33
AC122	13	AF115	27	BC154	33	BD136	44	BF187	30
AC125	19	AF116	27	BC157	20	BD137	50	BF188	44
AC126	19	AF117	27	BC158	13	BD138	55	BF194	13
AC127	20	AF118	39	BC159	13	BD139	61	BF195	13
AC128	20	AF124	33	BC160	50	BD140	66	BF196	16
AC132	16	AF125	33	BC161	55	BD155	88	BF197	16
AC134	16	AF126	31	BC167	13	BD175	66	BF200	50
AC137	16	AF127	31	BC168	13	BD176	66	BF222	£1·05
AC141	20	AF139	33	BC169	13	BD177	72	BF257	50
AC141K	32	AF178	55	BC170	13	BD178	72	BF258	66
AC142	20	AF179	55	BC171	16	BD179	77	BF259	94
AC142K	28	AF180	55	BC172	16	BD180	77	BF262	61
AC151	17	AF181	55	BC173	16	BD185	72	BF263	61
AC154	22	AF186	55	BC174	16	BD186	72	BF270	39
AC155	22	AF239	41	BC175	24	BD187	77	BF271	33
AC156	22	AL102	72	BC177	21	BD188	77	BF272	88
AC157	27	AL103	72	BC178	21	BD189	83	BF273	39
AC165	22	ASY26	28	BC179	21	BD190	83	BF274	39
AC166	22	ASY27	33	BC180	27	BD195	94	BFW10	66
AC167	22	ASY28	28	BC181	27	BD196	94	BFX29	30
AC168	27	ASY29	28	BC182	11	BD197	99	BFX84	24
AC169	16	ASY50	28	BC182L	11	BD198	99	BFX85	33
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AC179	31	ASY55	28	BC184L	13	BD206	68	BFY50	22
AC180	22	ASY56	28	BC186	31	BD207	£1·05	BFY51	22
AC180K	32	ASY57	28	BC187	31	BD208	£1·05	BFY52	22
AC181	22	ASY58	28	BC207	12	BDY20	£1·10	BFY53	19
AC181K	32	ASY73	28	BC208	12	BF115	27	BPX25	94
AC187	24	ASZ21	44	BC209	13	BF117	50	BSX19	17
AC187K	25	BC107	12	BC212L	12	BF118	77	BSX20	17
AC188	24	BC108	12	BC213L	12	BF119	77	BSY25	17
AC188K	25	BC109	13	BC214L	16	BF121	50	BSY26	17
ACY17	28	BC113	11	BC225	28	BF123	55	BSY27	17
ACY18	22	BC114	17	BC226	39	BF125	50	BSY28	17
ACY19	22	BC115	17	BC301	30	BF127	55	BSY29	17
ACY20	22	BC116	17	BC302	27	BF152	61	BSY38	20
ACY21	22	BC117	20	BC303	35	BF153	50	BSY39	20
ACY22	18	BC118	11	BC304	40	BF154	50	BSY40	31
ACY27	20	BC119	33	BC440	34	BF155	77	BSY41	81
ACY28	21	BC120	88	BC460	40	BF156	53	BSY95	14
ACY29	39	BC125	13	BCY30	27	BF157	61	BSY95A	14
ACY30	31	BC126	20	BCY31	29	BF158	61	Bu105	£2·20
ACY31	31	BC132	13	BCY32	33	BF159	66	C111E	55
ACT34	23	BC134	20	BCY33	24	BF160	44	C400	33
ACY35	23	BC135	13	BCY34	28	BF162	44	C407	28
ACV36	31	BC136	17	BCY70	16	BF163	44	C421	28
ACY40	19	BC137	17	BCY71	22	BF164	44	C425	55
ACY41	20	BC139	44	BCY72	16	BF165	44	C426	39
ACY44	39	BC140	33	BCZ10	22	BF167	24	C428	22
AD130	42	BC141	33	BCZ11	28	BF173	24	C441	33
AD140	53	BC142	33	BCZ12	28	BF176	39	C442	33
AD142	53	BC143	33	BD115	68	BF177	39	C444	39
AD143	42	BC145	50	BD116	88	BF178	33	C450	24
AD149	55	BC147	11	BD121	66	BF179	33	MAT100	21
AD161	39	BC148	11	BD123	72	BF180	33	MAT101	22
AD162	39	BC149	13	BD124	76	BF181	33	MAT120	21

