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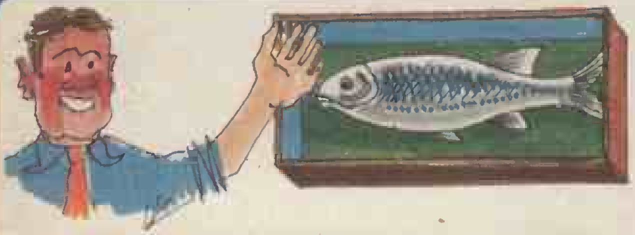

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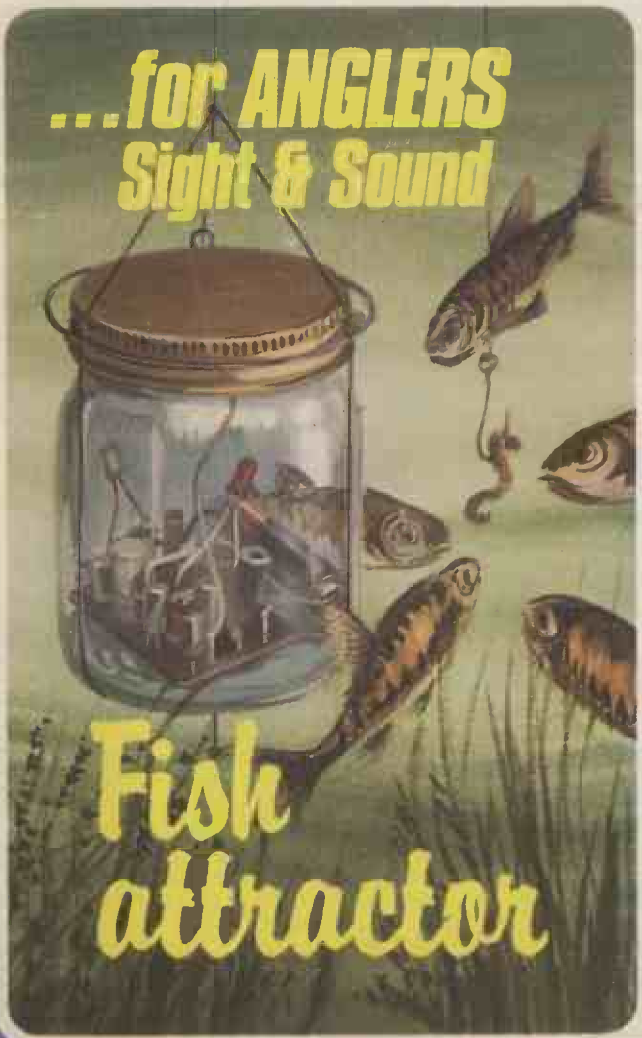

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VOL. 6 NO. 6 JUNE 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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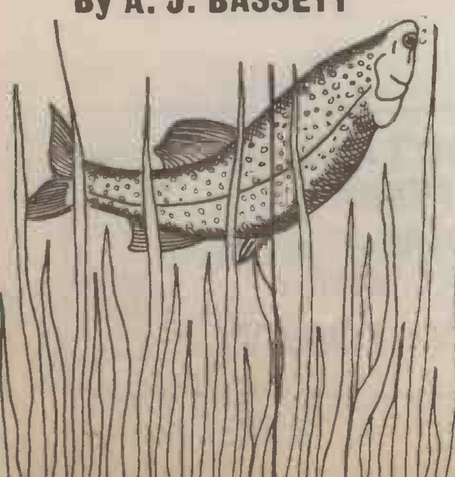
...Sight & Sound FISH ATTRACTOR

By A. J. BASSETT



THERE are many ways in which fish may be attracted and caught. Some ways are legal and sportsmanlike. Other methods are illegal, unsporting and in some cases so efficient that, in the hands of irresponsible persons they could quickly clear our fishing places of stock and might, if uncontrolled, even lead to the extinction of whole species of fish.

One method which is illegal, but which might, paradoxically, be useful in helping to conserve the fish stocks if it were correctly used, involves passing electronic currents through the water in which the fish live. If a heavy current is used, the fish are stunned, paralysed or even killed by its effects.

If a weaker current is used it has an effect on the muscles and nerves of the fish, causing them to swim towards one of the electrodes in a zombie-like manner. Most fish are unable to escape this compulsion and are in effect, trapped the moment the current begins to flow in the water.

PRINCIPLES OF OPERATION

The electronic fish attractor described here is legal and sportsmanlike; it does not cause electronic current to flow in the water or rely on anything illegal. The fish are attracted, by their own curiosity, to the vicinity of the device, and, having investigated the strange object, are free to swim away.

However, if a fisherman's hook is placed near the attractor with a suitable bait, the chances of a catch are definitely increased. The fish, having investigated the electronic attractor and found that they cannot eat it, will be quite likely to take the bait. It's this element of chance, combined with the fact that the fisherman must still exercise his skills in order to land a catch, that separates this electronic fish attractor from other less sporting methods.

Fish are naturally attracted by certain sounds and repelled by others. Low audio frequencies are for most fish a danger sign from which the fish will flee.

The clicking, buzzing and other high-pitched sounds made by insects and other potential prey are very attractive to fish, and a small flashing light is also attractive, especially at night or in a dark pool. Many highly-effective fish attractors have been made by mechanical or electrical means to produce similar sounds, or sounds in the same frequency range. The use of lights to attract fish, especially for night fishing, is also well known.

THE VERY IDEA

The idea for a Sight & Sound Fish Attractor was proposed by a reader of E.E. who receives our special award.

IT IS THE THOUGHT THAT COUNTS

CIRCUIT DESCRIPTION

The complete circuit diagram of the Sight And Sound Fish Attractor is shown in Fig. 1. Transistors TR1, TR2 and associated components form a circuit called an astable multivibrator (free-running square wave oscillator) which operates as follows.

When the circuit is switched on, both transistors attempt to turn on (become conducting) but due to component tolerances, one will draw current faster than the other. Say for argument's sake TR1 turns on faster than TR2, then the voltage on the collector of TR1 will become more positive, and this change will be fed back

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ESTIMATED COST OF COMPONENTS excluding V.A.T.

£3.00

excluding fishing line and weights

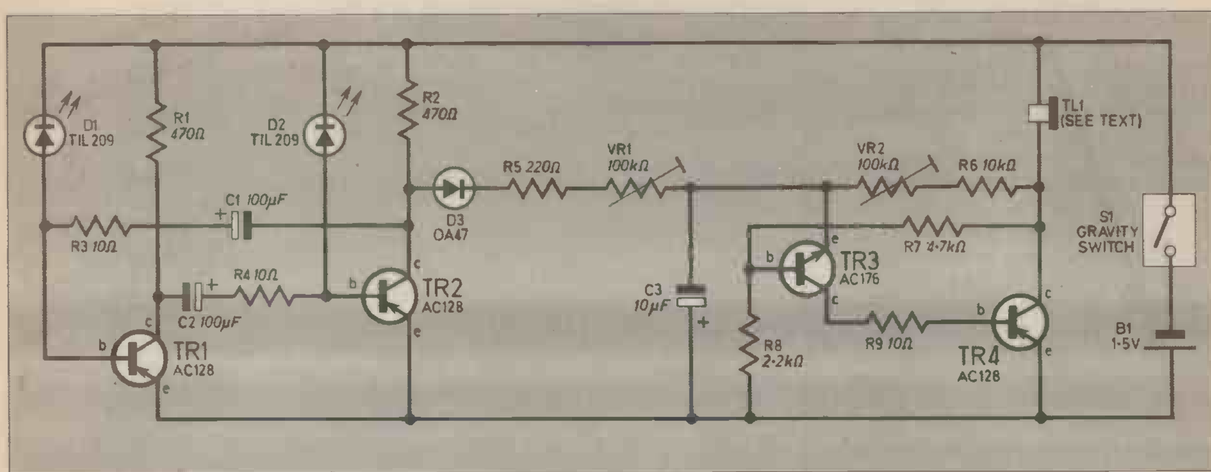


Fig. 1. Circuit diagram of the Sight and Sound Fish Attractor. Switch S1 is a home constructed gravity switch.

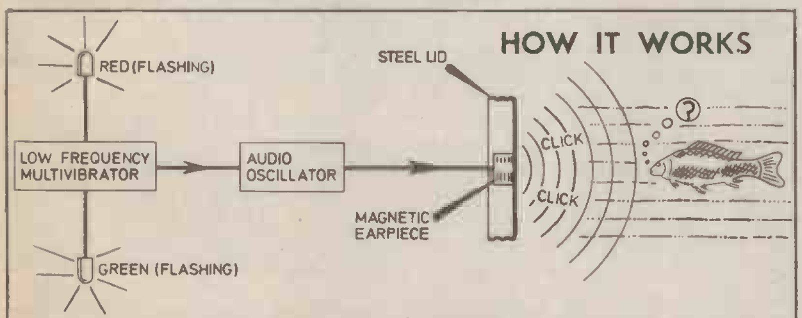
to the base of TR2 via C2 and R4. A positive voltage on the base of TR2 will cause TR2 collector current to fall thereby causing the collector potential to move towards the negative rail. This falling negative voltage is fed back to the base of TR1 via C1 and R3 causing TR1 to conduct more and in turn cause TR2 to move towards a non conducting state.

This regenerative action will continue until TR1 is completely on and TR2 is off. Only one transistor can be on at any one time.

Capacitor C2 now charges via D2 and R4 until the charge on the positive plate reaches a sufficiently negative potential such that TR2 starts to conduct and switches hard on. We now have the situation where TR2 is on and TR1 is off.

Since the collector voltage of TR2 is at a low potential, capacitor C1 is free to charge via D1 and R3. The capacitor in charging reduces the collector current of TR1 and increases the voltage. This increase is fed back via C2 and R4 to the base of TR2, thus increasing the action still further. This continues until such time as when TR1 is on and TR2 is off. The entire process continues in this way illuminating the l.e.d.s, each time the transistors switch on and off, thus producing the "sight" part of the attractor.

HOW IT WORKS



The fish attractor comprises two oscillators. The first oscillator runs at a low frequency about 1Hz and causes two l.e.d.s to flash on and off. The l.e.d.s have been chosen to be of different colours, one red, one green to enhance the effect.

The second oscillator is set to produce an audible tone in the magnetic transducer attached to the lid of container holding the unit. The lid being of "magnetic" material oscillates in sympathy. To enhance the sound effect produced the output of the first oscillator is used to modulate the second to produce both clicks and a varying audio tone.

The resulting combination of lights and tone has a strange effect on fish, in which they find themselves attracted to the source, and hence the bait conveniently left there by the angler.

Components TR3, TR4 and associated circuitry form a second oscillator, this one being known as a relaxation oscillator. The principle of operation of this type of oscillator is that capacitor C3 is charged up to a pre-determined value and then rapidly discharged through the transistors TR3 and TR4 and this process repeated.

At the instant of switching on, capacitor C3 is discharged, hence the emitter voltage of TR3 is more positive than its base. Therefore no current flows in TR3 and remains non-conducting. As a result no base current flows in TR4 and so this is also in a non-conducting state.

The capacitor begins to charge through TL1, VR2 and R6 and a point is reached where the emitter of R3 becomes less positive than the base and TR3 starts to switch on (conduct). This allows TR4 base current to flow i.e. TR4 begins to conduct. Because the collector/emitter resistance of TR4 has now reduced slightly due to its conduction, the potential on the base of TR3 is made to rise causing TR3 to conduct more heavily, which in turn causes TR4 to conduct more (reducing still further the collector/emitter resistance). The end result is that both transistors become saturated (turned on fully).

The capacitor now starts to discharge through VR2, R6 and the collector/emitter resistance of TR4. As C3 discharges, TR3 emitter potential rises and so reduces TR3 collector current and hence TR4 base current. The resultant increase in the collector/emitter resistance of TR4 reduces the potential on TR3 base thereby reducing collector current. This

Components

Resistors

R1	470 Ω
R2	470 Ω
R3	10 Ω
R4	10 Ω
R5	220Ω
R6	10kΩ
R7	4·7kΩ
R8	2·2kΩ
R9	10 Ω

All ¼W ± 10% carbon

See **Shop Talk** page 263

Potentiometers

VR1	100kΩ horizontal skeleton preset
VR2	100kΩ horizontal skeleton preset

Capacitors

C1	100μF elect. 10V
C2	100μF elect. 10V
C3	10μF elect. 10V

Semiconductors

TR1	AC128 germanium *pnp*
TR2	AC128 germanium *pnp*
TR3	AC176 germanium *npn*
TR4	AC128 germanium *pnp*
D1	TIL209 light emitting diode (green)
D2	TIL209 light emitting diode (red)
D3	OA47 or similar germanium diode.

Miscellaneous

TL1	magnetic transducer insert (see text)
S1	gravity switch (see text)
B1	1·5V U7 battery

Stripboard 0·1 inch matrix 10 strips x 21 holes; small plastic tube; small ball-bearing; washer; wide necked screw top jar; Blu-tak or plasticine as required; 18 s.w.g. or 20 s.w.g. soft steel wire (see text); fishing line, weights as required; connecting wire; solder.

clearly leads to both transistors being fully off with the capacitor discharged. This chain of events is repeated for as long as the supply is connected and produces an audible tone in TL1, the collector load of TR4, forming the "sound" section of the attractor.

A modulated tone is produced in TL1 by coupling the output of the first oscillator to a voltage sensitive point in the second oscillator, this point being the emitter of TR3.

The flash rate of the l.e.d.s may be altered by changing the values of R1 and R2 or C1 and C2, however the values of these capacitors determine the brightness of the l.e.d.s if they are decreased to a very low value, this will result in an apparent loss of brightness.

By varying the resistance of VR2, the basic frequency of the relaxation oscillator may be changed, and by altering the value of VR1, the modulating signal, which consists of a series of square waves may also be changed.

TRANSDUCER

The circuit may be installed in a container such as a clear screw-top jar with a thin steel lid. A low-cost magnetic transducer causes the steel lid to vibrate at the frequency of the audio oscillator.

By this means the audio output of the oscillator is coupled to the water in the form of acoustic waves, Fig. 2a shows how the transducer operates.

A horseshoe magnet carries a coil of wire, and a pulsating current through this coil causes a soft iron diaphragm to vibrate at the frequency of the pulses.

A vast number of moving-diaphragm headphone-inserts were made for the Government and these are available at a number of Government Surplus and electronic stores. The correct type can be easily identified by unscrewing the cover, which reveals the loose iron diaphragm. When this is removed the poles of the magnet can be seen. The d.c. resistance of the coil is usually about 25 ohms.

Instead of using the iron diaphragm which comes with the headphones insert, place the magnet and coil assembly inside the lid of the jar, so that the rim of the inset automatically spaces the steel lid a little away from the magnets, but the insert is magneticaly stuck to the lid. Momentarily connect a 1·5 volt battery to the coil. A loud click should be heard from the lid. A small quantity of adhesive may then be used to attach the lid to the rim of the insert. Do not use a lot of adhesive as this may interfere with the efficiency.

Alternatively, remove the plastic ear insert and the soft iron diaphragm from a magnetic type radio or hearing-aid piece, and attach the magnet and coil assembly to the inside of the lid. In this case, there is usually a central pole-piece, around which the coil is wound, surrounded by an outer circular magnet as shown in Fig. 2b.

GRAVITY SWITCH

The author considered a number of methods of switching the circuit on and off, without opening the jar, as it would disturb the waterproof seal each time. Magnetic switches operated by means of the influence of a magnet through the glass, were considered, as was a mercury switch which proved successful but because the latter are not readily available, a home-made gravity switch was devised using a moving ball-bearing to make contact.

The construction of the gravity switch is shown in Fig. 3. A short piece of plastic tubing, and a ball-bearing are chosen so that the ball-bearing is a loose fit inside the tube and will easily roll about. Two small holes are drilled opposite one another about 3mm from one end of the tube, and into each hole is inserted a bent piece of solid copper wire, so that when the ball-bearing falls to this end of the tube, it bridges both pieces of wire and switches the circuit on.

A check is made to ensure that the ball-bearing makes and breaks contact freely when the tube is tilted. The opposite end of the tube is then sealed by cementing in place a plastic disc or a

...Sight & Sound

FISH ATTRACTOR

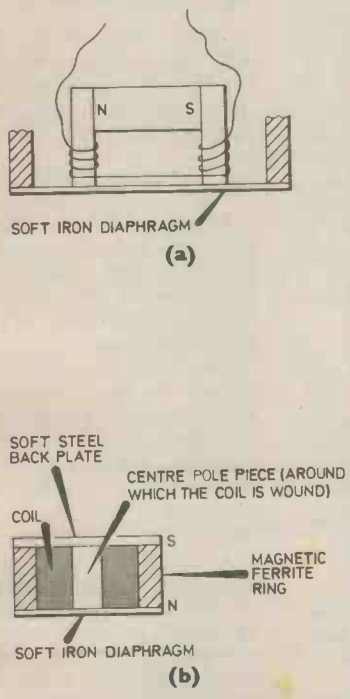


Fig. 2 (a) Illustrating the operation of a transducer. (b) A small earphone is usually constructed as in the diagram. For use in the Fish Attractor, the plastic insert and diaphragm are removed.

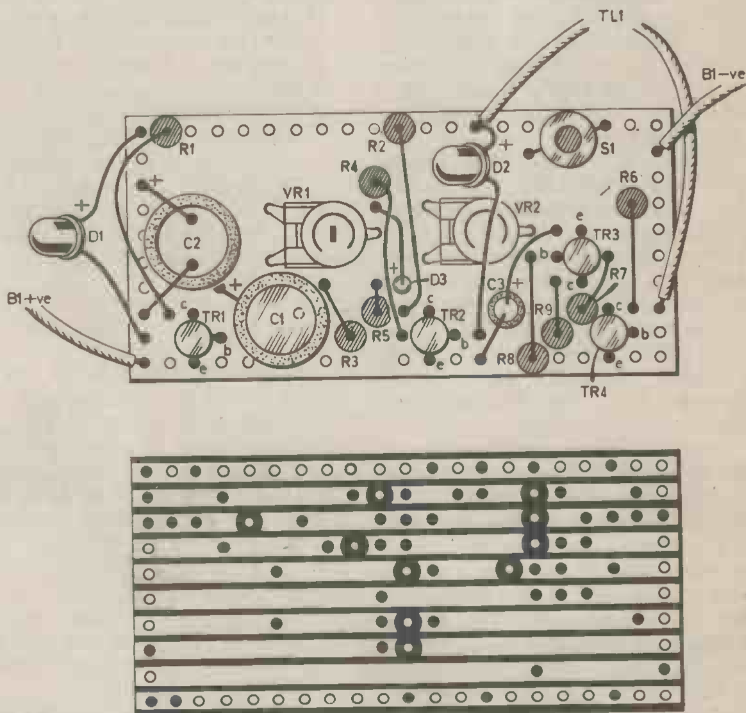


Fig. 4. Component layout on the stripboard, also showing the breaks required on the underside.

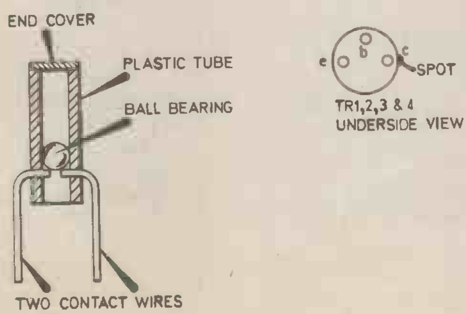


Fig. 3. Construction of the gravity switch. Ensure that the ball bearing makes and breaks contact freely.

Photograph showing the completed circuit as built on a piece of stripboard.

suitably sized washer. This traps the ball-bearing in the tube and completes the construction of the gravity switch.

CONSTRUCTION AND TESTING

The circuit is built on a piece of 0·1 inch matrix stripboard size 10 strips by 21 holes. The layout of the components on the topside and the breaks to be made along the copper strips on the underside of the stripboard are shown in Fig. 4. The layout is not critical and may be changed to suit requirements.

Begin by making the breaks and then positioning and soldering the resistors, capacitors, potentiometers and gravity switch leaving the semiconductors until last. It is recommended that a heatshunt be used on the leads of the semiconductors when these are being soldered in position reducing the risk of thermal damage from the hot soldering iron.

The magnetic earpiece transducer is next connected to the board by means of about 15cm of thin flexible twin wire, and the battery connected by means of short lengths of wire soldered to its terminals. If the battery is not leakproof, it should be wrapped in several layers of blotting paper.

The circuit can now be tested. When the stripboard is held with the component side upwards, the gravity switch should make contact, the l.e.d.s should begin to flash alternatively, and if the transducer is placed in contact with the lid of the jar, it should produce a sound dependent upon the setting of VR1 and VR2.

The sound can be varied from a series of clicks through a low buzz to a high pitched note, which varies in sympathy with the flashing of the l.e.d.s all of these sounds appear to attract fish and the degree of attraction depends upon the type, age and size of the fish, among other factors which allow plenty of room for experiment.

To install the circuit, use a wide necked screw top jar. Press a layer of Bostik-Blu-Tak or plasticine over the bottom of the inside of the jar, which must be clean and dry in order that the material will stick. It also helps if both the jar and the material are slightly warm. Use a quantity sufficient to ensure that the jar will float upright in water, but insufficient to cause it to sink when the circuit components and lid are added.

Press the circuit board and battery lightly into the material, as in the photograph and secure in place using several strips of plasticine.

When satisfied that it is in working order, and the gravity switch is functioning satisfactorily seal the lid in place with a thin layer of Blu-Tak or other non-setting water-resistant adhesive to act as a water resistant seal.

Although the lid should be easily removable for adjustment of VR1, VR2 and battery changing, it is best not to open the jar very frequently as this may require frequent attention to the water seal.

WIRE CASE

Prepare a wire case for the jar as shown in Fig. 5 using soft steel wire about 18 s.w.g. or 20 s.w.g. Suitable wire is often used for binding parcels or packing cases, and this is best as it is treated with a rust-resistant coating. Alternatively thin birdcage wire can be used, and is obtainable from some pet stores. Three fixing-loops are made, equally around the neck of the jar and connected to a fourth loop underneath.

Now the jar may be used with a float and weight as seen in Fig. 6a, or with a weight only as in Fig. 6b, as circumstances require, together with a recovery line for retrieval.

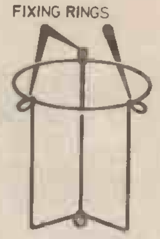


Fig. 5. Details of the wire cage.

USING THE ATTRACTOR

When using the attractor with a weight only, the length of line between the weight and the attractor will determine the distance between the attractor and the bottom.

The breaking-strain of this line should be less than that of the recovery line, so that if the weight is caught by some underwater obstacle, a heavy pull in the recovery line will snap the thinner line and allow the jar to float free.

A useful tip here, is that if a float is also being used, and the weight is lost in this way and, if by some misfortune the recovery line also comes off, the attractor can be recovered by casting in between the jar and the float.

Remembering too that for positive sinking in salt water a heavier weight is needed than for fresh water, and that by tying a cloth around the weight the jar is less liable to be broken.

Good Fishing! ⌑

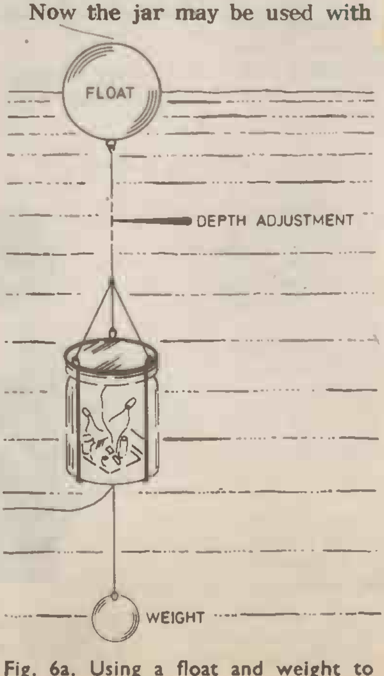


Fig. 6a. Using a float and weight to position the unit.

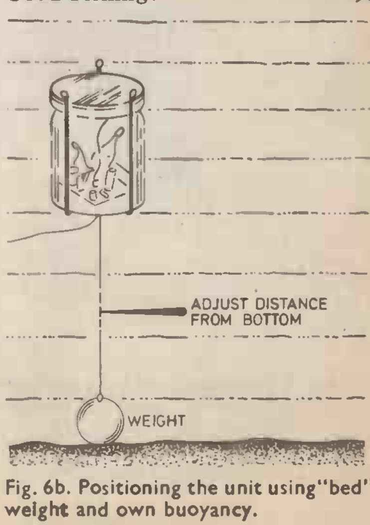
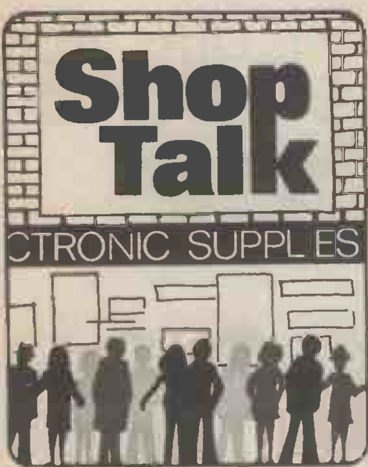


Fig. 6b. Positioning the unit using "bed" weight and own buoyancy.



By Brian Terrell

New products and component buying for constructional projects.

AS FROM this issue I shall be writing this column now that Mike Kenward has departed, and will endeavour to maintain the high standard of the services of this page that you have been accustomed to in the past years.

Component Packs

Two packs of components arrived on my desk last month, for my inspection, from Home Radio Ltd. One contained 400 resistors with values in the E12 range from 4·7 ohms to 1 megohm, all gold band tolerance (5 per cent) with wattages in the range $\frac{1}{8}$ to $\frac{1}{2}$W. This pack designated SP22 costs £6 excluding V.A.T., making the cost per resistor $1\frac{1}{2}$p.

The other pack, No. C121 contained many different types of capacitor and covered an extensive range. There were 30 electrolytics, 22 silver mica, 20 paper/polyester and 32 ceramics, with values between 1·5pF and 5000μF. The cost of this is £7 excluding V.A.T. giving a mean unit price of 7p. These packs could make an economic start for those wishing to build up a stock of components for project building.

The contents of the SP22 resistor pack.

Last Month

In the May '77 issue we published details for building a *Remote Reading Thermometer* which specified the use of a 10mA d.c. meter. Some readers have found difficulty in locating a meter of the type specified/used in the prototype. Only more expensive types could be found. We see from advertisements that 1mA types are more readily available at less cost. These can be used if fitted with a shunt resistor (R_s) the value of this being determined from $R_s = 0{\cdot}11 \times$ meter resistance (ohms). The minimum wattage required is obtained from $W = (0{\cdot}009)^2 \times R_s$ watts.

Electronic Component Kit

The Denshi electronic construction kits now available from Electroni-Kit Ltd., (advertising in this issue) are ideal for those people who want to learn about electronics but do not wish, or do not feel competent enough to handle a soldering iron, component board, wiring etc. The method employed in this system is that of plug-in components encapsulated in transparent plastic boxes which are marked with component symbol and value.

All kits are accompanied by manuals which explain technical details of projects with diagrams and explanations.

The three kits available SR-3A (100 projects), SR-3ADX (105 projects) and SR-4ADX (150 projects) also include basic electrical experiments and theory such as Ohm's law, resistors in parallel and series etc.

Transistor Lead Out Indicator

There should be no buying problems encountered when buying components for the *Transistor Lead Out Indicator*. The 3-pole 6-way switch seen in the photograph is most difficult to locate, hence the Maka switch assembly specified—these are available from many component suppliers. Some constructors may be lucky enough to find a suitable type in a Government surplus store and save themselves some cash as the Maka switches are costly.

Almost any miniature push-pull output transformer will do for the inductor, if not you have details for a home-made version which will probably call for a larger case than that listed.

Sight & Sound Fish Attractor

Only two components out of the ordinary are called for in the *Sight and Sound Attractor* these being the magnetic transducer insert and the gravity switch. The first component is dealt with fully in the text and you have two alternatives. If you are going to cut open an earpiece, make sure that it's the magnetic type as this is the only one that will work.

Mechanical details are given in the text for constructing the gravity switch. Instead a mercury switch can be used, a suitable type is available from J. Bull (Electrical) Ltd., 7 Park Street, Croydon, Surrey for a cost of £1·95 including V.A.T. and post and packing.

Remaining Constructional Projects

Very few components are used in the remaining two constructional projects this month and all should be easily obtainable. With regards the relay in the *Door Chime Inhibitor* any type that will operate from a 9 volt battery and has two sets of normally open contacts may be used. Bear in mind that if a type other than that specified is chosen, the wiring up on the component board will probably need adjustment.

Bright Idea

An American invention, known as a Lightstick, is now available in the U.K. It provides up to 10 hours of light without using batteries, flame, sparks or heat. The light is the result of a chemical reaction contained in a 125mm long plastic tube, activated by bending the tube.

It provides sufficient light in an average sized room for reading, telephoning, repairs, etc, and can also be used with complete safety in potentially dangerous environments where petrol and gas are about.

The light produced can be seen a mile away; it is unaffected by adverse weather conditions and works underwater.

Generally available in the shops later this year priced at £1.95 per pack of three, but at present only available from Tye Security Ltd., Dolphin Road North, Sunbury-on-Thames, Middlesex.

A motorist putting a Lightstick to good use.

DOOR CHIME Inhibitor

Only allows one "ding dong" from your chime however many times the bell-push is operated during a preset period

THE simple unit to be described was designed to thwart the efforts of those bent on destroying the author's sanity. There are various ways of abusing door chimes—all of them annoying. Children sometimes give the button a very short press, so that the "ding" part of the "ding-dong" hardly sounds, and they tend to do this over and over again. One tradesman, having rung our chimes and not receiving an immediate reply, rang it again and again. This sort of thing is gharanteed to disturb any sleeping baby.

Since our door chimes are loud enough to be heard with just one "ding-dong", the following circuit was devised to impose this limitation. It allows only one "ding-dong" no matter how the button is pressed. Further pressing will give no results until about 20 seconds have elapsed and this time delay may be easily varied to suit individual requirements.

THE CIRCUIT

The circuit is shown in Fig. 1 and is seen to be hardly "electronic" at all, in the sense that there are no active components. It consists of a general-purpose relay, which is an electromechanical component, a resistor of about 10 kilohms and an electrolytic capacitor of about 1,000 microfarads. Details of the relay are given later.

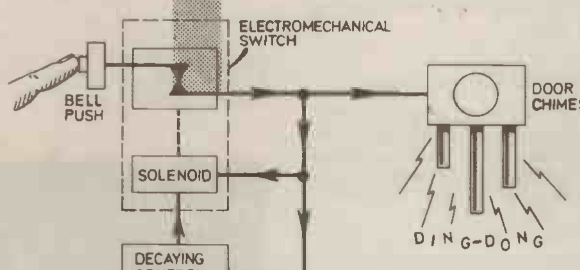
On pressing the bell-push, and thus closing the circuit, the relay is energised and the capacitor begins to charge up from the 9 volt battery. This charging current falls off as the capacitor charges and, typically, takes about one second for the relay to drop out into its original state.

The relay switches the chimes via RLA2, one set of normally-open contacts, which remain closed just long enough to give the initial ding-dong. If this time is too short or too long, a different value of electrolytic capacitor can be tried, or a different relay used. A higher value of capacitor will give a long 'ding———dong', while a smaller value will have a shortening effect.

CHARGE AND DISCHARGE TIME

Further operation of the bell-push will fail to work the chimes because the capacitor will be left in a charged state and cannot be charged further and so will not allow sufficient current to flow to energise the relay. Under such conditions the capacitor would take a long time to discharge sufficiently to render the circuit operational again and so a resistor of 10 kilohms is placed across it. This allows the

HOW IT WORKS



On depressing the bell-push the chimes start to sound but further chime action is prevented by the electromechanical switch becoming open circuit. It is kept in this state by the derived control voltage. Further action of the bell-push has no effect.

After a while (about 20 seconds in the prototype) the control voltage decays to a level such that the switch is once again closed (rest position). This process is repeated next time the bell-push is operated.

FOR GUIDANCE ONLY

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

£2.50

excluding case

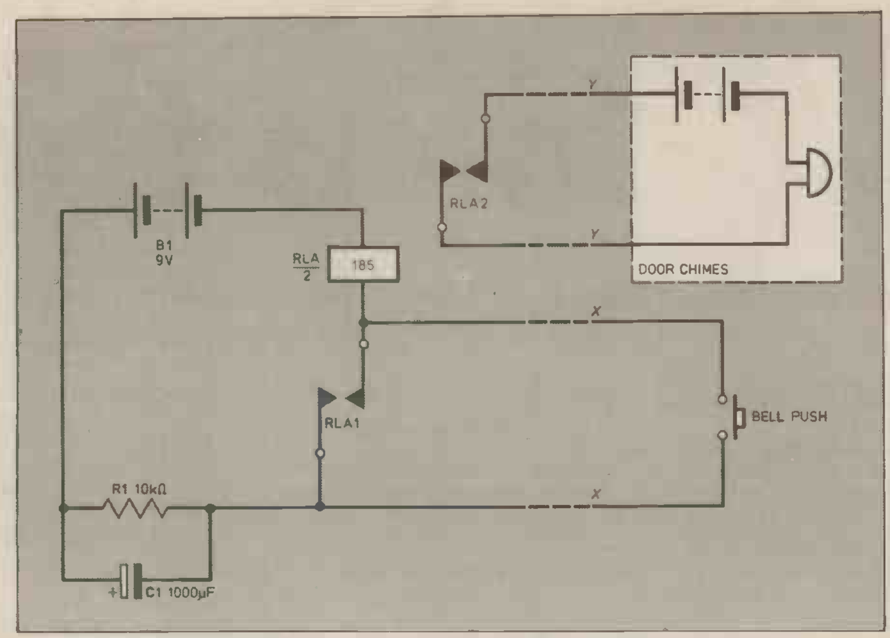


Fig. 1. The complete circuit diagram of the Door Chime Inhibitor.

capacitor to discharge through the resistor in about 20 seconds.

If it is required to shorten or lengthen this time, a lower or higher value resistor could be used, but a more flexible arrangement is to use a small preset variable resistor of about 100 kilohms which can be adjusted to give the desired time factor.

Another feature of the circuit is that even a very short press of the bell-push will give a full ding dong. This is because a second set of normally-open contacts (RLA1) on the relay short circuits the bell-push while the relay is energised.

OPERATION OF RELAY

Constructors who have not previously used relays may find a brief description of their action helpful. A small current flows through a coil consisting of many turns of fine copper wire. This coil is wound around a soft-iron core so that as the current flows it becomes energised and behaves as a magnet. Near the coil is an armature which is attracted to it by the magnetic field and in moving is caused to make or break various contacts which may be used to switch circuits on or off.

When the current is turned off, the magnetic field collapses and due to spring action the armature moves away to its original position, thus rendering the relay static again.

The simplest relays have only one normally-open or one normally-closed set of contacts. Normally-open contacts will switch a circuit on when the relay coil carries current; normally-closed contacts will switch it off. Relays frequently have change-over contacts, which are a combination of normally-open and normally-closed contacts.

CHOICE OF RELAY

The relay to be used for this project should not have a coil which demands a high voltage for operation. Some 'surplus' or cheap relays have 24V coils and, although they may very well work on less than this, they are unlikely to operate reliably from a 9V supply as specified here.

Some 12V relays may prove to be suitable, but reliable operation is essential and they must be checked by connecting their coils to batteries, taking care to avoid touching the bare connections with the hands. The rapid collapse of the magnetic field causes a high induced e.m.f. which can, on occasions, deliver an unpleasant shock!

The relay chosen for the prototype was a Doram type No 348-908, which has a coil resistance of 185 ohms; coils with resistances of much less than this are unsuitable. This relay operates reliably from about 6V upwards.

Components

See Shop Talk page 263

Resistor
R1 10kΩ ¼W carbon ± 10%

Capacitor
C1 1000μF 10V elect.

Miscellaneous
RLA 9V 185 ohm relay with at least two sets of normally open contacts (Doram 348-908)
B1 9V type PP3
Plain matrix board 0.1 inch pitch size 36 x 21 holes; p.c.b. type base to suit RLA1; Veropins; case to suit; battery clip to suit B1; connecting wire; solder.

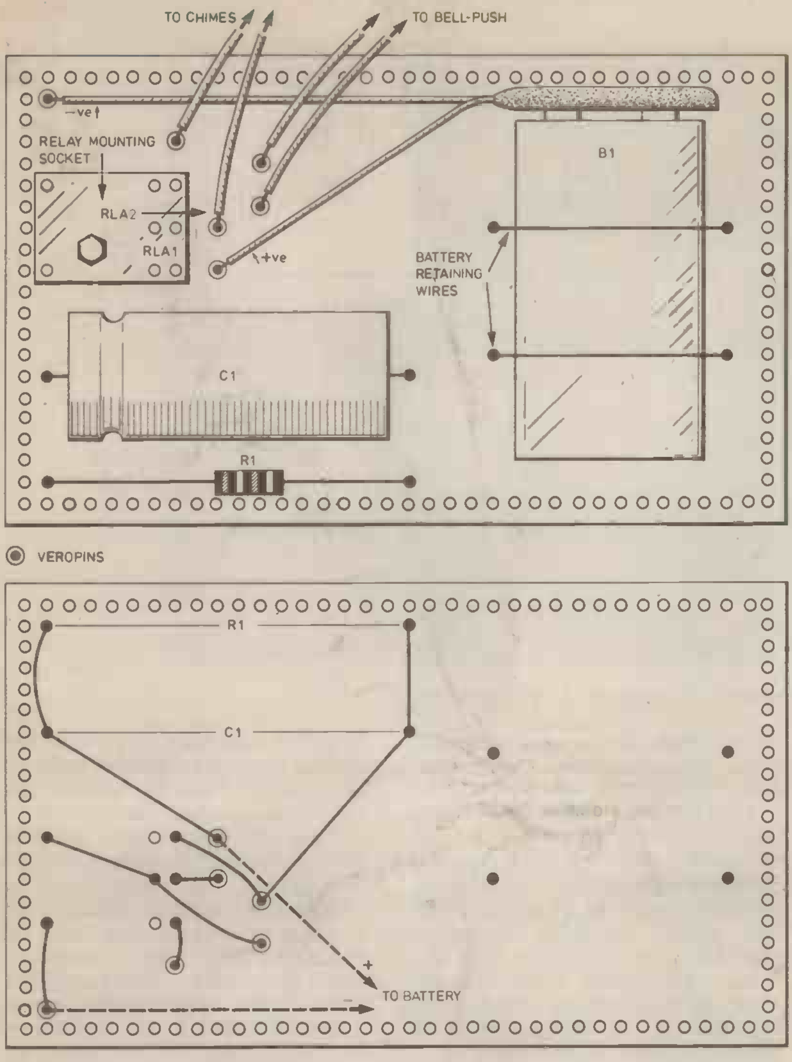


Fig. 2. The layout of the components on the topside of the plain matrix board and the interconnections on the underside.

The relay to be used must be fitted with two sets of normally-open contacts. The 348-908 has two pairs of changeover contacts which, of course, may be used as normally-open contacts. If a relay is fitted with too many unused contacts, the mechanical complexity may render it slow and perhaps unreliable. The resourceful constructor may take such a relay to pieces and remove any unwanted contacts.

It was decided to power the prototype from a small 9 volt battery mounted on the circuit panel itself. Although a battery clip is shown in the diagram, the connections could be soldered directly to the terminals since battery life will be quite long. It is possible to draw the power from the batteries of the door chimes themselves, if they are battery operated, but if they are run from a transformer then the trouble of providing rectification and smoothing would not be worthwhile.

CONSTRUCTION

The layout of the project is non-critical, as the drawings of the prototype will reveal. Layout details and wiring will depend largely on the type of relay used.

When wiring up, however, be sure to observe the polarity of the electrolytic capacitor (the positive end is marked + or will be colour coded; the negative end is connected direct to the metal casing). The capacitor should have a working voltage in excess of 9V and, although small 15V types are available (and suitable), a 25V one was used in the prototype because it happened to be handy.

The battery itself was secured to the matrix board by the simple but effective method of using two loops of wire to secure it in place.

The unit should be housed in some kind of small box, preferably of wood. If a metal box is used, take care not to short circuit any of the wiring.