Type	Price p	Type	Price p	Type	Price p	Type	Price p	Type	Price p
MAT121	22	2G308	39	2N2192	39	2N3391A	18	2N4062	13
MJE2955	95	2G309	39	2N2193	39	2N3392	16	2N4284	19
MJE3055	62	2G339	22	2N2194	39	2N3393	16	2N4285	19
MJE3440	55	2G339A	18	2N2217	24	2N3394	16	2N4286	19
MPF102	46	2G344	20	2N2218	22	2N3395	19	2N4287	19
MPF104	41	2G345	18	2N2219	22	2N3402	23	2N4288	19
MPF105	41	2G371	18	2N2220	24	2N3403	23	2N4289	19
OC19	39	2G371B	13	2N2221	22	2N3404	31	2N4290	19
OC20	70	2G373	19	2N2222	22	2N3405	46	2N4291	19
OC22	52	2G374	19	2N2368	19	2N3414	17	2N4292	19
OC23	54	2G377	33	2N2369	16	2N3415	17	2N4293	19
OC24	62	2G378	18	2N2369A	16	2N3416	31	2N5172	13
OC25	42	2G381	18	2N2411	27	2N3417	31	2N5294	60
OC26	32	2G382	18	2N2412	27	2N3525	83	2N5457	35
OC28	55	2G401	33	2N2646	52	2N3614	74	2N5458	35
OC29	55	2G414	33	2N2711	23	2N3615	82	2N5459	44
OC35	46	2G417	28	2N2712	23	2N3616	82	2N6211	75
OC36	55	2N388	39	2N2714	23	2N3646	10	2S301	55
OC41	22	2N388A	61	2N2904	19	2N3702	13	2S302A	46
OC42	27	2N404	22	2N2904A	23	2N3703	13	2S302	46
OC44	17	2N404A	31	2N2905	23	2N3704	14	2S303	61
OC45	14	2N524	46	2N2905A	23	2N3705	13	2S304	77
OC70	11	2N527	54	2N2906	17	2N3706	13	2S305	86
OC71	11	2N598	46	2N2906A	20	2N3707	14	2S306	86
OC72	16	2N599	50	2N2907	22	2N3708	09	2S307	86
OC74	16	2N696	14	2N2907A	24	2N3709	10	2S321	62
OC75	17	2N697	15	2N2923	16	2N3710	10	2S322	46
OC76	17	2N698	27	2N2924	16	2N3711	10	2S322A	46
OC77	28	2N699	39	2N2925	16	2N3819	31	2S323	62
OC81	17	2N706	09	2N2926(G)	14	2N3820	55	2S324	77
OC81D	17	2N706A	10	2N2926(Y)	12	2N3821	39	2S325	77
OC82	17	2N708	13	2N2926(O)	11	2N3823	31	2S326	77
OC82D	17	2N711	38	2N2926(R)	11	2N3903	31	2S327	77
OC83	22	2N717	39	2N2926(B)	11	2N3904	33	2S701	46
OC139	22	2N718	27	2N3010	77	2N3905	31	40361	44
OC140	22	2N718A	55	2N3011	16	2N3906	30	40362	50
OC169	28	2N726	31	2N3053	19	2N4058	13		
OC170	28	2N727	31	2N3054	51	2N4059	11		
OC171	28	2N743	22	2N3055	55	2N4060	13		
OC200	28	2N744	22	2N3391	16	2N4061	13		
OC201	31	2N914	16						
OC202	31	2N918	23						
OC203	28	2N929	23						
OC204	28	2N930	23						
OC205	39	2N1131	22						
OC309	44	2N1132	24						
OCP71	48	2N1302	16						
ORP12	48	2N1303	16						
P20	55	2N1304	19						
P21	50	2N1305	19						
P346A	22	2N1306	23						
P397	46	2N1307	23						
ST140	14	2N1308	26						
ST141	19	2N1309	26						
TIS43	33	2N1613	22						
UT46	30	2N1711	22						
ZN414	£1·20	2N1889	35						
2G301	21	2N1890	50						
2G302	21	2N1893	41						
2G303	21	2N2147	79						
2G304	27	2N2148	63						
2G306	44	2N2160	66						

DIODES AND RECTIFIERS

AA119	9	BY133	23	OA70	8
AA120	9	BY164	55	OA79	8
AA129	9	BYX38/30	46	OA81	6
AAY30	10	BYZ10	39	OA85	10
AAZ13	11	BYZ11	33	OA90	7
BA100	11	BYZ12	33	OA91	7
BA116	23	BYZ13	28	OA95	8
BA126	24	BYZ16	44	OA200	7
BA148	16	BYZ17	39	OA202	8
BA154	13	BYZ18	39	SD10	6
BA155	16	BYZ19	31	SD19	6
BA156	15	CG62		1N34	8
BY100	17	(OA91 Eq.)	6	1N34A	8
BY101	13	CG651		1N914	7
BY105	19	(OA70-OA79		1N916	7
BY114	13	Eq.)	7	1N4148	7
BY126	16	OA5	39	1S021	11
BY127	17	OA5SI.	23	1S951	7
BY128	17	OA10	39		
BY130	18	OA47	8		