CHECKING THE UNIT

Basic operation may be checked, without connecting the unit to the chimes, by listening to the clicking of the relay. Final checking, to ensure that it is working as desired, will be made by temporarily connecting it to the chimes. To do this, the two bell-push wires should be broken at some convenient point. The broken ends still leading to the bell-push are then connected to the points marked *X-X* in the circuit diagram (i.e. to RLA1 contacts) and the ends of the wires leading to the chimes are connected to the points *Y-Y* (i.e. to RLA2 contacts). ☒

PLEASE TAKE NOTE

Concerning *Doing It Digitally Part 6*, there is an error in Fig. 6.5 which gives details of a tape reader. The "post" between the ones marked "recorded" and "B" should read 0V and not +6V as printed. The diagram in Fig. 7a is correct.

With reference to the *Info. Chart* presented free with the March '77 issue, there is a mistake in the capacitor colour code table. The "Tens/Units" column under "C280 Series and Ceramics" should read the same as the "Tens/Units" column under "Tantalum Capacitors".

Physics is FUN!

By DERRICK DAINES

Pitch and Volume

THE pitch of a note is entirely dependent upon the number of pressure waves reaching the ear in any small unit of time. This is termed its frequency, in the past expressed as c.p.s. (cycles per second) but nowadays in hertz (contracted to Hz.) The terms are synonymous. The humming top is a familiar example but observers sometimes think that the sound is getting louder when in fact it is getting higher. They are not to be scorned for this since the human ear is not too good at the differentiation at the extremes of the hearing range, generally given as about 50Hz to about 15,000Hz.

Readers with access to a variable tone generator can conduct a series of experiments on the acuity of their friends' hearing, but start with the generator giving a note *outside* the range of human hearing and ask them to raise a hand when they hear it and not vice-versa, as sometimes a zealous participant will insist that he can still hear the sound long after it has been switched off! It goes without saying that the speaker system used must be able to generate these very high frequencies.

A reasonable substitute to a tone generator is afforded by a paint-stirring paddle in an electric drill that is fitted with a variable-speed control see Fig. 1. The drill is mounted in a frame and a springy flap of metal is arranged so that the paddle blades strike it. If the drill is run at full speed

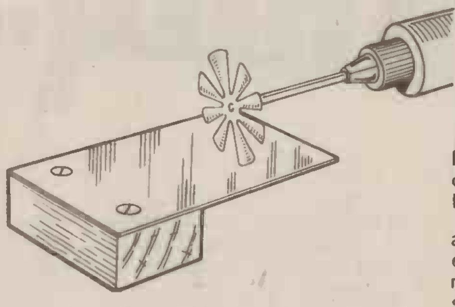


Fig. 1. A note is produced when a paint stirring paddle is struck against a springy flap of metal.

the metal flap acting like a sounding board will give off a note which is the product of the motor speed and the number of paddle blades. Slowing the drill will lower the tone, lower and lower, until the individual beats will be discernible.

Cardboard Discs

A toy suitable for children to play with is made out of four discs of tough card, see Fig. 2. Cut them all the same size with a radius of about 10 to 12cm and pierce the centres with a knitting needle. Now round the circumference of the first disc mark out 12 teeth equidistant. The others have 24, 36 and 48 teeth respectively. Mount them on the knitting needle with a slice of cork between each, secured with a dab of glue. The whole

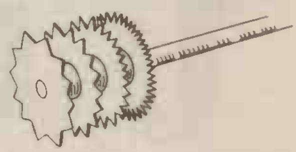


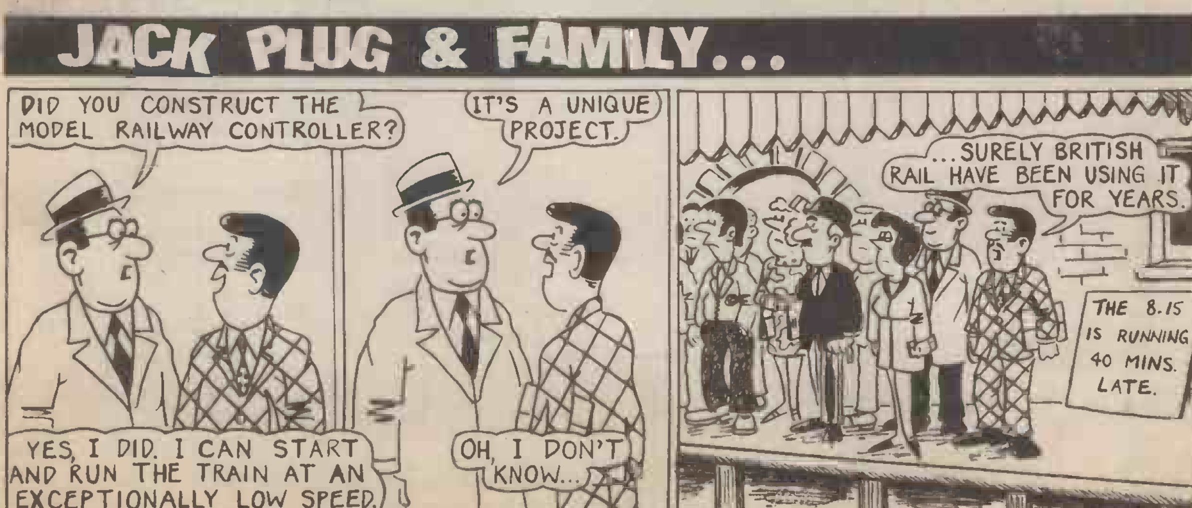
Fig. 2. If a card is held against all four discs, a chord is heard when the knitting needle is rotated.

arrangement may be spun by a small electric drill, driven by a clockwork motor, or by some domestic appliance such as a food mixer.

A strip of postcard applied to each disc in turn will produce four different notes, while if a wider strip of card is allowed to touch all four at once a pleasant chord is sounded. In fact, if we call the lowest notes the fundamental, the others are the 2nd, 3rd and 4th harmonics respectively. Incidentally, this tone-wheel system is the foundation of the Hammond organ sound.

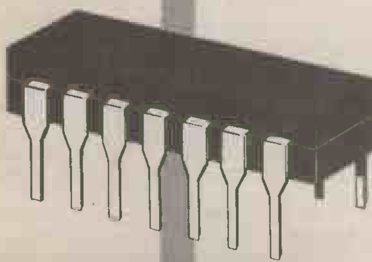
In our cardboard toy all the discs sound at roughly the same volume or amplitude. Were we to make a sound generator with a fundamental note and (say) all of the next 16 harmonics at equal volume, the result might not be all that pleasant since some harmonics are not harmonious to the ear.

However, it is axiomatic that every musical instrument sounds some harmonics louder than others and that as a general rule the higher harmonics are softer than the lower. It is the blending of the various harmonics that gives each instrument much of its timbre or quality of sound.



Doing it Digitally... Part 9

By O. N. Bishop



THIS MONTH we continue with more projects illustrating the uses to which digital circuits can be put.

DIGITAL DICE

A digital dice can be used instead of an ordinary cubical dice when playing many kinds of games—it is absolutely cheat-proof!

The dice uses a 7493 counter driven by a clock working at several hundred (or even thousand) hertz. The circuit is shown in Fig. 9.1.

The counter starts at zero (0000) but when it gets to six (0110) the two outputs *B* and *C* both go high. These outputs are fed to a NAND gate, the output of which immediately goes low. This signal is then inverted by another NAND gate giving a high which resets the counter to zero.

The reset acts immediately the counter gets to six so the actual sequence of counting is: 0-1-2-3-4-5-0-1-2-3-4-5-0 ... and so on.

Use a slow clock to check that this really happens, but in actual use a fast clock is necessary so that it is impossible for anyone watching to see what number the counter has reached.

To stop the clock the switch is closed, thus preventing pulses reaching the counter and freezing it at what ever state it was in. If all lamps are at zero this should be counted as six, the other numbers being indicated by their binary equivalents.

Of course this is a very simple form of dice yet it is cheat-proof because nobody can possibly know exactly when to press the switch to score any particular number. Also the counter is operating regularly so there is no bias towards any one number as there would be with a "loaded" dice.

It is also possible to design circuits which will count from one to six (instead of 0 to 5) and will also display the result on a set of seven lamps arranged like the face of an ordinary dice.

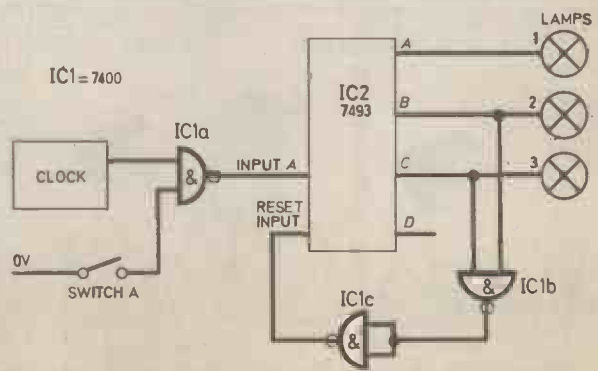


Fig. 9.1. Circuit diagram of a simple digital dice. The throw of the dice is indicated on the lamps when the switch is closed.

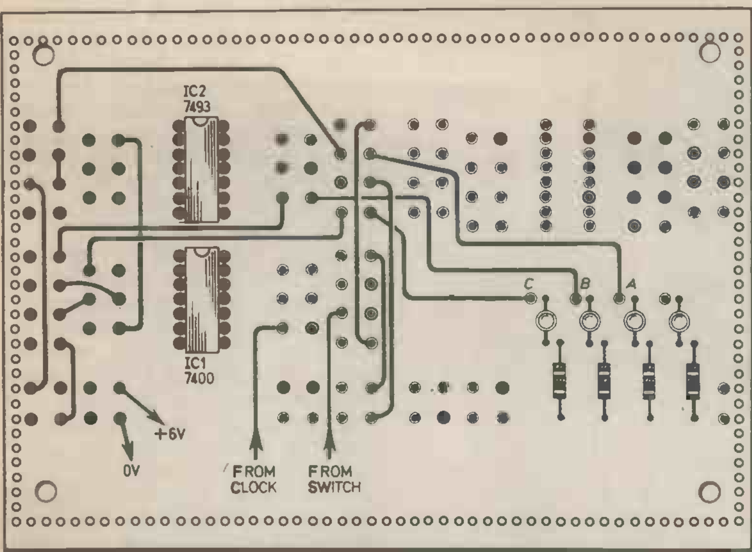


Fig. 9.2. Layout of the components for the digital dice on the experimental board.

Such circuits are more complex and the seven lamps add to the expense. Several circuits have been published in this magazine so you could try making up one of these for yourself or better still try designing one.

The layout for the Digital Dice excluding the clock is shown in Fig. 9.2. The clock can be constructed around the third i.c. socket if it has not been made permanent.

WHO WAS FIRST?

The circuit shown in Fig. 9.3. indicates which of two events happened first—even if one was only a millionth of a second before the other. Logic circuits act quickly!

The two "events" are the opening of switch *A* and switch *B*.

It can be seen that the two switches are connected to two bistables via NAND gates. Each bistable is connected to a lamp to show which switch was opened first.

The circuit is first reset by closing both switches and taking the reset line low. Since a low input on either of the inputs to a NAND gate causes the output to go high, this forces the outputs of gates IC1a, IC1b and IC2d to go high. Both inputs to gates IC2a and IC2c will be high causing the outputs of these gates to go low and the lamps to be off. Providing the switches *A* and *B* are still closed, the circuit will stay in this state when the reset line is released.

Now supposing switch *A* is released. Both inputs to IC1a will be high so pin 6 will go low thus setting the bistable in its other state—pin 11 high (lamp on) and pin 8 low. Since pin 8 is low, gate IC1b is effectively closed—operating switch *B* can have no effect on the output of the gate. Thus *A* has blocked the action of *B*.

Exactly the reverse situation occurs if button *B* is released before *A*.

The circuit can be used when playing "snap" or some similar game to decide "who was first".

A pair of light-operated switches can be attached to the circuit to see which of two model racing cars wins a race. These go high in the dark so will give a brief high pulse as a car passes between the lamp and the photocell. A phototransistor circuit is required because of its fast response.

The layout on the experimental board is shown in Fig. 9.4. The switches used are those constructed on the "keyboard" in an earlier part of this series.

A set-up for a race track is shown in Fig. 9.5.

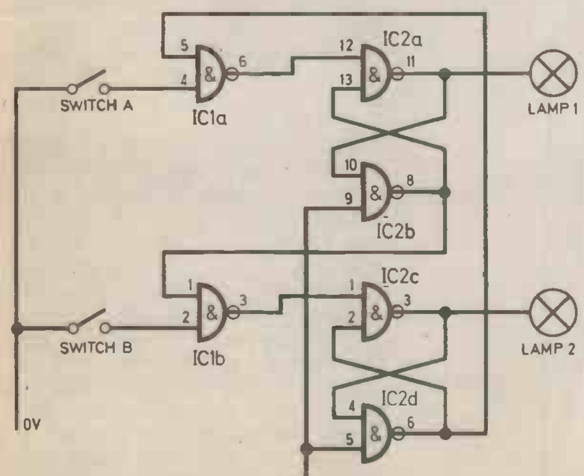


Fig. 9.3. Circuit diagram of the "Who Was First" unit. Switches *A* and *B* are normally closed. The lamp will indicate which switch was opened first.

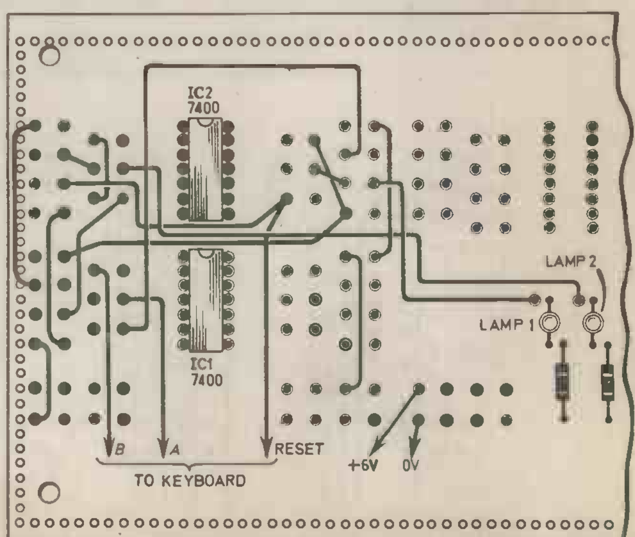


Fig. 9.4. Layout of the components on the experimental board for the "Who Was First" circuit. The switches used are those on the keyboard described earlier in the series.

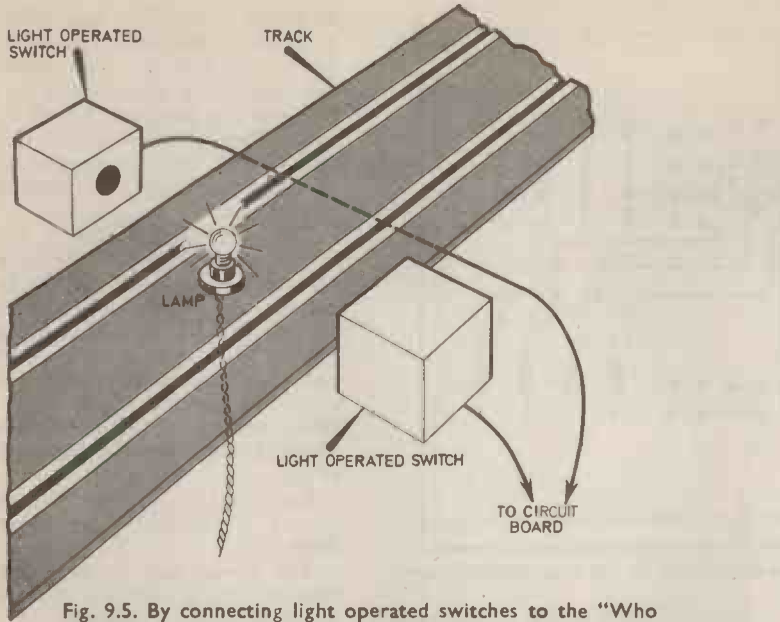


Fig. 9.5. By connecting light operated switches to the "Who Was First" circuit and placing them as shown, the first car past the lamp can be indicated.

FLIP OR FLOP

The game "flip or flop" is just about as difficult to play as noughts and crosses and is like that game in that after playing it a few times one never loses—except by making a mistake!

The game is based on the 7472 flip flop. This i.c. has only one flip flop inside it as compared with two in the 7473 but it is cheaper. The flip flop has three each *J* and *K* inputs, also a clear which sets the *Q* output low and a preset which sets it high. These act independently of the state of the clock pulse.

The i.c. is shown connected up in Fig. 9.6. To play the game start with all the *J* and *K* inputs low (to ground) and ground the clear input for a moment so that *Q* goes low and the lamp is out.

The two or more players play in turn. At each turn a player must change any two of the inputs. If, after he has done this, he thinks that the lamp will change state when the clock input is taken low he may ground the clock input. If the lamp changes he wins a point if it does not then his opponent has the point. If the player does not wish to ground the clock line the turn passes to the next player and no points are scored. The winner of the game is the first to score 20 points.

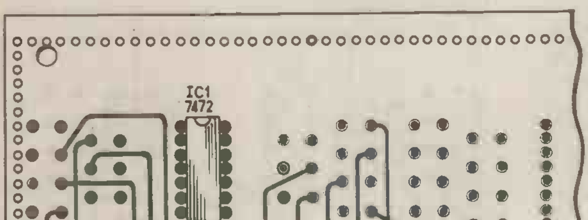


Fig. 9.6. Layout of the wiring on the experimental board for the "Flip Or Flop" game.

This is not a difficult circuit to build permanently. Some variations could also be incorporated. For instance, playing blind: Instead of using toggle switches where it is easy to tell the state of each input just by looking at the switch, use push-on, push-off switches. This makes the game almost one of chance.

One could also play against the clock. Instead of having a clock button to ground the clock input when a player thinks he can change the state of a lamp, this version has a slow clock with a period of about 0·2 seconds. The player who is in the middle of his turn or the player who has just completed his turn when the lamp changes scores a point.

In this version one has the additional feature of trying to get the inputs to the right state at the right time. One could wire an extra lamp to show the state of the lamp or one could just leave the players in the dark!

EGG TIMER AND PHONE TIMER

The device to be described will time short periods and light a lamp or sound an alarm when the period is complete. There are lots of uses for this sort of device in the home.

The circuit uses a clock operating at about 0·2Hz, the output of which is connected to a 7493 counter. This will register one count every five seconds so will reach the full capacity of the counter in 75 (5 times 15) seconds. This may not be long enough for some applications but the period can be extended in several ways. The count can be passed first through a flip flop which will double the period, or through two flip flops which will extend the period to 300 seconds or five minutes (long enough for an egg timer).

The circuit with just the 7493 is shown in Fig. 9.7. and with the two extra flip flops in Fig. 9.8.

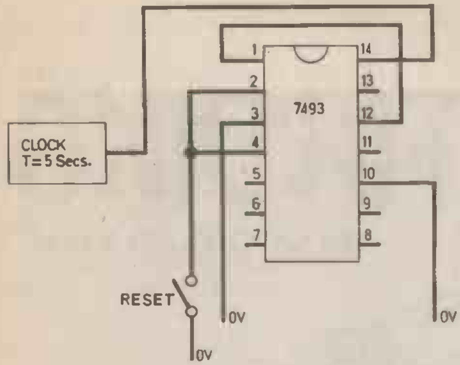


Fig. 9.7. A simple timer using a slow clock and a counter.

Components

Digital Dice
7400
7493
Clock circuit
Push-to-make switch

Who Was First?
7400 (2 off)
Keyboard switches (2 off)

Flip or Flop
7472
Push-to-make, push-to-break (8 off)

Timers
Clock: 7473
7493
7400
7440

Alarm Unit: Rotary switch 1-pole 5-way

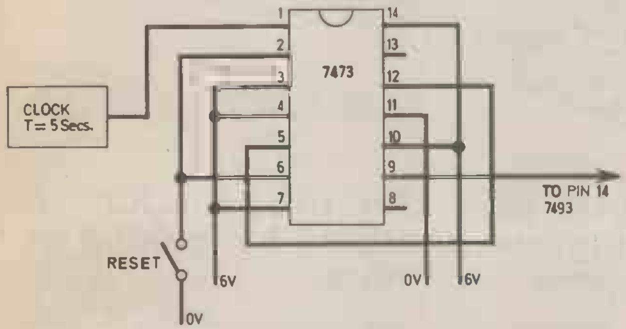


Fig. 9.8. The period of the counter may be extended placing two flip flops between the clock and the 7493.