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Type No.	Price 1	25	100+
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72741C	45p	48p	40p
72741P	38p	36p	34p
72748P	38p	36p	34p
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SL701C	50p	45p	40p
SL702C	50p	45p	40p
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TAA293	£1·00	95p	90p
TAA350A	£1·85	£1·80	£1·70
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ZN414 .. .. .. £1·20 each
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BP935	16p	15p	14p
BP936	16p	15p	14p
BP944	16p	15p	14p
BP945	30p	28p	25p
BP946	15p	14p	13p
BP948	30p	28p	25p
BP951	70p	65p	60p
BP962	15p	14p	13p
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BI-PAK STILL LOWEST IN PRICE. FULL SPECIFICATION GUARANTEED. ALL FAMOUS MANUFACTURERS

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7401	0·18	0·17	0·16	7450	0·18	0·17	0·16	74123	3·00	2·90	2·80
7402	0·18	0·17	0·16	7451	0·18	0·17	0·16	74141	0·85	0·82	0·79
7403	0·18	0·17	0·16	7453	0·18	0·17	0·16	74145	1·65	1·55	1·45
7404	0·18	0·17	0·16	7454	0·18	0·17	0·16	74150	2·90	2·80	2·70
7405	0·18	0·17	0·16	7460	0·18	0·17	0·16	74151	1·10	1·05	1·00
7406	0·39	0·34	0·31	7470	0·32	0·29	0·27	74153	1·30	1·20	1·10
7407	0·39	0·34	0·31	7472	0·32	0·29	0·27	74154	1·98	1·90	1·75
7408	0·20	0·19	0·18	7473	0·41	0·39	0·35	74155	1·50	1·45	1·35
7409	0·20	0·19	0·18	7474	0·41	0·39	0·35	74156	1·50	1·45	1·35
7410	0·18	0·17	0·16	7475	0·50	0·48	0·46	74157	2·00	1·90	1·80
7411	0·28	0·27	0·26	7476	0·44	0·43	0·42	74160	2·10	2·00	1·90
7412	0·39	0·34	0·81	7480	0·74	0·71	0·64	74161	2·10	2·00	1·90
7413	0·33	0·31	0·30	7481	1·30	1·25	1·20	74162	4·40	4·15	3·85
7416	0·48	0·44	0·42	7482	0·96	0·95	0·94	74163	4·40	4·15	3·85
7417	0·48	0·44	0·42	7483	1·20	1·15	1·05	74164	2·20	2·10	2·00
7420	0·18	0·17	0·16	7484	1·10	1·05	1·00	74165	2·20	2·10	2·00
7422	0·55	0·53	0·50	7485	3·50	3·30	3·30	74166	3·20	3·10	3·00
7423	0·55	0·53	0·50	7486	0·35	0·34	0·33	74174	2·50	2·40	2·30
7425	0·55	0·53	0·50	7489	4·00	3·75	3·50	74175	1·75	1·65	1·55
7426	0·50	0·46	0·44	7490	0·74	0·71	0·64	74176	1·85	1·75	1·65
7427	0·50	0·46	0·44	7491	1·10	1·05	1·00	74177	1·85	1·75	1·65
7428	0·55	0·53	0·50	7492	0·74	0·71	0·64	74180	1·50	1·40	1·30
7430	0·18	0·17	0·16	7493	0·74	0·71	0·64	74181	5·00	4·50	4·00
7432	0·50	0·46	0·44	7494	0·85	0·82	0·75	74182	2·00	1·90	1·75
7433	0·75	0·73	0·70	7495	0·85	0·82	0·75	74184	3·20	3·10	3·00
7437	0·70	0·68	0·65	7496	0·96	0·93	0·88	74190	2·15	2·10	2·00
7438	0·70	0·68	0·65	74100	1·50	1·45	1·40	74191	2·15	2·10	2·00
7440	0·18	0·17	0·16	74104	1·07	1·04	1·00	74192	2·15	2·10	2·00
7441	0·74	0·71	0·64	74105	1·07	1·04	1·00	74193	2·15	2·10	2·00
7442	0·74	0·71	0·64	74107	0·44	0·42	0·40	74194	2·98	2·86	2·75
7443	1·20	1·15	1·10	74110	0·60	0·55	0·50	74195	2·00	1·95	1·90
7444	1·20	1·15	1·10	74111	1·38	1·27	1·21	74196	1·95	1·90	1·85
7445	1·98	1·95	1·90	74118	1·10	1·05	1·00	74197	1·95	1·90	1·85
7446	1·20	1·15	1·10	74119	1·50	1·40	1·30	74198	5·00	4·75	4·50
7447	1·10	1·07	1·05	74121	0·50	0·48	0·45	74199	5·00	4·75	4·50

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U33	15	Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series	0·55
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U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·55
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U42	10	VHF Germanium PNP Transistors TO-1 NKT667, AF117	0·55
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U44	20	Sil. Trans. Plastic TO-5 BC115/116	0·55
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Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Suitable replacement for BSX 21, C 407, 2N 1893 120vcb.