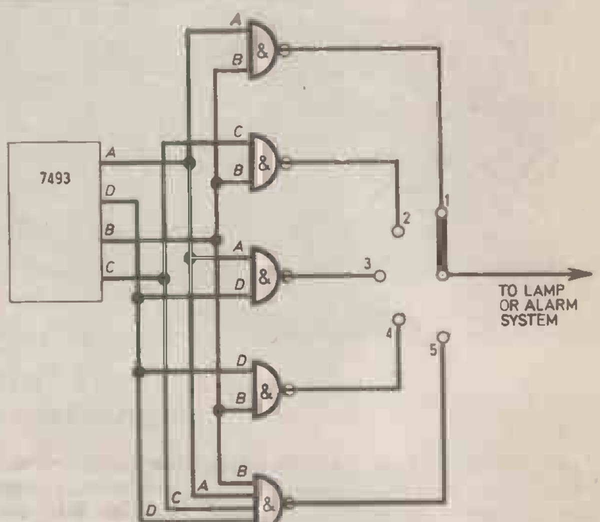


Fig. 9.10. Four two input and one four input NAND gates can be used to give timing periods of one to five minutes as selected by a rotary switch.

The time is up when all the outputs of the 7493 go high. If all outputs are fed to a four-input NAND gate the output will stay high for five minutes then go low. This can be used to drive a lamp or alarm.

If the counter keeps going even after the alarm has gone off then the alarm will cease at the next count. To overcome this, the output of the NAND gate could be fed to a bistable which feeds the alarm. This will then continue sounding even when the counter has gone back to zero.

The alarm can be made to sound after shorter periods than the full capacity of the counter. This can be achieved by using only some of the outputs of the 7493 fed into a NAND gate. For instance if the *A* and *B* outputs are fed into a two-input NAND gate then the alarm will sound after 60 seconds.

Thus the timer may be wired up in several ways and Fig. 9.9. shows the complete system. Parts of this may be left out depending on the application required.

Several NAND gates can be wired up if desired to give the option of different timing periods. The outputs of the gates can be taken to a rotary switch as shown in Fig. 9.10. so that the switch selects the period.

As can be seen this is the sort of circuit which can be tailor made to specific requirements. It is best to set it up on the circuit board, play around with it until the desired results are achieved (learning a lot about logic in the process) and then build up the circuit permanently.

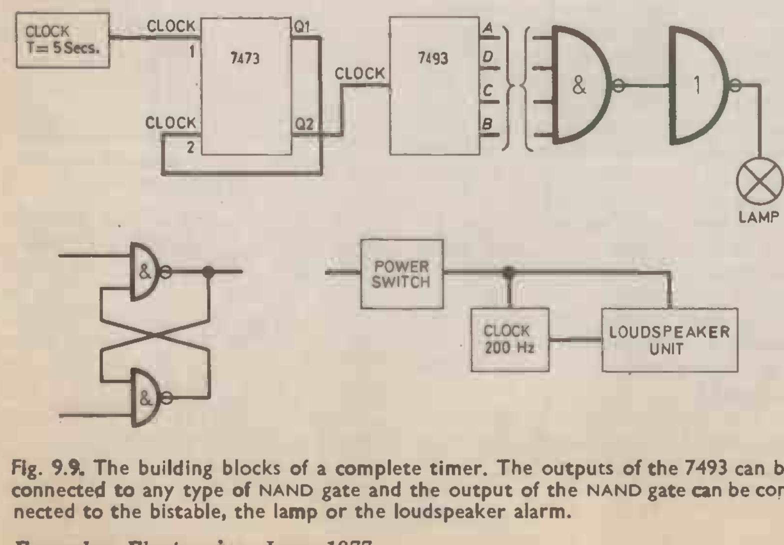
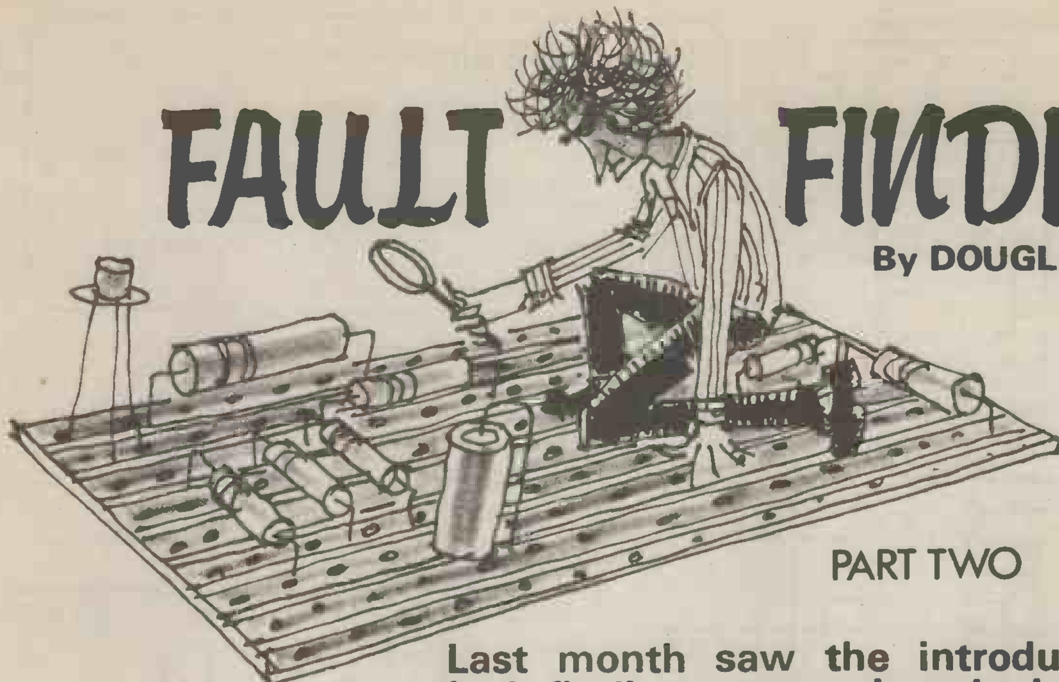


Fig. 9.9. The building blocks of a complete timer. The outputs of the 7493 can be connected to any type of NAND gate and the output of the NAND gate can be connected to the bistable, the lamp or the loudspeaker alarm.

To be continued

FAULT FINDING



By DOUGLAS VERE

PART TWO

Last month saw the introduction to fault finding, we continue by looking at one-transistor amplifiers.

IN ANCIENT China, it is said, patients paid their doctors only when they were *healthy*. It must have given the doctors a great incentive to cure diseases quickly! But it must also have raised a few problems. What is health? Until you know, it becomes hard to diagnose a disease.

It's the same with circuitry. Unless you know how a circuit *should* work, you are unlikely to be much good at diagnosing faults. It may seem a tall order to expect everybody to know how every circuit works, in detail, just so that he can do a bit of fault-finding.

Fortunately it isn't necessary to know anything like as much as the chap who *designs* circuits. If he is a competent designer, then he gets his component values right in the first place. The fault-finder only needs to know enough to see where things have gone wrong. Another fortunate circumstance is that the same types of circuit tend to repeat themselves over and over again, in slightly modified forms. Once you've got the hang of them fault-finding becomes easy.

DEDUCTIONS

Knowledge of the d.c. voltages to be expected in a working circuit is invaluable. If a particular voltage is wrong, some component or device associated with it is faulty. But how do you know what the circuit voltages should be? It's much easier to make intelligent deductions than you might think, because everybody, even the beginner with only a knowledge of Ohm's law and a general idea of how a transistor works has enough knowledge to do so.

We'll begin by looking at a simple single-stage transistor amplifier (Fig. 2.1a). This is an a.c. amplifier, as you can see by the input and output capacitors, put there to block d.c. Suppose you have traced a fault to this stage (by the signal-tracing methods mentioned in the last article), how can you identify the precise cause of trouble? D.c. voltage checks are normally used by repair men to do this. So what should the voltages be in a working amplifier of this type?

To work, the transistor must be turned on. This means that base current must flow in R1 and collector current in R2. In both cases the flow is down from the positive line (marked V_{CC} on many diagrams, or with the actual voltage).

The current flow in the two resistances produces voltage drops, and we can say, just by noting these, various useful things. First, the collector must be more positive than the base, because there is a drop across R1 which goes from collector to base. Secondly, the collector must be *less* positive than the V_{CC} line, because of the drop in R2.

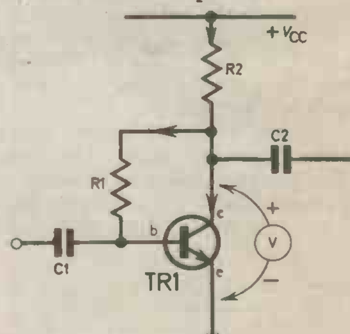


Fig. 2.1a. Single stage transistor a.c. amplifier.

A third, perhaps less obvious fact can also be deduced. Where does the base current go after entering the transistor? It can only flow to the negative terminal of the battery. In doing so it must set up a voltage drop across the base-emitter junction of the transistor, making the base more positive than the emitter.

Even without knowing anything about the actual sizes of these voltages, you can still begin to fault-find with your voltmeter. If, on measurement, it turns out that the collector is *less* positive than the base, not more, as it should be, then there's obviously something amiss. (We'll discuss what it might be later.)

EARTH

However, it is much better to get *some* idea of what the voltage should be. Before looking into that, let's just get one or two general points straight. First, in transistor circuits it is usual to quote voltages with respect to the *common* side of the power supply. In *npn* circuits like this, the common side is normally the negative battery line, and is normally drawn at the bottom of the diagram. (In *pnp* circuits all the voltages and current flows are reversed, but the principles are the same.)

To measure a voltage in this *npn* circuit you connect the negative terminal of the voltmeter to the negative battery connection and the positive voltmeter terminal to whatever point in the circuit you are interested in. By the way, the "common" side of the circuit is often referred to as the "earthy" or "grounded" side. British technicians just call it "earth" (whether it is really connected to the earth or not.) This is a convenient short way of talking about it which I'll use from now on.

TRANSISTOR VOLTAGES

Where were we? Oh, yes, the voltages. The base-emitter voltage of a working silicon transistor is usually in the range 0·5 to 0·9V (at room temperature). The lower voltages are found when the transistor is passing only a small current. To a rough approximation, it's reasonable to say that the base-emitter voltage is 0·7V, and I'll do so from now on. (For germanium transistors a typical voltage is 0·25V, but the variation is much greater than for silicon, and it could be as low as 0·1V for a small audio transistor.)

The only other voltage of interest is the collector voltage. There is no way of estimating it unless you know the d.c. current amplification factor (h_{FE}) of the transistor.

In general, the circuit designer chooses resistances which set the collector voltage to about half the supply voltage, but variations may be quite large. The collector voltage is about half the supply voltage when R1 is h_{FE} times R2. Thus if V_{CC} = 6V, R2 = 1kΩ and h_{FE} = 100, the collector voltage will be about 3V if R1 = 100kΩ.

Usually, in practice, h_{FE} is not known precisely. Transistor makers give it only between certain limits (e.g. 100 to 300) and designers use average values. Since an individual transistor may have an h_{FE} which differs quite significantly from the average, the collector voltage may deviate significantly from what is expected. Fortunately there is a certain degree of d.c. negative feedback in the circuit which helps to reduce the effects of h_{FE} variations, but it can't eliminate them. (The same applies to Fig. 2.1b, where the *emitter* voltage is about half V_{CC} when R1 = h_{FE} × R2.)

A short way of referring to the d.c. voltages between the various electrodes of a transistor is to write V_{BE} for base-emitter voltage, V_{CB} for collector-base voltage, V_{CE} for collector-emitter voltage. If in Fig. 2.1a, V_{BE} = 0·2V instead of the expected 0·7V you know either that you are hot on the trail of the fault or that something has gone wrong with the measurement! I'll deal with measurement errors (caused by using an unsuitable voltmeter) later.

SHORT

A common fault in transistors is an internal "short" between base and emitter. Often this not a complete short but has enough resistance to drop a small voltage. This could explain the 0·2V. Before unsoldering the transistor, however, ask yourself what the left-hand terminal of C1 is joined to. It's just dangling in the air in Fig. 2.1a, of course, but in a real circuit it must be connected to something.

If C1 has an internal short (or "leak" this could affect V_{BE}. For example, if C1 (left hand) were connected to earth via a low value resistance such as a 5 kilohm volume control, then an internal short could allow d.c. to flow in the 5k volume control, robbing a transistor of base current and pulling down the base voltage. A quick test checks this. Measure the voltage at C1 (left hand). If it's not zero, C1 is leaky.

In other circuits C1 (l.h.) is connected, not to an earthed resistance but to the collector of a previous stage. In this case the l.h. side of C1 should be at a voltage above earth. A leaky C1 then allows current to flow from the previous stage collector TR1 base. This augments the a.c. base current and turns on TR1 harder, pulling down V_{CE}, and perhaps to such a low value that TR1 can no longer work properly. (With this fault, V_{BE} is raised slightly, but not necessarily enough to detect with a meter, unless you have already measured it before the fault developed and noted exactly what it should be.

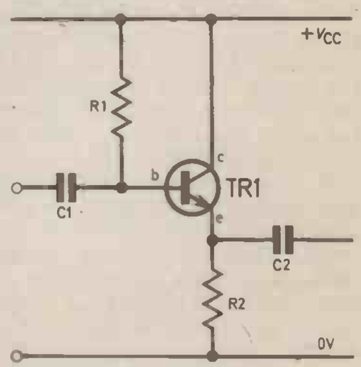


Fig. 2.1b. Emitter follower stage, Note that the transistor "load" is R2.

In the circuit shown in Fig. 2.1b the transistor "load" R2 is in the emitter connection. This "emitter follower" stage has an a.c. output voltage slightly less than the a.c. input voltage. Since the collector and base currents flow in R2, the emitter voltage is raised above earth voltage. If R1 is h_{FE} times R2, the emitter voltage is about half V_{CC}. The base must be the usual 0·7V more positive than the emitter, making the base-earth voltage that much more positive than the emitter-earth voltage.

POTENTIAL DIVIDE BIAS

The simple circuit of Fig. 2.1c uses what is often called "potential divider bias". Here R1 and R2, which are connected across the battery, pass a current much greater than the base current of TR1. As a result, the flow of base current in R1, being so much smaller, makes little difference to the voltage drop in R1. Thus the drop in R1, and therefore the base voltage, is nearly independent of base current.

If R1 = R2, the base voltage (base to earth, that is), is half V_{CC}. If R1 is three times R2, then three-quarters of V_{CC} is dropped in R1 leaving one quarter across R2 and so the base voltage is $V_{CC}/4$. In a word, R1 and R2 form a potential divider which applies a certain fraction of V_{CC} to the base.

Suppose V_{CC} is 12V and R1 = 3 × R2 then the base-earth voltage is 12/4 = 3V. The emitter voltage is about 0·7V less, i.e. 2·3V. This 2·3V is across R4 and the emitter current I_E must therefore be 2·3V/R4. If R4 = 1kΩ, I_E = 2·3mA. The collector current is virtually the same, so if R3 is 2 kilohms it drops 4·6V and the collector voltage must be about 7·4V. So if you know the resistances, the supply voltage (V_{CC}) and V_{BE} you can make a fair estimate of all the circuit voltages. Not a 100 per cent accurate estimate, of course, but quite good enough to be of use in fault finding.

If the collector voltage is measured as 4V, for example, this should strike you as much too low. Is a leaky C1 feeding current to the base from the collector of the previous stage? Is C2 leaky and by-passing R4 to d.c.? Has a resistor changed value, or the transistor developed a fault? Checking all the expected voltages in the circuit should help to limit the possibilities.

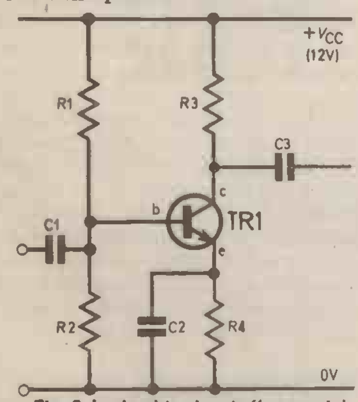


Fig. 2.1c. In this circuit "potential divider bias" is used, as explained in the text.

OVERLOADING PROBLEMS

Incidentally, there is one quite common fault which can throw out all the circuit voltages even though every component in the circuit is perfect. This fault is "overloading" of the transistor by very strong signals. Quite often, the signals get there by accident. For example, an audio amplifier may, because of accidental coupling between output and input, burst into radio frequency oscillation. You hear nothing (except perhaps a loud hiss) in the speaker, but the strong oscillations upset the voltages (and may easily wreck the transistors).

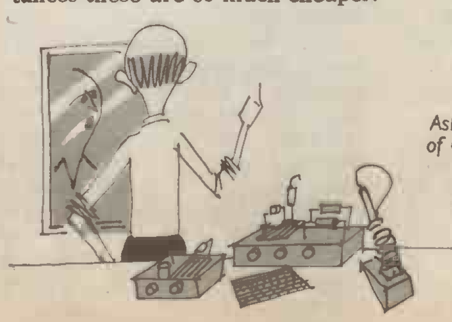
SHUNTS

A small piece of auxiliary equipment takes care of the problem, temporarily. It is a genuine bit of test gear in its own right, though not often referred to in the textbooks. It's just a capacitor, of 100nF (0·1μF) or more, fitted with flexible leads which terminate in crocodile clips. One lead is clipped to earth. The other is attached to points in the circuit where the unwanted oscillations may be present—say the collectors or bases of transistors.

The impedance of 100nF to radio frequencies is low, usually low enough to short the r.f. to earth and so stop the oscillation. The transistor voltages should then return to normal, if the transistors have not been damaged.

In some circuits, especially radio receivers, the mere act of connecting a voltmeter to a point in the signal path may cause oscillation, and in such circuits it is a wise precaution to connect the "shunt capacitor" (I'll call it that in future) before starting to test.

In audio circuits, connecting a meter to a sensitive amplifier may accidentally introduce strong "hum" which upsets the d.c. conditions. To bypass the hum (which is at the mains frequency, a low frequency) a large shunt capacitance is required. Whereas the 100nF can with advantage be a metallised foil type, its larger hum-shorting brother will probably have to be an electrolytic, because in large capacitances these are so much cheaper.



In this case, remember to get the polarity right. And, in both cases, make sure that the working voltage is at least as high as V_{CC}. A reasonable "hum shunt" would be 10μF, 64V working. This will suit most circuits.

In theory, 10μF should perform equally efficiently both as a hum shunt and an oscillation stopper. However, theory is misleading. The impedance of electrolytic capacitors does not go on falling as the frequency is increased, as it should, but starts to *rise* again somewhere above the audio range. So at, say, 10MHz, your 10μF electrolytic may have a much higher impedance than your 100nF metallised foil, and be less effective as a shunt to h.f. signals.

If you have an assortment of capacitors, and two double ended croc-clip leads, you can, of course, lash up shunt capacitors as the occasion arises, and try out different ones on the spot.

CIRCUITRY

To return to our circuitry. We've now looked at some common types of single-stage amplifier, and indicated the circuit voltages, or at least how to estimate them. Practical transistor circuits seldom fall neatly into one of these categories. Designers modify them or use combinations of them to suit their purposes.

For example, a designer may put a resistance in the emitter lead of Fig. 2.1a. This has the effect of increasing the input impedance and reducing distortion at the expense of gain. The circuit is then a sort of hybrid between Figs. 2.1a and 2.1b. Then again, two or more transistors may be direct-coupled, with the collector of one stage connected directly to the base of the next. This is a common arrangement in audio power amplifiers. We'll look at one of these multi-transistor combinations later.

To be continued

Ask yourself what the left-hand terminal of C1 is joined to.

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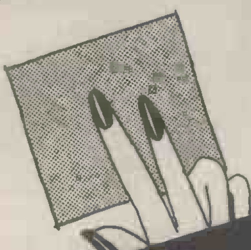

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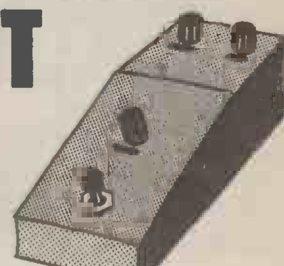

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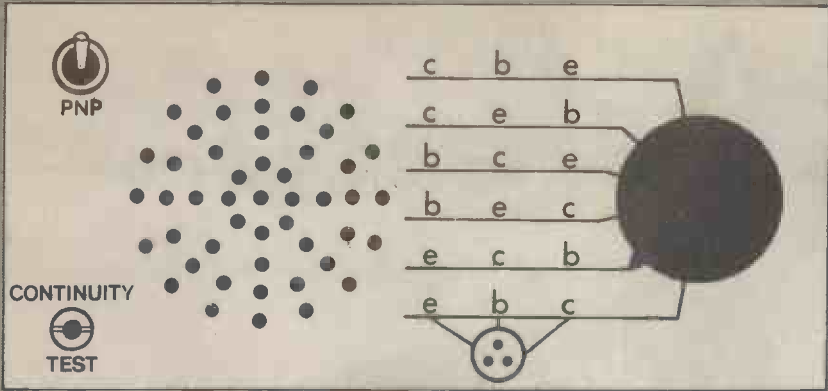

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TRANSISTOR LEAD OUT INDICATOR

ALL electronics constructors, from the professional to the occasional dabbler, find that over a period of time a homogenous collection of electronic bits and pieces is amassed, which invariably includes a large number of transistors. Many of these will have had their markings rubbed off, while others may bear an unidentifiable code number.

It is possible with the aid of a multimeter to identify the lead-outs of unknown transistors, but the process is very tedious and one is never very sure of the results.

With the unit described in this article, however, the lead-outs of bipolar transistors can be identified in a couple of seconds, which is just what is required by those who invest in semiconductor packs containing unmarked and untested transistors.

The indicator will also identify the transistor as *pnp* or *npn*, confirm that the transistor is serviceable, and as a fringe benefit serves as a very useful audible continuity tester.

It will not, however, work with field effect or unijunction transistors.

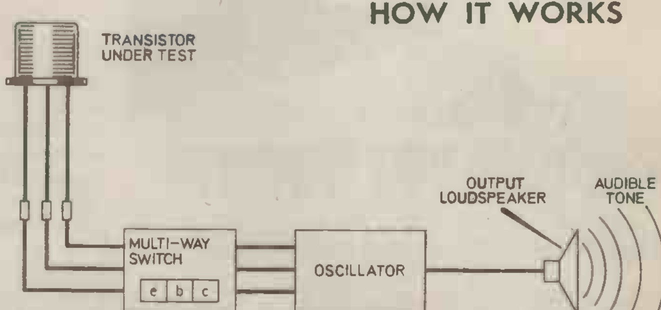
THE CIRCUIT

The complete circuit diagram of the indicator is shown in Fig. 1. The heart of the indicator is a Hartley oscillator. If the collector, base and emitter of a transistor are connected to *c*, *b* and *e* respectively the circuit will oscillate and a tone will be produced by the loudspeaker.

If therefore an unknown transistor is connected to the oscillator via a switch capable of selecting all possible combinations of the transistor's three leads, a tone from the loudspeaker will indicate that the correct combination has been made; the switch position can then identify the three leads.

While this switching is being carried out the full supply voltage is applied across the transistor's terminals in all possible combinations, and to avoid breakdown of the semiconductor junctions this voltage has to be kept to the minimum. In the event, tests revealed that a supply voltage of 1·5 volts was sufficient for a very adequate signal to be

HOW IT WORKS



The circuit of the *Transistor Lead Out Indicator* is an oscillator made complete by the insertion of a transistor (the one under test). Being a 3-lead device, the transistor can be connected in circuit in six different ways. This is accomplished by means of the multi-position switch. For only *one* position of the switch does the device oscillate and produce an audible tone in the loudspeaker. (Some transistors may produce a tone when c and e are transposed, but with less intensity.)

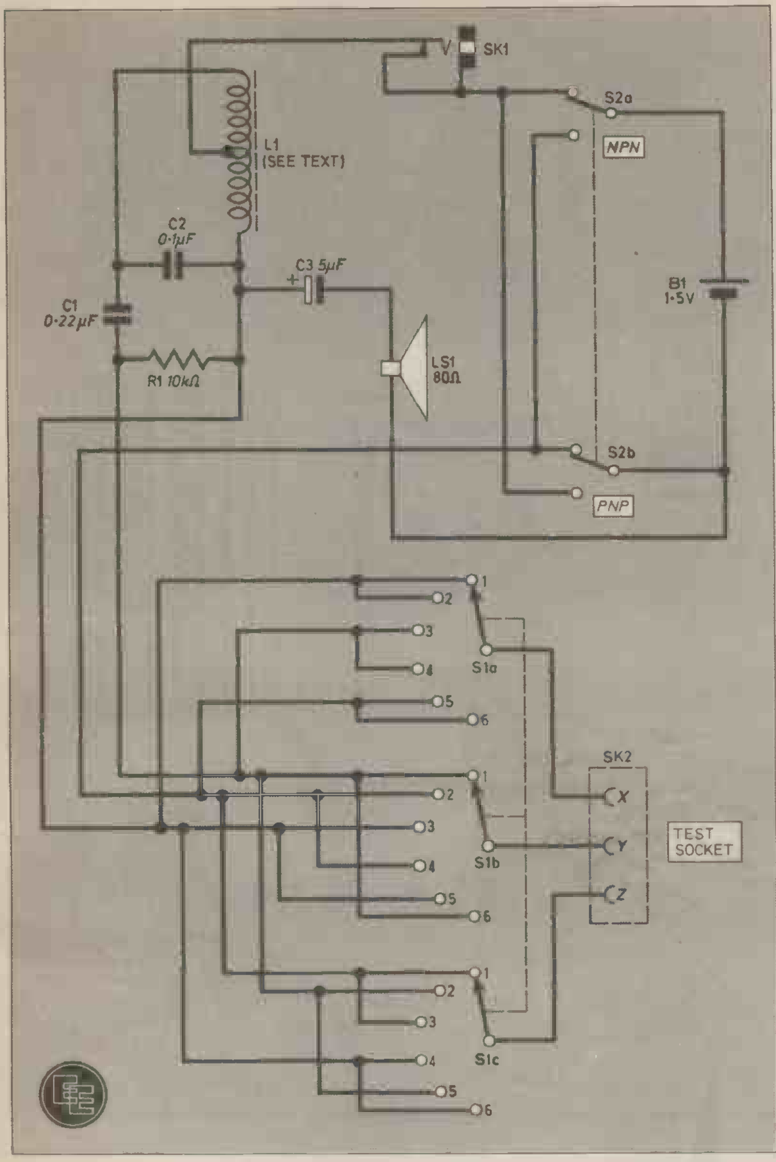


Fig. 1. Circuit diagram of the Transistor Lead Out Indicator.

produced. Some transistors gave a stronger output than others, but in all cases the tone was clearly audible.

Resistor R1 provides base bias for the transistor under test, while the positive feedback path is through C1; C3 couples the output to the loudspeaker. It is important that the ground connection of the loudspeaker be brought to the supply side of S2: this ensures that the negative terminal of electrolytic capacitor C3 is correctly connected whatever the position of S2. When S2 is in the *pnp* position the loudspeaker ground connection is made through the dry cell.

The frequency at which the unit oscillates is governed by C2 and the inductance of L1, but it is also affected by C1. It was found that the frequency varied with different transistors—some transistors in fact oscillated at near supersonic frequencies. The unit had therefore to be designed to oscillate at as low a frequency as feasible, and the values quoted for C1 and C2 were found to be the most suitable for the coil used in the prototype.

INDUCTOR

This coil in the prototype was a miniature push-pull output transformer filched from an unserviceable transistor radio. Various types from the spares box were tried and all worked with varying degrees of efficiency. Only the primary (i.e. the winding with three connections) is used. The two leads from the other winding may be used to anchor the transformer in place, but must be electrically isolated from the rest of the circuit.

A home-constructed coil was also tried, with excellent results. For those who may be interested a suitable coil can be made by pile-winding 600 turns of 30 to 40 s.w.g. enamelled copper wire on to a piece of 9mm ($\frac{3}{8}$in.) ferrite rod about 70mm long. A centre-tap must be drawn out at 300 turns, see Fig. 2.

Switch S1 used on the prototype was a rotary 3-pole 6-way type. It may be difficult to obtain a ready-made switch of this specification but one can very easily be assembled from "Maka-Switch" parts by using two 2-pole 6-way wafers, one of the poles being surplus.

The switching circuit is shown in Fig. 3 and is drawn using two 2-pole 6-way wafers as mentioned above. This looks rather complicated mainly because of the cross-connections involved; constructors may find it easier to make up the connections by following the switch position table.

Socket SK1 is a miniature 2·5 or 3·5mm jack socket with built-in switch, and provides the continuity testing function of the unit. A pair of prods are connected to a suitable jack plug, see Fig. 3: when this is inserted into the socket the built-in switch interrupts the supply, which is only restored when a short-circuit is presented to the prod ends.

Readers will notice that no on/off switch has been incorporated in the design. There is no need for one because the supply is always interrupted when there is no transistor in the test terminals and when the jack plug is inserted in its socket (provided, of course, the prods are not shorted!).

CONSTRUCTION

The prototype was built into a wooden case measuring 180 x 83 x 48mm. The sides were covered with laminate simulating wood veneer, and the lid with

TRANSISTOR LEAD OUT INDICATOR

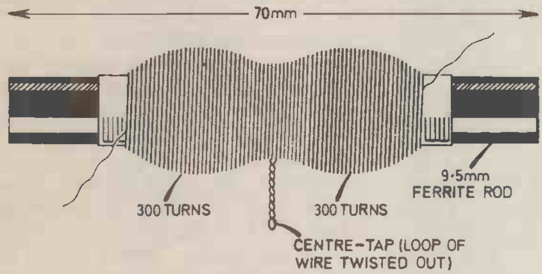


Fig. 2. Construction of the alternative coil, which may be used in place of the push-pull transformer.

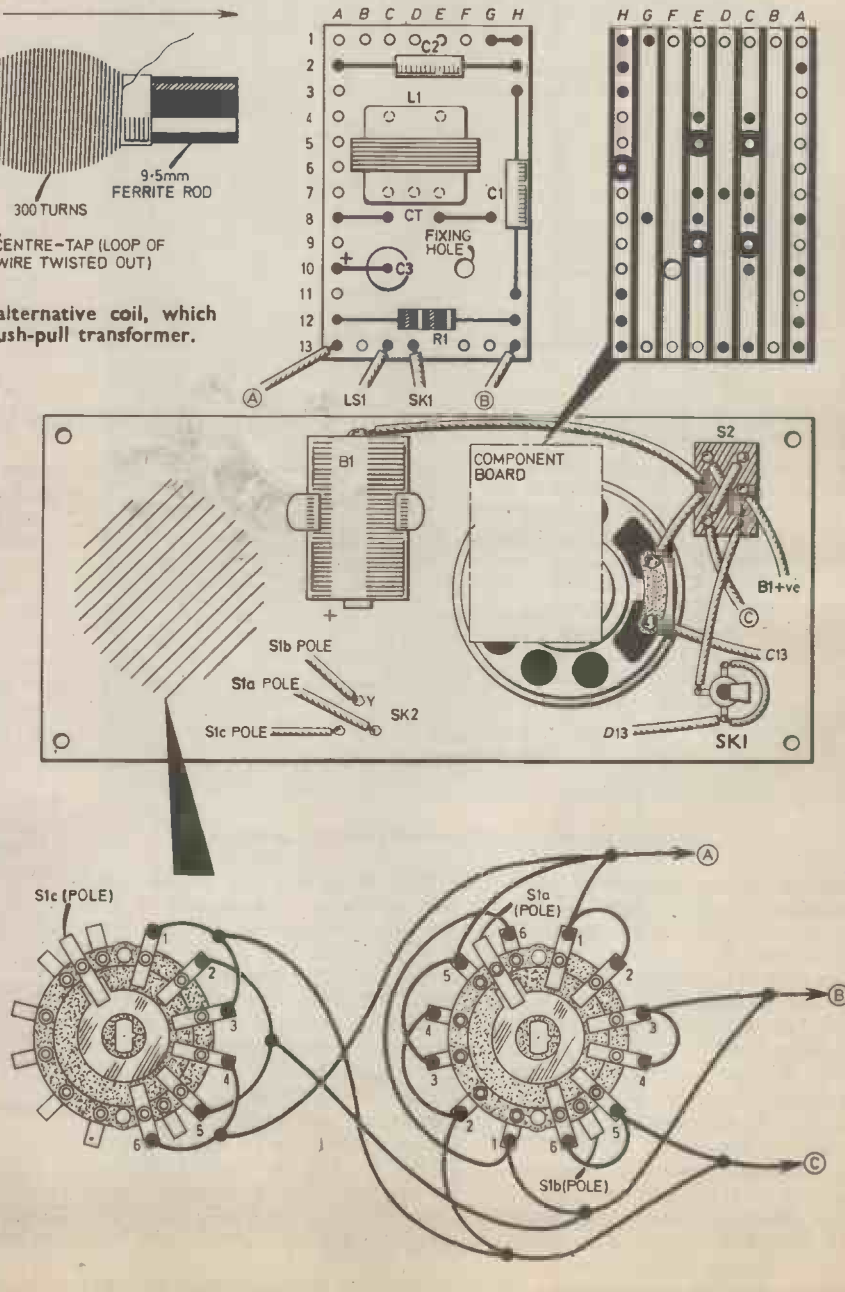


Fig. 3. Diagram showing the stripboard layout, with the breaks shown on the underside. Also shown is the wiring details for the 2 pole 6 way switches, and the connectors required on the front panel.

Components

Resistor
R1 10k Ω ¼W carbon ± 10%

Capacitors
C1 0·22μF plastic or ceramic
C2 0·1μF plastic or ceramic
C3 5μF 3V elect.

Miscellaneous
S1 3-pole 6-way rotary switch (see text)
S2 2-pole 2-way toggle switch
SK1 2·5 or 3·5mm switched jack socket
SK2 three-pin transistor socket
L1 miniature push-pull output transformer or home made inductor—see text
LS1 80 ohm miniature loudspeaker approx. 60mm diameter
B1 1·5V type U7 or similar
Stripboard 0·15inch matrix 8 strips x 13 holes; Terry clip for B1; knob with pointer; jack plug to suit SK1; crocodile clips (2 off); case—prototype size 180 x 83 x 48mm; connecting wire.

See Shop Talk page 263

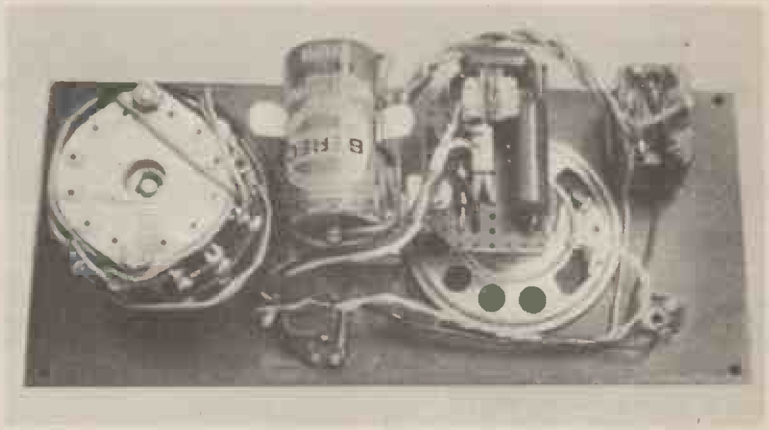
white laminate. All the components were mounted on the lid, as can be seen in Fig. 3 and photograph. The layout and wiring of the various components is not critical and constructors may if they so wish adopt a different layout.

The dry cell, B1, is held in place by a Terry clip, the supply connections being soldered to the cell's terminals. Current consumption when the unit is in use is in the region of 2 milliamps, and since use is not continuous it should be a very long time before the cell has to be replaced.

The layout of the components on the stripboard and the breaks to be made on the underside are shown in Fig. 3. Begin by mounting the components on the prepared board as shown and then prepare the lid of the case to accept S1, S2, SK1 and SK2. The front panel (lid) can be drilled with a series of holes immediately above the location of the loudspeaker cone, or a suitably sized hole backed with speaker fret will do.

With all the components in position wiring up should be carried out according to Fig. 3. The component board was mounted on an aluminium bracket and positioned over the loudspeaker which was held in place with a few dabs of Evostik.

The panel lettering was made with Letraset transfers, which give a very professional effect. After lettering the face of the panel should be coated with a clear varnish (preferably matt) to protect it.



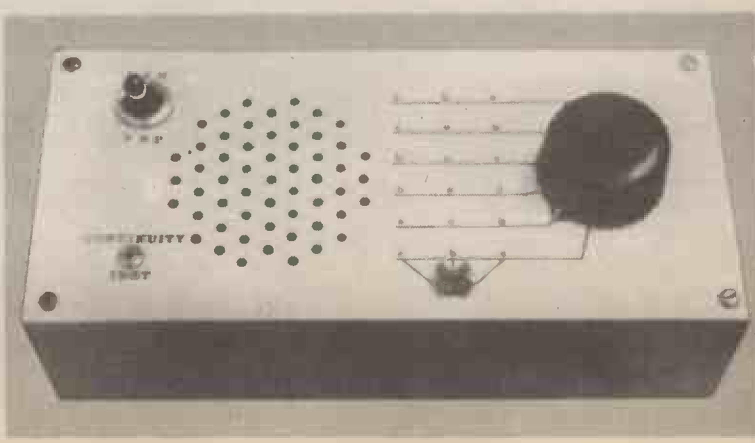
Photograph showing how the components are mounted on the lid.

USING THE INDICATOR

The indicator is extremely simple to use. The unknown transistor is inserted in the transistor holder and S1 rotated through its six positions; if no tone is heard, S2 (*pnp/npn* selector) is changed over and S1 again rotated until a signal is heard. The pointer on the knob of S1 will then indicate the identity of each of the transistor's terminals, and S2 the polarity of the device.

With some transistors the unit will oscillate in two positions of S1 i.e. with the emitter and collector transposed. In these cases there is usually a stronger output at the position corresponding to the correct terminals. In any case the base terminal will always be correctly indicated.

To use the unit as an audible continuity tester a transistor has to be inserted and the unit adjusted until a tone is produced. The jack plug is then put in place and the tone will then sound only when the prods are shorted. In practice the presence of a resistance of a few ohms between the prods still produces a tone: there should be no confusion however because the pitch of the tone changes noticeably. ☐



For your ENTERTAINMENT

By ADRIAN HOPE

ALMOST everyone has a love/hate relationship with their telephone. Recently the British Post Office made a gesture that should engender a little more love. We all know it costs considerably more to place a call through an operator than to dial it direct. But until recently this extra charge was levied even where the subscriber had only called the operator out of desperation, for instance, because direct dialling had produced wrong numbers or dead or crossed lines.

This surely made the Post Office one of the only firms that penalised customers for its own mistakes! But now a concession has been made, and if a call fails the operator will connect you at around the cost of dialling direct.

Incidentally, it isn't an old wives' tale that calls fail and the phones always go wrong in wet weather. It's fact. Because our skylines are now largely clear of telephone lines (think when you last saw a telephone pole, and it may surprise you), virtually all our phone cables run in channels underground. And, quite simply, when it rains the channels fill up with water, the wires get wet and circuits short. It's as simple as that; but you'd be surprised how many people don't realise it.

Interference Problems

A reader wrote recently asking if there were any steps one can take to minimise the interference one gets on a.m. mains intercoms, i.e. wireless intercoms. Because he was thoughtful enough to enclose a stamped addressed envelope, I promptly wrote back, but with the depressing news that there is really absolutely nothing one can do.

As we have previously reported the mains is now horribly cluttered with audio interference, as generated by thermostats, fluorescent lights and worst of all thyristor dimmers. As a result a.m. intercoms, which use the mains as their audio frequency link between station and station, are inevitably terribly noise-prone. Things got so bad in the USA that f.m. (frequency modulation) rather than a.m. (amplitude modulation) intercoms are now available, and at least one model is now sold in this country. The cost is high, over £40 a pair. However, because virtually all mains-borne interference is a.m. rather than f.m., they can provide virtually noise-free communication, just as f.m. radio reception is virtually immune from most forms of interference.