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Ideal for Organ Builders.

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AD161/162

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PIV	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
50	0·26	0·28	0·39	0·39	0·52	0·55	0·59	1·27
100	0·28	0·37	0·52	0·62	0·55	0·64	0·70	1·54
200	0·39	0·41	0·54	0·54	0·63	0·67	0·83	1·76
400	0·48	0·52	0·62	0·62	0·74	0·83	1·03	1·93
600	0·59	0·63	0·75	0·75	0·85	1·07	1·38	—
800	0·70	0·77	0·88	0·88	0·99	1·32	1·65	4·40

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50	0·04	0·06	0·06	0·08	0·16	0·23	0·66
100	0·04	0·07	0·06	0·15	0·18	0·26	0·83
200	0·06	0·10	0·07	0·16	0·22	0·27	1·10
400	0·07	0·15	0·08	0·22	0·30	0·41	1·38
600	0·08	0·18	0·11	0·26	0·38	0·50	2·05
800	0·11	0·19	0·12	0·28	0·41	0·61	2·20
1000	0·12	0·28	0·16	0·33	0·51	0·70	2·75
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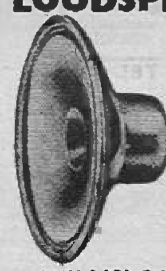

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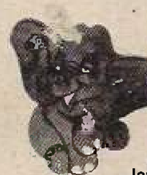

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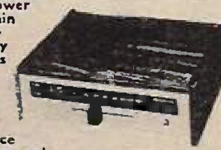

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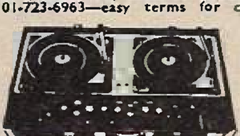

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LOW COST HI-FI SPEAKERS

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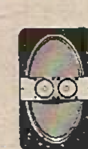
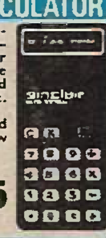


EMI 13" x 8"—full range speakers (post 20p each or 30p pair)
*150TC—8 ohms Twin Cone 10 watt £2·20 each or £4·00 pair.
*450 10 watt C/o Twin Tweeters 3, 8 or 15 ohms £3·85 each
EW 15 watt 8 ohms C/o Tweeter £5·25 each or £7·40 per pair
350 20 watt C/o Tweeters 8 or 15 ohms £7·80 each
* Polished wood cabinet £4·80 post 35p.

8 ohms full range (post 20p)				
FR4	4"	5 watt		£4·75
FR65	6½"	10 watt		£6·30
FR8	8"	15 watt		£8·50
FR23	9 x 6"	15 watt		£8·40
BASS & MID RANGE—8 ohms (post 20p)				
AA12	5"	15 watt		£3·75
B110	5½"	15 watt		£7·20
B200	8"	15 watt		£8·50
B139/2	13" x 8"	30 watt LF		£13·75
TWEETERS AND CROSSOVERS (post 20p)				
K2006	10 watt	8 or 15 ohms		£2·10
FHT6	15 watt	8 ohms		£3·35
K2011	30 watt	8 ohms		£4·80
T27	KEF			£5·50
Axcent 100	30 watt	8 ohms		£5·52
K4009	1kHz/5kHz C/o			£2·70
SN75	3kHz var. C/o			£3·10
SPEAKER KITS (carr. etc. 35p)				
20-2	8"	30 watt		£24·50 pair
20-3	8"	40 watt		£35·95 pair
LINTON 2		20 watt		£18·30 pair
GLENDALE 3		30 watt		£32·95 pair
DOVEDALE 3		50 watt		£51·50 pair
KEF KK2				£55·00 pair
KEF KK3				£78·00 pair

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—thats the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4½" long x 2" wide x 11/16" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs. Tangents. Sines etc.



SPECIAL OFFER **£13·60** + VAT. Also available assembled ready to use. **£19·95** + VAT.

10% VAT to be added to all orders. Export supplied. Prices and descriptions correct at time of proof. Subject to change without notice. E & O E. ALWAYS BARGAINS FOR CALLERS.

See page 424 of this magazine

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