Money In Your Pocket

With Post Office rental charges continually rising, it is opportune to recall how one can quite legally cut Post Office costs in a small business situation by using these instruments. Consider, for instance, boss in one room and secretary in another. Ideally both have a telephone extension, but the secretary has one of the type which enables her to receive calls, talk to boss, and selectively route calls through. But of course these (the Post Office call them Plan 107 installations) cost more to rent than ordinary extension phones. What you do instead is have ordinary extension phones in each room, with the boss's phone equipped with the standard Post Office switch to enable its bell to be silenced. You also have a pair of f.m. wireless intercoms, one in each room. The crucial point, often overlooked, is that when a telephone *receives* an incoming call it can be temporarily hung up without disconnecting that call. So when secretary receives an incoming call, she simply says "hold on", hangs up her phone and buzzes through and talks to boss on the wireless intercom to advise him of the call.

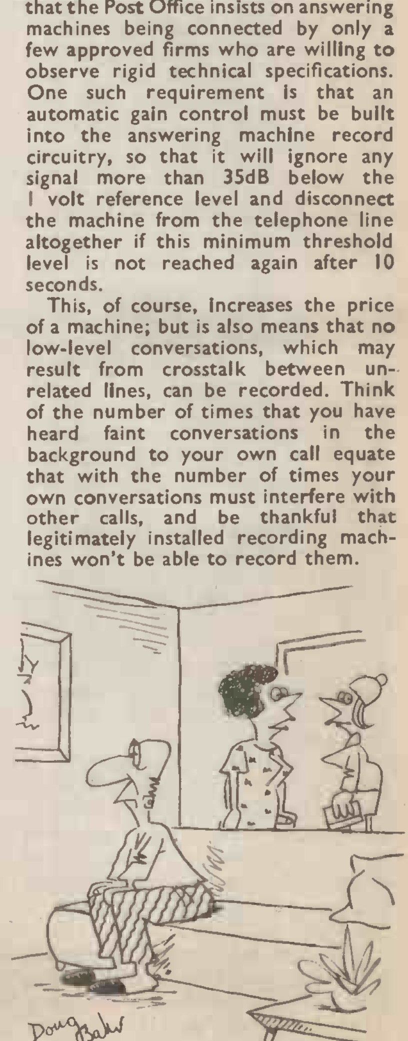
Boss then either picks up his extension phone or asks secretary to pick up hers again and deal with the call. What the secretary must never do is hang up her phone on an *outgoing* call before boss has picked up his, because this will disconnect it.

At current Post Office prices, you save £17·60 per year on phone rental by adopting this simple approach! All we need now is for an enterprising British electronics firm to produce a cheap and reliable f.m. wireless intercom. (*Certain regulations govern the use of a.c. mains intercoms, and the Local Electricity Area Board should be consulted before installing such instruments.—Ed.*)

Regulations

Finally, although the Post Office regulations may seem irksome to anyone encountering them they are founded on sound common sense. For instance, it seems highly irritating that the Post Office insists on answering machines being connected by only a few approved firms who are willing to observe rigid technical specifications. One such requirement is that an automatic gain control must be built into the answering machine record circuitry, so that it will ignore any signal more than 35dB below the 1 volt reference level and disconnect the machine from the telephone line altogether if this minimum threshold level is not reached again after 10 seconds.

This, of course, increases the price of a machine; but is also means that no low-level conversations, which may result from crosstalk between unrelated lines, can be recorded. Think of the number of times that you have heard faint conversations in the background to your own call equate that with the number of times your own conversations must interfere with other calls, and be thankful that legitimately installed recording machines won't be able to record them.



"A computer made Nigel redundant—it took up all his office space."

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For many amateur gardeners, the watering of plants is a rather sporadic affair, depending on luck rather than judgement when they actually are watered. For optimum results, however, it is necessary to know how wet the soil is at root level, and to a reasonable degree of accuracy.

Obviously, some sort of gadget is needed which can display this information in a clear and direct way. A design to do just this was published in E.E., March 1975. It used the principle that the moisture of the soil is proportional to its resistance. Using one transistor in an emitter follower configuration, a light emitting diode was made to light up, its brightness being proportional to the resistance between two probes inserted into the earth

In theory, this circuit is excellent, and has the advantage of being cheap and simple Its limitation, however, lies in the use of a light emitting diode to display the information. There is not very much difference between, say an l.e.d. which is at 40 per cent of its potential brightness, and one which is at 50 per cent. The use of a visual method means that the ambient lighting can make results seem misleading; in bright sunlight, the l.e.d. might seem to be almost off, while in subdued lighting, it might seem quite bright, even though the current flowing through the diode in the two cases was the same.

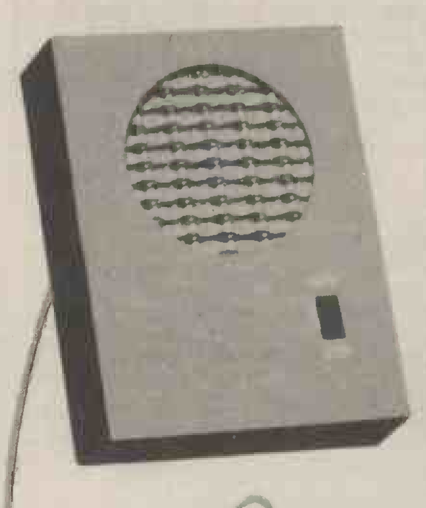
The author decided to try to improve the situation and toyed with the idea of using an ammeter to display the current flowing, but this idea was abandoned, mainly because of the high cost of meters. Instead the following design was evolved.

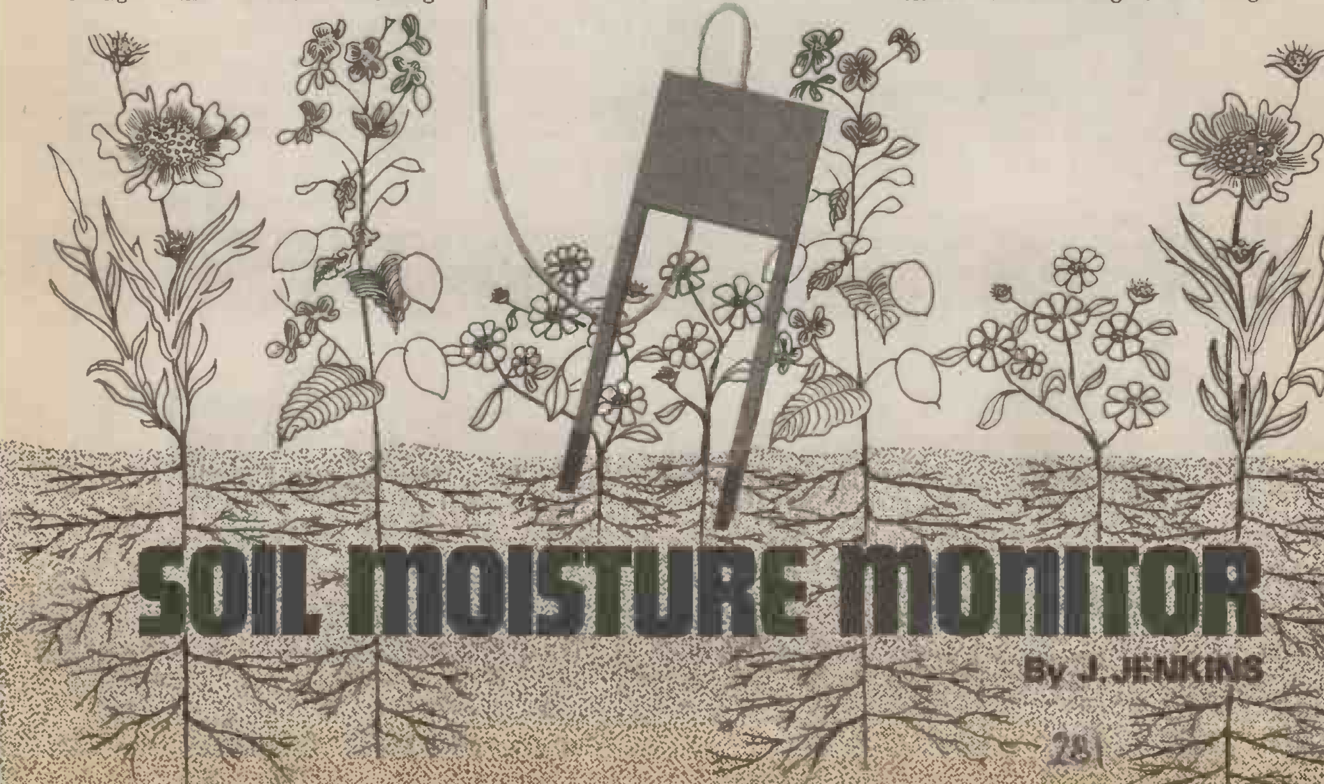
The controlling factor is the resistance of the soil between two probes, but the indication is through a loudspeaker, which emits a loud clicking noise when a circuit is made between two probes; the rate of clicking is dependent on the resistance between the probes.

CIRCUIT DESCRIPTION

The circuit diagram of the Soil Moisture Monitor is shown in Fig. 1. It is in fact a relaxation oscillator. Its advantages over a standard multivibrator are that it only needs one capacitor, and it can be made to have long off periods, and short on periods, thus cutting down on current consumption.

When the voltage is applied to the circuit, capacitor C1 begins to charge up. The base of TR1, which is an *npn* type is almost at negative supply potential. It begins to get more and more positive as the capacitor charges up until it begins to conduct. Transistor TR2 now begins to charge

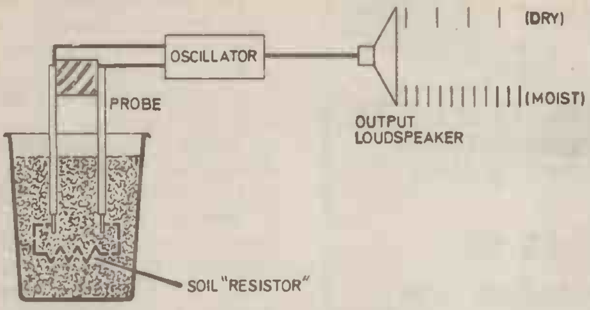




SOIL MOISTURE MONITOR

By J. JENKINS

HOW IT WORKS



The *Soil Moisture Monitor* consists of an oscillator with a component missing—a resistor. This resistor is vital for the oscillator to work and its ohmic value determines the frequency of oscillation. This "resistor" is the d.c. resistance between two specified points in the soil and is brought into circuit by means of the probes inserted in the plant pot, usually to root level.

Moist earth has a lower resistance than dry earth so the output frequency (heard in the loudspeaker) will indicate the dampness of the earth in the vicinity of the probe tips.

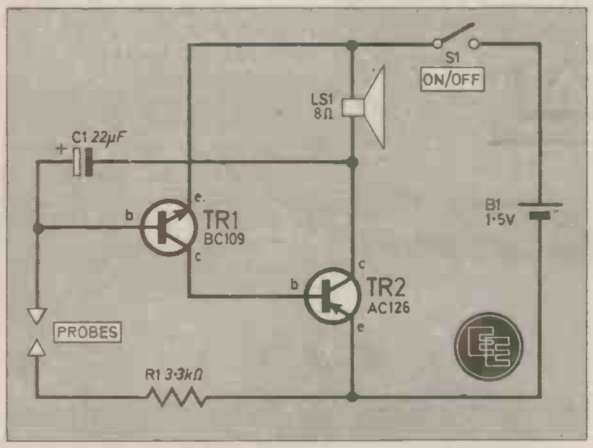


Fig. 1. The circuit diagram of the Soil Moisture Monitor.

up until it too conducts. At this point, a current is passed through LS1. The voltage on the collector of TR2 now becomes more positive, discharging C1, and starting the whole process again.

The rate at which this all happens depends on how quickly the capacitor can charge up, and its value. The former depends on the resistance between the probes, together with R1 in series with it.

It was found that almost any species of transistor will function in this circuit, the only critical factor being that one must be *npn* and the other *pnp*. The two named in the component list were chosen because of their cheapness and ready availability.

Soil resistance is typically 100,000 ohms and 2,000 ohms ranging from completely dry to saturated, and so the component values have been chosen to give between 3 clicks per second, and one click every 3 seconds.

CONSTRUCTION

The unit was constructed on a small piece of 0·1in. stripboard, measuring 18 holes x 10 strips. The board, with components is shown in Fig. 2. Capacitor C1 is mounted upright on the board, taking note of the connections. The lead out connections to the two transistors are shown. These should be noted, as the two are different.

Just about any case could be used to house the project. An old tobacco tin covered with Fablon was used to house the prototype, but some will prefer the rather more conventional aluminium cases available. It is a good idea to put a piece of foam rubber in the box, to stop the battery rattling inside. Holes must be drilled to accommodate the switch, and for the leads to the probes. If a metal case is used, it is a good idea to have a rubber grommet on the hole to stop the wires rubbing against the metal. Holes must also be drilled to allow the sound to escape from the speaker.

PROBES

Details for constructing the probes are given in Fig. 2. Although the dimensions given are not absolutely critical, it is a good idea to stick reasonably close to them. They are constructed from strong aluminium.

Components

Resistor
R1 3·3kΩ ¼W 10% carbon

Capacitor
C1 22μF 10V elect.

Semiconductors
TR1 BC109 silicon *npn*
TR2 AC126 germanium *pnp*

Miscellaneous
S1 d.p.d.t. slide switch
LS1 8 ohms miniature loudspeaker approx. 56mm round
B1 1·5V U7 battery
Stripboard 0·1 inch matrix 18 holes by 10 strips; small aluminium case; grommet; connecting wire; insulation tape; wood for probes 25mm x 40mm x 15mm; aluminium 100mm x 15mm 14 s.w.g. (2 off); No. 8 round head screws (4 off).

See **Shop Talk** page 263

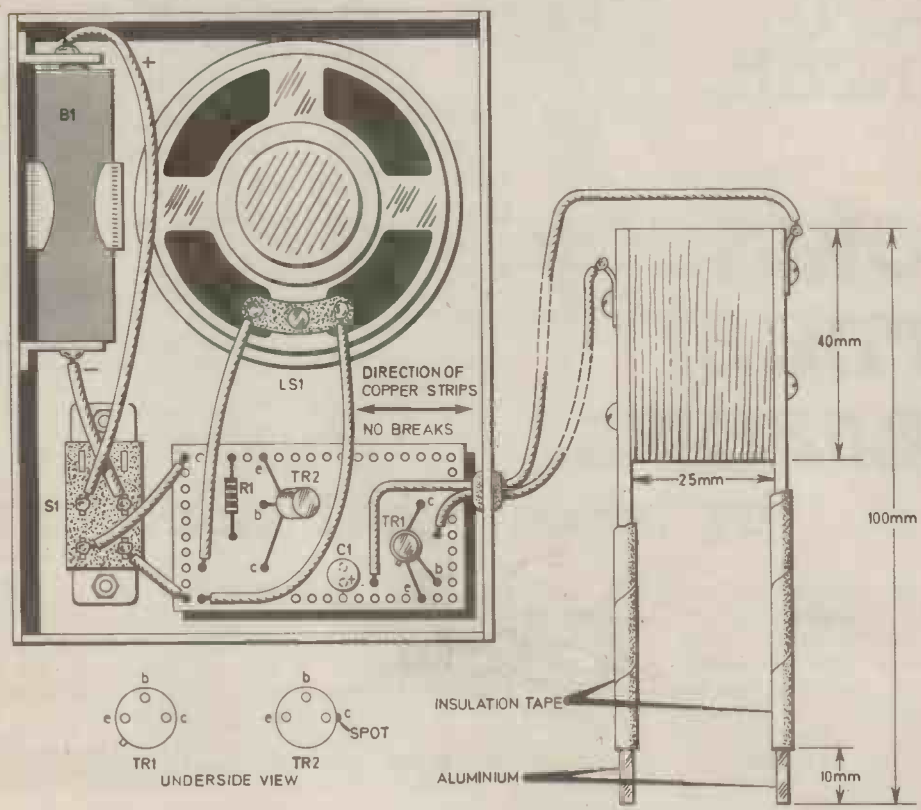


Fig. 2. Layout of the components within the case and complete wiring up details. Also shown are details of the probe.

The easiest way to cut this is with a hacksaw, and then filing down the rough edges.

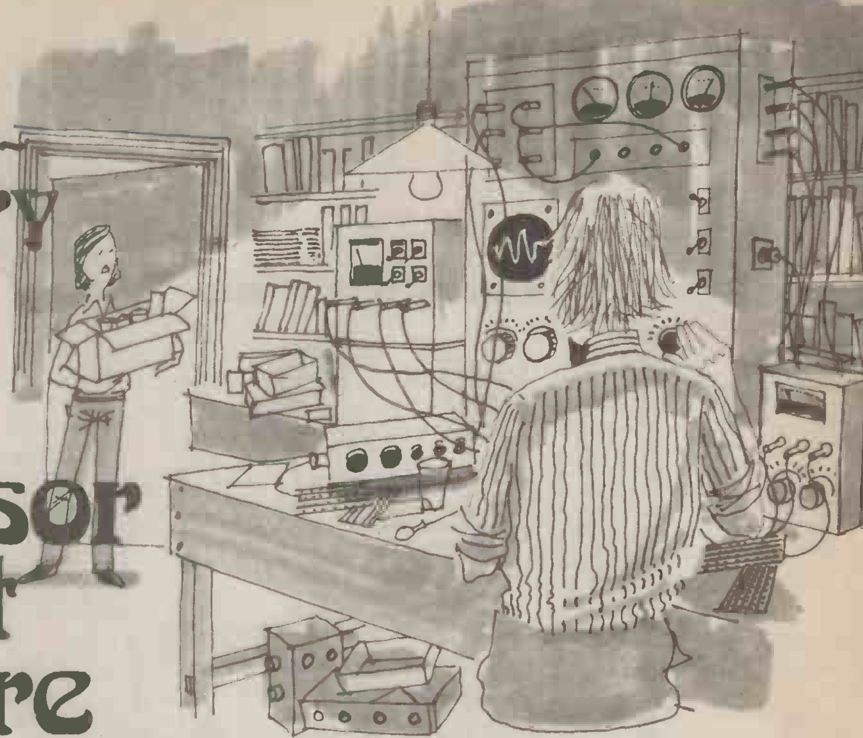
The aluminium is covered with insulation tape, except for the extreme ends. Care should be taken that the screws which secure the metal do not touch inside the wood, or the probes will be shorted out.

TESTING

After connecting the battery, switch on, and short out the probes with a short length of wire. A rapid clicking, possibly even a buzz, should be heard from the loudspeaker. If there is nothing, the things to check are battery polarity, transistor connections, the polarity of the capacitor, and to make sure that all the soldered joints are firm.

Assuming that something is heard from the speaker, grasp the probes firmly in both hands. The clicking should continue, but much slower (body resistance is roughly the same as that of dry soil). Now insert the probes into samples of soil with varying moisture content. If, in general the clicking is too rapid, add some more insulation tape. If it is too fast, remove some. If this makes no difference try changing the value of R1. The value given should, however, be adequate. ◻

The Extraordinary Experiments of Professor Ernest Eversure



by Anthony John Bassett

THE Prof. has just constructed a simple contact-microphone which can also be used to test various materials for piezo-electric activity. By placing a slice of material which has been coated with metal or graphite on its opposite sides, underneath a spring, the experimental samples can be changed very easily.

"Here is an interesting sample, Bob," the Prof. remarked. He carefully unwrapped a tiny disc of metallic appearance from its tissue-paper packaging. "It is a specially prepared ceramic material which has been silver-coated on its opposite faces by the manufacturer. We'll try this in the contact-microphone, as I think you'll find the result is quite surprising."

Bob turned down the volume on the audio amplifier whilst the Prof. lifted the spring and carefully substituted the ceramic disc for the previous sample. With the disc firmly in place, Bob turned the volume back up. Immediately a loud rustling and rumbling sound came from the loudspeaker, and a startled Bob quickly turned the volume back down again.

"Wow, Prof! That is amazing," Bob cried out in astonishment. "That little disc is obviously very much more sensitive than the other samples which you suggested. You were still handling the contact-microphone when I turned up the volume and the sound was picked up and amplified to such an extent, that I thought it might damage the amplifier!

"With such high sensitivity it is hardly surprising that ceramics are used so much in pick-ups and microphones!"

"Yes," agreed the Prof., "and ceramic materials have a number of other advantages, when used for piezo-electric purposes, over grown crystals of materials such as Rochelle Salt and quartz. Although the ceramics materials are not as easy to prepare as, say, crystals of Rochelle Salt, I will describe their preparation briefly to you, and then you will see what some of these advantages are, and how they come about during the production processes.

"In many ways the production of these materials is similar to the making of other ceramics such as unglazed pottery and porcelain, which are made by carefully shaping a wet mixture of clays, drying it out, then heating it to a high temperature in a kiln.

BLENDING

"When the claylike mixture is prepared, one obvious advantage is that other ingredients can be blended in, to modify the properties of the product. Materials can be added to make the product stronger, to change its density or its co-efficient of thermal expansion, to make its output more linear and to modify its properties in many, many desirable ways which cannot be done with grown crystals.

A DANGER

"A disadvantage is that many of the materials used at this point, such as lead zirconate, and barium titanate, are poisonous, and precautions must be taken to ensure that the material is not eaten or allowed to enter cuts or wounds, and that any airborne dust or fumes are not breathed in.

"When the material has been blended, it can be shaped, by pressing, moulding or stamping, into shapes which may be simple, like the disc which we have here, or rings, squares, cylinders, bowls etc, and also other more complicated shapes may be prepared with electrically conducting inserts moulded in, and each of these shapes has special uses.

"When the shapes are fired in the kiln they change slightly due to shrinkage, so that wherever accuracy is required, the final shape and dimensions are reached by grinding the ceramic after it has been fired.

POLARISATION, MAGNET OR ELECTRET

"Thin coatings of silver, or other electrically-conducting substances, are applied and the material is then polarised." "What does this mean, Prof?" Bob enquired, "Is it something to do with magnetisation?"

"The polarisation of a ceramic material for piezo-electric purposes is very similar in some ways to magnetisation, Bob, but instead of using a magnetic field we use an electrostatic field. Instead of becoming magnetically polarised like a magnet, the material becomes electrically polarised. Sometimes a material which has been permanently electrically polarised is referred to as an *electret*.

"The effects of temperature changes are very important during the process of polarisation. If we consider the classic case of a charged capacitor with a solid dielectric, and use the concept of lines of force to represent the electric field, the capacitor can be represented by a simple diagram." The Prof. drew a sketch (Fig. 1a.)

"Now if we remove the conductive plates from the dielectric", the Prof. again sketched on his notepad (Fig. 1b), "the dielectrice remains charged. The *lines of force* of the electric field are held in place in the dielectric by the electric charges which remain on its opposite faces. But the dielectric is only temporarily polarised, and by removing the charges, which can be done by re-assembling the capacitor and discharging it, the electric field can be made to disappear." (This can be done with different metal plates, proving that the charged field resides in the dielectric.)

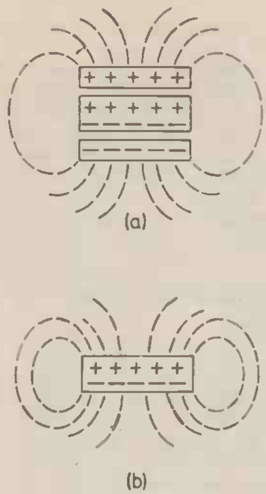


Fig. 1. Lines of force associated with a charged capacitor (a) with conductive plates (b) without plates.

ELECTROPHORUS

"Prof!" Bob interrupted excitedly, "that reminds me of a really interesting experiment which we did at school with a gadget called an *electrophorus*. It produced such a powerful electric field that it caused small objects to *take off* and hover in mid air or fly through the air. After the school teacher showed us that, there was quite a crop of home-made ones which the lads made for themselves, and I was so fascinated that I made one myself at home. Next time I come to see you I'll bring it to show you!"

"Hmmm, yes" mused the Prof., it's quite a while since I last experimented with an electrophorus. It's also quite late, I must remind you."

Bob in his enthusiasm had stayed much later than he had intended, and as he looked with dismay at the time displayed in huge luminous figures on the viewscreen of one of the Prof's computers, and hastily prepared to leave, the Prof. continued: "I'll be interested to see your home-made electrophorus so I hope you'll bring it soon! It will certainly help to illustrate and demonstrate some of the points I am explaining about polarisation, and then we can continue our discussion of piezo-electric, magnetic and various types of pick-ups. See you soon, Bob."

"Yes, bye Prof," and Bob hastily made his way out of the laboratory and sped off home, his head full of thoughts about electric polarisation pick-ups and microphones and anticipation of his next visit to show the Prof. his home-made electrophorus.

To be continued

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

HEAT SHUNT

I have thought of a tip that may prove useful to constructors. It is the use of a split pin as a heat shunt for use on transistor and diode lead-outs when the latter are being soldered in place.

I have been using a 4mm thick pin with the ends of its legs cut square, one being longer than the other. The pin then clips over the lead-out on the component side of the board and is small enough to thread its way in among other components in the vicinity.

O. Maxwell,
I.O.M.

P.C.B. AID

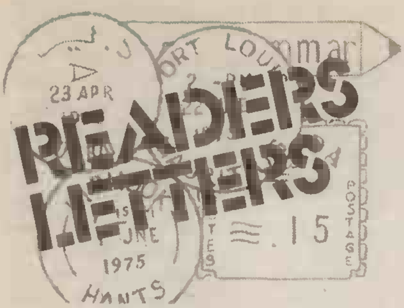
I have recently come across a way of accurately placing an integrated circuit on a piece of copper clad printed circuit board.

Take a small piece of 0·1 inch matrix stripboard and drill through the holes where the i.c. pins go through using a No. 45 drill (2mm).

This then acts as a template, for it can now be placed in the required position on the copper side of the p.c.b. and a sharp pointed pencil used to mark each hole through onto the board. The outlines produced are next filled in using an etch resist pen, and the rest of the pattern then drawn on in the usual way.

I have found this ideal for making printed circuit boards using i.c.s of various kinds.

K. Nuttall,
Bureley,
Lancs.



Quasi-Quad Queries

I am one of your so called non-specialist onlookers, and whilst browsing through your March '77 issue, I decided that I would have a go at constructing the *Quasi-Quad Adaptor*. Being a potential starter, with your article my trainer, I am writing to ask a few questions and ask for tips.

I have had limited experience of electronics ('A'-level Physics failure, and I have knocked up radio's etc. from kit form and many years ago played with those early Phillips kits of electric wizardry for the under-15's), but I have never touched a circuit-board and I was confused by the diagram of Fig. 5 (page 116), of the *Quasi-Quad Adaptor* article, as I cannot differentiate between the "dots" and "circles" etc.. Could you clarify?

Another point I do not understand (or cannot visualise) is the fitting of copper strips to act as heatsinks to the whole of the stripboard (or is this because I have never seen a section of stripboard?).

Also the LM380 has a rated output of 2 watts, but in my stereo system (20 watts per channel), this would surely not suffice, as on average, the output will be at 8 to 10 watts per channel. Does this mean that the speakers will be at less power, i.e. less volume? Will this destroy the effect created (especially if four similar speakers are used)? And lastly is there any real danger to my hi fi system if I make a constructional error?

J. Westray,
London SE23

The area of Fig. 5 you refer to (dots and circles) shows the underside of a piece of Stripboard. Stripboard consists of strips of copper (shown white) bonded to a synthetic board (shown black). The board is perforated, with holes drilled on a regular matrix at 0·1 inch or 0·15 inch pitch. Not all these holes are shown on the drawing in order to avoid a cluttered effect, in fact only those immediately inside the perimeter of the board are shown.

The black dots you refer to are the soldered connections of the component leads (sited on the topside of the board—shown adjacent to the underside view) to the copper strips. What at first sight appears to be a white dot surrounded by a black area is used to represent a break along the copper strip made by using say a twist drill.

The second part of your query should be answered by the above and by you inspecting a piece of stripboard.

Concerning the power rating of the LM380, this should be adequate. You are over-estimating the listening level. For comfortable listening in the home, your amplifier will only be delivering about 1 watt or even less.

See Please Take Note *in April issue for wiring correction.*

Indentification Data Service

With respect to Mr. Pascoe's plea for someone to operate a device data and identification service I am willing to undertake this operation for a cost of 10p per device for a minimum of 10 devices. An additional 15p needs to be included for postage and packing expenses. With respect to i.c.s it would be helpful if one or two of them could be sent to assist with their identification.

R. Houghton,
49 Addington Road,
Irthlingborough,
Northants.

Lin. and Log.

I am aged 12 and have been reading your magazine for quite a while now. I have constructed some of your "starter projects" and am now ready to construct the *Transistor Tester* in the May '74 issue. (I found it while looking through some of my back-copies.)

One thing that puzzles me is linear, logarithmic, anti-logarithmic etc., when referring to potentiometer slider rotation. I would be grateful if you could explain these to me. Keep up the good work publishing an excellent magazine.

Paul Bailey,
Rutherglen, Glasgow

The terms, logarithmic (log.), linear (lin.) and anti-logarithmic (anti-log.) refer to the variation of resistance between the slider and one end of the potentiometer as the shaft is rotated. In a linear type, the resistance is directly proportional to the angle of rotation, i.e. if 45 degrees rotation produces 10 kilohms, then 90 degrees rotation produces 20 kilohms.

Now in a log. type, the variation of resistance with angle of shaft rotation, obeys a logarithmic relationship i.e. if a 45 degree rotation produces 10 kilohms, then 90 degrees rotation produces 100 kilohms. A further 45 degree step increases the resistance to 1,000 kilohms (1 megohm).

The anti-log. type potentiometer, has as its name implies an anti-log relationship of resistance with shaft rotation.

Revival Rally

We have been informed by the Radio Society of Great Britain, that a rally, named the "East Suffolk Wireless Revival" is to take place at the Civil Service Sports Ground, Straight Road, Bucklesham, Ipswich The rally will be open from 11am to 4pm, 29th May 1977.

It is intended to revive some of the interest and enjoyment of the "pre-black box" type of rally The emphasis will be on finding out, participating as well as purchasing.

By holding the event out of doors rather than in a school or hall, whilst providing covered areas for traders and demonstrators, there will be freedom to move around with the family or just sit and ragchew.

Trade participation and the ability to look for that special component etc will be well catered for in a large marquee. Presenting practical demonstrations, competitions and information it is hoped to encourage attendance from licence holders, short wave listeners (swl) and those interested in the whole spectrum of amateur radio

It is hoped that by reference to those with experience, ideas as to solutions with problems on TV and radio interference etc may be found.

A comprehensive range of equipment will be used to provide a facility for testing mobile equipment and an antenna test range to check the gain of both professional or home built aerials brought to the rally It is hoped to arrange demonstrations, to both encourage the newcomer and interest the active participant in, RTTY, RAYNET, SSTV etc.

Plastic Money

I have read with interest the *Counter Intelligence* article in the March '77 issue of E.E. and note the comments regarding the "Metal Strip" in pound notes This metal is in fact a fine strip of polythene which has been sandwiched between two pieces of fine quality paper.

I note that the editor makes mention in his editorial of the "barrier" which often surrounds the whole subject of electronics. I have to date assembled a capacitive discharge electronic ignition system kit and the *Wiper Delay* unit published earlier this year in E.E. Other than this the subject is very new to me.

The greatest hurdle is understanding your abbreviations and nomenclatures of components, i.e. s.p.s.t.; 500 kilohm carbon lin.

Is it practical to publish some form of dictionary or supplement to help beginners like myself to understand what these abbreviations mean? Apart from this I find E.E. easy to follow and most interesting.

J. Little,
Yorks.

We have recently, in the Feb. and April issues published a list of abbreviations of technical terms used in E.E. It is hoped to publish such a list from time to time and possibly extend it to include such things as explanations of . . . 500 kilohm carbon lin. The latter refers to a potentiometer whose maximum resistance is five-hundred-thousand ohms, is constructed (internally) of carbon and has a linear resistance/rotation relationship. See reply to Mr. Bailey's letter above.

LAST month, details of the mixer, oscillator, and i.f. amplifier were given. We continue this month with the construction and details of the optional b.f.o. unit.

Note once again that Denco coils should now be used, as mentioned in part one (May '77 issue).

PANEL AND CHASSIS

The case sides are plywood, 190×115mm, and the chassis a 255×100mm "universal chassis" flanged member secured with four bolts through the flange holes, and set 63mm back as in Fig. 5. The chassis top is at a height of 38mm.

The panel is a similar member, but is fixed vertically with bolts through the flange holes, and leaving about 35mm clear between chassis and panel, as in Fig. 5. Holes for the lower controls are 25mm from the bottom, and 41mm and 100mm from the sides. Variable capacitor VC2 is mounted as shown in Fig. 5, so that the drive drum is about 3mm clear of the panel top.

A piece of wood 127×45×10mm thick is screwed to the panel to carry the scale.

Pivot one of the drive pulleys on a bolt as shown in Fig. 5 so that the top of the cord is level; the second pulley is mounted about level with the bottom of the drum. The cord has one complete turn round the tuning control shaft, and runs over the pulleys to the drum. Here, the ends are taken through the perimeter slot, and are tied to the spring, which keeps the cord taut.

A scale about 100mm long is needed, and in the author's model a 10cm paper rule was used, glued to card which was in turn stuck to the wood. A small piece of tinplate is bent and clipped to the cord with pliers, and the pointer is a straight wire soldered to this.

The front of the receiver is Perspex, 250×100mm, covered with self-adhesive material in which an aperture 115×28mm is cut, to match the scale position. Thin plywood or a metal front could be used instead, with an aperture cut in it. The front is secured by four 6BA bolts (at least 25mm long) with extra nuts, and running through the holes present in the flanged member.

ADDITIONAL WIRING

The boards are fitted as shown in Fig. 5, which also shows interconnecting wiring. Inductors L5 and L6 are secured with 6BA bolts, and wired to a tag (MC) bolted to the chassis. After making the connections of Fig. 5, reference should be made to Fig. 6, an underside plan with the panel shown flat to clarify the switch wiring. It may be preferred to first wire S1/4 for one waveband only and then test the tuner. If this system is not used, take special care to ensure that the correct tags are used in wiring up the switch.

Inductors L1 and L2 are wound on a cored former 11mm (7/16 inch) in diameter, although formers of 9mm to 13mm (3/8 to 1/2 inch) diameter would be suitable.

Designed to receive transmission on short, medium and long wavebands.

Multi-band TUNER

PART 2

By F. G. RAYER

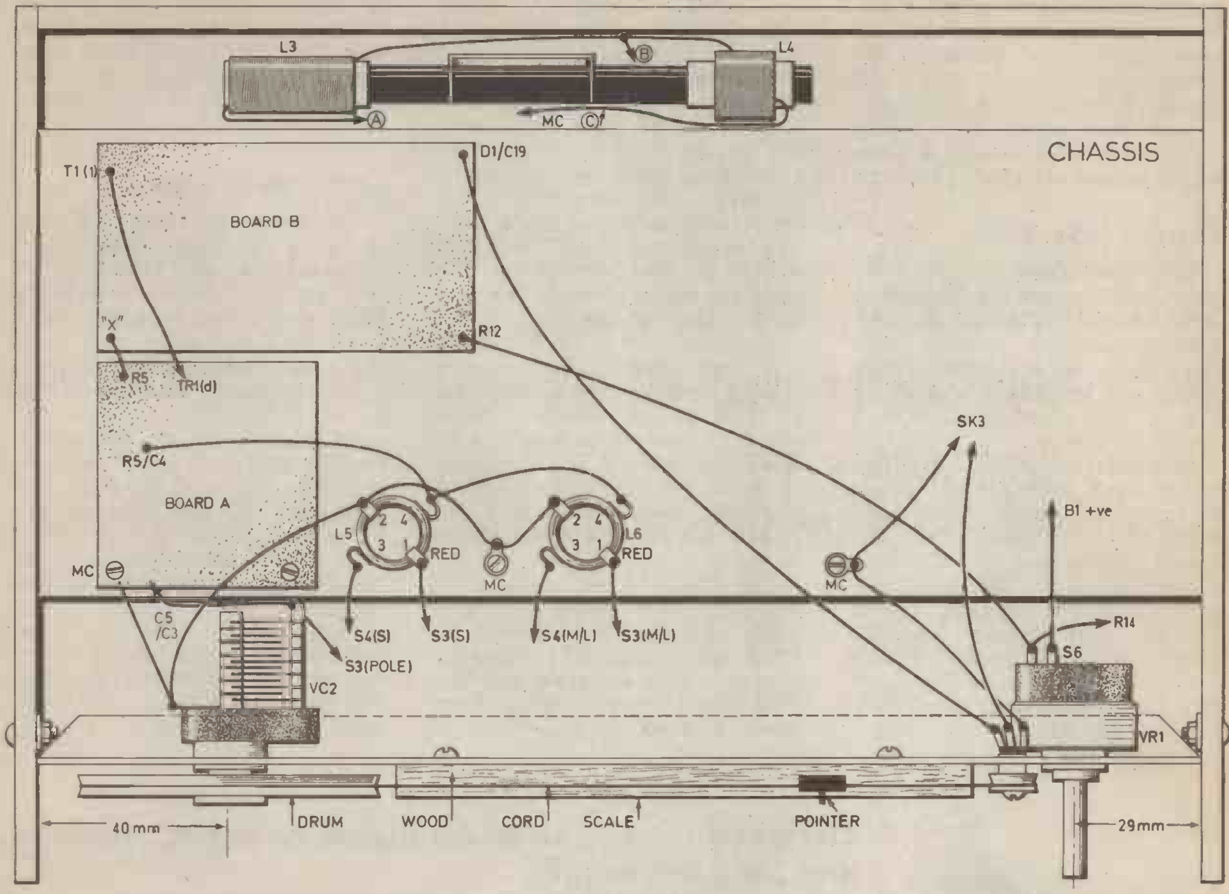


Fig. 5. Topside view showing position of component boards. Note that Wearite coils are shown as used in the prototype.

The secondary winding of L2 (points *1* to *2*, Figs. 1 and 6) consists of 31 turns of 26 s.w.g. enamelled copper wire, the turns being wound side by side. The primary winding of L1 (points *3* to *4*) is made up of 8 turns of cotton-covered wire (or enamelled wire on insulating tape) of 26 to 32 s.w.g. The ends of *2* and *4* should be taken to the tag MC, to which also is wired the stator connection of VC1. Ends *1* and *3* should be long enough to reach S1 and the aerial socket. A few touches of adhesive should be used to secure the coil turns in place.

A 75×25mm strip of wood or paxolin is bolted to the rear flange of the chassis (Fig. 5) and the ferrite rod is secured to this with adhesive and thread or string. Coils L3 and L4 are positioned as shown and the leadout wires are taken to a small tag strip near the rod, so that longer leads can be run to S1 and S2; L4 must be the correct way round on the rod, as shown in the maker's leaflet, otherwise it will not be possible to obtain proper long wave tuning.

DIAL MARKINGS

A slow-motion drive is not essential for the aerial tuning capacitor VC1, but it should be provided with a pointer. The two multiway switches will also require pointers. The scale for S1/4 should be marked up as follows:
Mark the *L* position: 125-309kHz
Mark the *M* position: 500-1685kHz
Mark the *S* position: 10-2·9MHz.

The scale for S5 should be marked up as follows:

On the *L* band, mark position *6* 309-238, position *7* 238-191, position *8* 191-158, position *9* 158-125.

On the *M* band, mark position *1* 1685-885, position *2* 885-620, position *3* 620-500.

On the *S* band, mark position *1* 10-7·3, position *2* 7·3-5·7, position *3* 5·7-5·0, position *4* 5·0-4·4, position *5* 4·4-3·9, position *6* 3·9-3·6, position *7* 3·6-3·35, position *8* 3·35-3·2, position *9* 3·2-2·9.

The bands are arranged so as to discount the slight overlap which will be found at the extreme positions of VC2 rotation.

The use of three different colours will make the scale of S5 easier to read. See Fig. 9 for suggested arrangement of the markings for the two waveband switch scales.

TUNING

Set the switches for the frequency sector required. Then tune in signals by means of VC2 and peak them with rotation of VC1. The handling of the two controls will soon become simple in practice. If VC1 cannot reach the lowest frequency on band *S* when fully closed, screw the core of L2 slightly into the winding. Similarly, place L3 and L4 on the ferrite rod so that VC1 covers the wanted ranges with a little to spare.

Multi-band TUNER

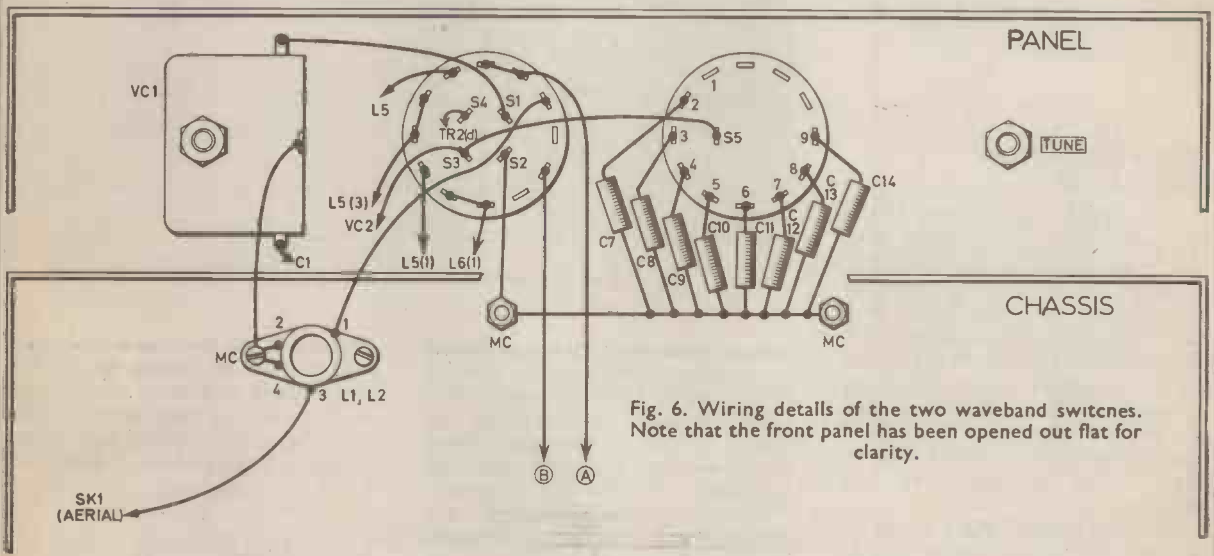


Fig. 6. Wiring details of the two waveband switcnes. Note that the front panel has been opened out flat for clarity.

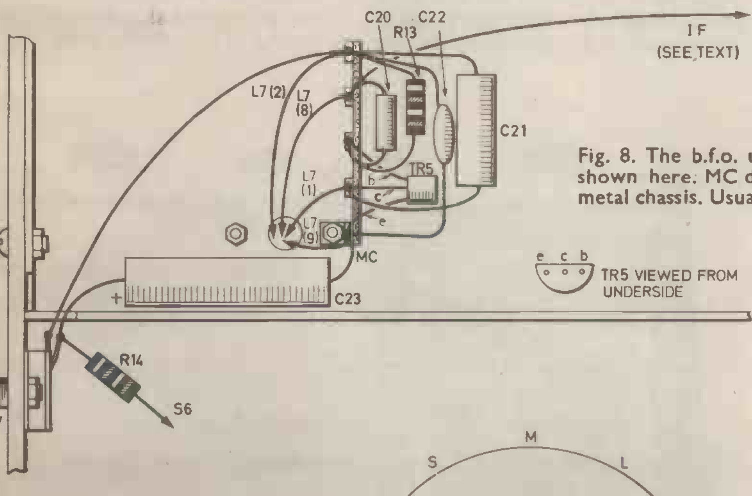


Fig. 8. The b.f.o. unit is wired on a small tagstrip as shown here. MC denotes a direct connection to the metal chassis. Usually made by fitting a solder tag with a nut and bolt.

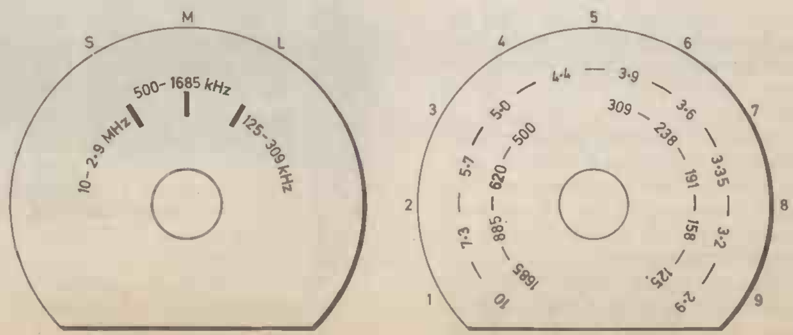


Fig. 9. Suggested markings for the two waveband switches. These are drawn full size, and may be traced.

The aerial for short wave reception may be an outdoor one or a wire indoors (perhaps running along a picture rail or similarly, as high and long as practicable).

If an earth is available, this should be plugged into a socket connected to MC. A short aerial will provide reasonable results on the more powerful stations, but for the weaker signals a long outdoor wire will give considerably improved results.

BEAT FREQUENCY OSCILLATOR

This unit is required only if the operator wants to receive c.w. and s.s.b. signals satisfactorily. Amateur and commercial stations using Morse code do so by using c.w. transmission (an interrupted unmodulated carrier wave) which normally cannot be heard on an ordinary receiver. Some stations use m.c.w., which is a c.w. signal modulated with an audio tone so that it can be heard on any receiver

The function of the b.f.o. is to render the c.w. signal easily audible. It is basically a simple oscillator and when in use the b.f.o. signal beats with the incoming c.w. signal to produce a heterodyne signal at a predetermined audio pitch.

With single sideband signals, the carrier wave and one sideband have been removed. The carrier/b.f.o. unit supplies a carrier at the tuner, thus enabling the s.s.b. signals to be resolved as speech This form of transmission is widely used by amateurs, particularly in the 3·5-3·8MHz band.

The circuit of the carrier/b.f.o. unit is shown in Fig. 7. The b.f.o. coil L7 is a Red Range 2 valve type coil and it has C21 in parallel across its primary winding to complete the tuned circuit. Adjustment of the coil core allows the oscillator to be tuned to the correct frequency, after which the core should be locked with a 6BA nut.

Switch S7 is the on/off switch which puts the b.f.o. off for a.m. reception. The purpose of the large value C23 is to prevent modulation of the oscillator via the battery supply.

The coil L7 is supplied in a can which serves as a screen. The lid should be bolted on the chassis behind the volume control, and a 6mm hole for the leads should be provided. Next drill the bottom of the can to take the coil. Solder on four leads (which may be colour coded) to the pins shown and take the leads through the hole and out under the chassis.

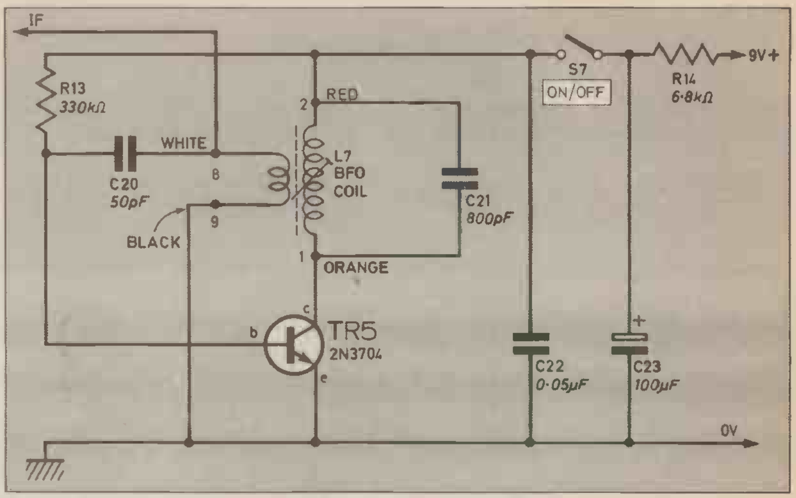
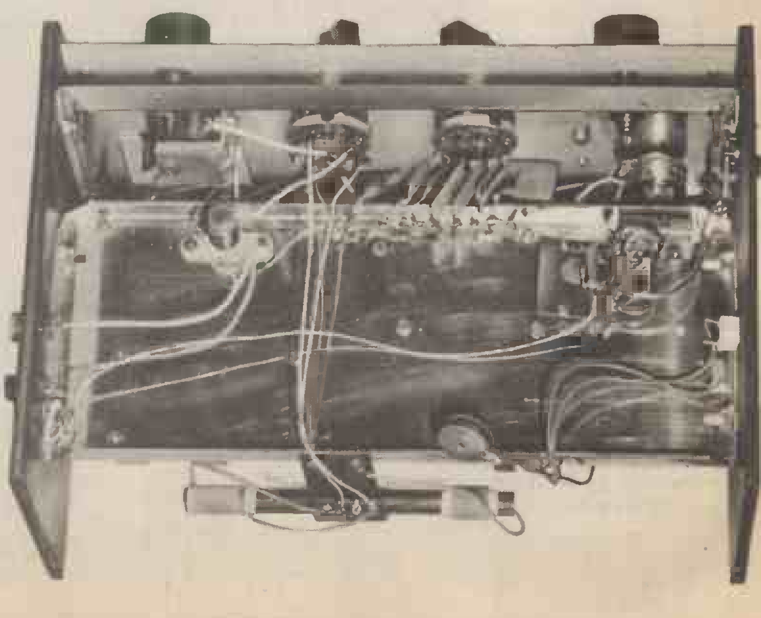


Fig. 7. Circuit for the b.f.o. unit used in the Multi-band tuner.

The other components are mounted on a tag strip as shown in Fig. 8, the oscillator coil L7 fitting nearby on the case side. A lead should be run from the tag used as a junction for the lead from coil lead 8 and along under the chassis and up to the pin from T1 (pin 1) on the i.f. board; this lead should be looped round the pin *without removing the insulation*. Because injection is at the i.f. amplifier input, this very small coupling capacitance is sufficient for the purpose required.

B.F.O. ADJUSTMENT

The b.f.o. performs best with the audio gain at or near maximum; if necessary the volume can be kept down by slightly detuning VC1. First tune in any



Underside photograph, showing the waveband switches, and the b.f.o. unit.

stable broadcast with the b.f.o. switched off. Then switch on (S7) and rotate the oscillator coil core until a strong heterodyne is obtained. This will fall in pitch as the correct core position is reached and rise again as it is passed. Set the core at the position where the tone is very low in pitch, or ceases. Slight detuning by means of VC2 either way will then produce an audio tone which rises as the tuning is moved away from the correct position.

Next, find a weak s.s.b. signal, which will be recognised as distorted, chopped up speech (try the 3·5-3·9MHz amateur band) and tune it for maximum volume with S7 switched off. Then switch S7 on and very slightly adjust the core of the b.f.o. coil, if necessary, for proper resolution of the speech. The core should then be locked in position.

With a.m. signals, of course, tuning should be made for the best volume. With c.w., note the tuning will change the audio pitch. With s.s.b., tuning is more critical for proper reception but is aided by the bandspreading effect of VC2.

It should be remembered that a supherhet tuner can provide reception of signals on its "second channel". This *image* appears 930kHz higher in frequency than the proper, wanted, signal on this tuner but is only likely to cause problems on the higher frequencies and with VC1 tuned to place the aerial circuit on a higher frequency than the oscillator tuning. ☒

Photograph showing the completed prototype tuner.

GEORGE HYLTON brings it

down to earth

Using Old Meters

A READER from Kent, Mr. L. N. Buik, writes to say that he has picked up a couple of meters cheaply. He asks if they can be adapted for use as test meters.

This is a common enough situation. There are always secondhand meters around. So let's look at it.

The first thing to do (preferably before buying) is to make sure a meter is operational. When a smoothly increasing current is applied does the needle move smoothly? A lot of old meters stick at some point. Secondly, do the scale markings tell the truth? If the scale reads 0 to 10V is the meter really a voltmeter or just an ordinary moving coil galvanometer masquerading as one?

Pocket Unit

A simple test circuit (Fig. 1) answers both questions. If you intend to go on a meter hunt to your local shops it's a good idea to make up this circuit as a pocket sized unit. To test a meter connect to the "110μA" range and turn up VR1. If no deflection is produced leave VR1 at the halfway point and switch S2 to progressively higher current ranges until some deflection appears, however small. Then adjust VR1 slowly to vary the deflection up to full scale and back again, watching for sticking points.

If all appears well, find a range which gives a substantial deflection with VR1 at maximum. In this position the currents on Fig. 1 are approximately correct. So you can see if the calibration of the meter is about right.

If the meter is a voltmeter the deflection will be about the same on all the higher current ranges. But many meters marked in volts are really current meters designed to be converted into voltmeters by adding an external series resistance (called a *multiplier*).

Voltmeter

On the whole the most useful meters are voltmeters but a reasonably sensitive current meter (1mA full scale or less) can easily be converted into a voltmeter. I'll illustrate how it's done using one of our reader's meters as an example. This is a 750μA "galvanometer" (moving coil d.c. meter) scaled 0 to 100. Its dial carries the useful information: Resistance 14 ohms @ 20°C.

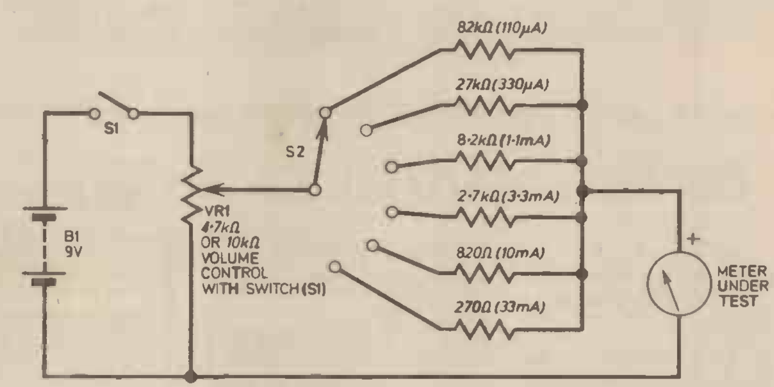


Fig. 1. The circuit diagram of the pocket meter tester. This may be constructed in a small plastic box, with VR1/S1 and S2 on the front panel. Two leads terminated in crocodile clips are used to connect the meter under test to the unit.

Ohm's Law

To use a "0 to 100" scale the voltage range must bear some simple relation to 100. Let's make it 10V. Then with 10V applied the current has to be full scale, i.e. 750μA.

By Ohm's law the resistance must then be 10V/750μA=13,333 ohms. The meter itself provides 14 ohms so the multiplier must provide the rest; i.e. 13,319 ohms. This is not a standard value. A fairly close approximation is given by 15 kilohm in parallel with 120 kilohm, both standard E12 series resistances. These give 13,333 ohms which as we've seen is too high by the meter's own resistance. But in practice 15 kilohm and 120 kilohm are as good as you'll get without great expense. Even if you buy 1 per cent tolerance resistors the error due to the tolerance can be far greater than 14 ohms. In any case the full scale current may not be exactly 750μA so unless you can check this against an accurate meter you just don't know whether it's worth buying close tolerance resistors. I suggest cheap 5 per cent ones: most voltage measurements in electronics don't need to be made with great accuracy anyway.

Other voltage ranges can be obtained by using a different multiplier calculated in the same way. Thus for a 300V range the total resistance is 300V/750μA=400kilohms.

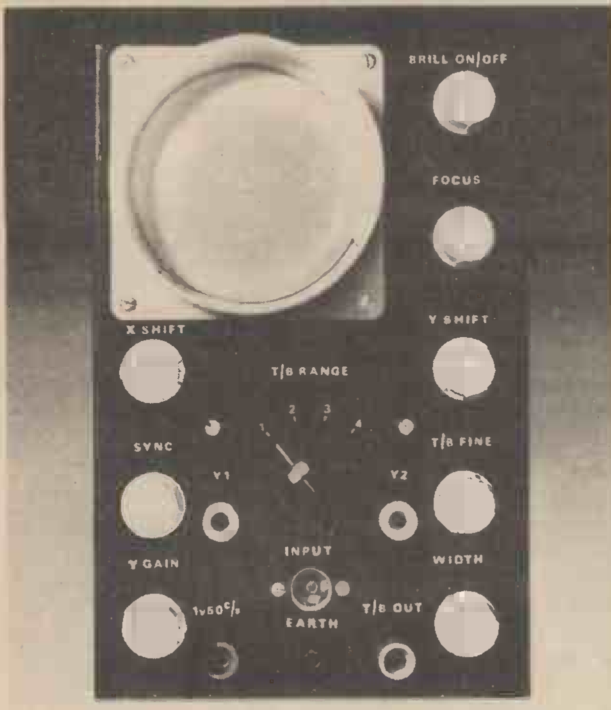
Higher Reading Ammeter

Our reader's other bargain meter was 15mA d.c., resistance not given. This is too insensitive for use as a voltmeter but is quite handy as it stands since currents in the 0 to 15mA range are frequent in transistor circuits. If a higher range is required and you can find out the resistance (please don't try to measure it on an ohmeter or you'll wreck your bargain) it is possible to connect a "current shunt" resistance across the meter terminals.

For example suppose the 15mA meter has a resistance of 9 ohms and you want to make it read 0 to 150mA. At full scale 15mA must go through the meter and the other 135mA through the shunt. Since the voltage drop across two resistances in parallel is the same for each of them and since 135 is nine times 15 it follows that the shunt must be one-ninth of the resistance of the meter; i.e. 1 ohm in our example.

Unfortunately real-life meter resistances seldom work out quite as easily as this one and making shunts is a lot less simple than making voltage multipliers.

Bring 'scope' to your interest.



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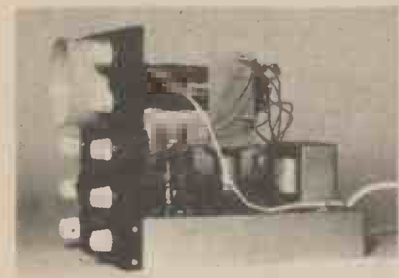

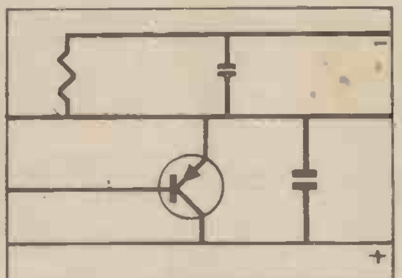

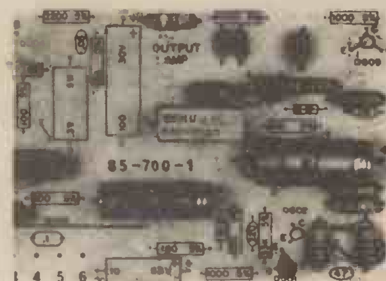

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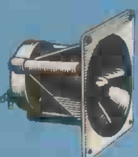
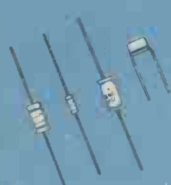

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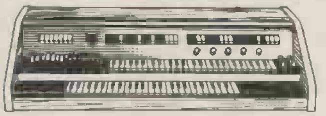

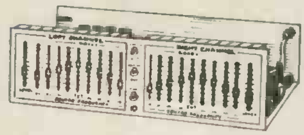

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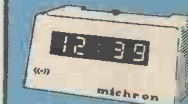



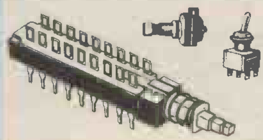

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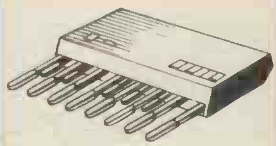

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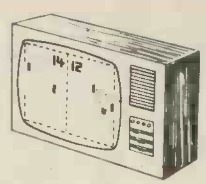

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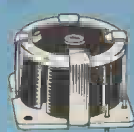




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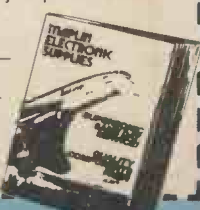

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