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JULY 77
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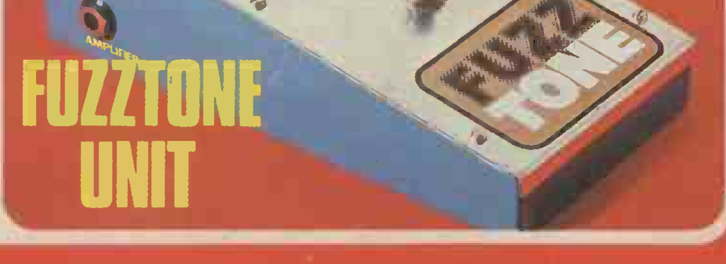

EASY TO CONSTRUCT
SIMPLY EXPLAINED

VOL. 6 NO. 7 JULY 1977

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

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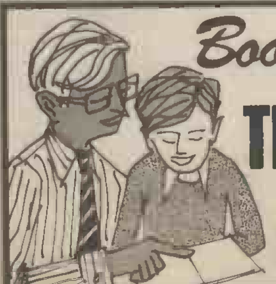

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STEADY HAND TESTER

By M.G. ARGENT

More than just a game.

THIS unit uses the age old principle of passing a ring over a bent wire, from one end to the other without allowing the ring to touch the wire. An addition to the circuit is the use of a control which is used as a "handicap" to help those of us who are not too steady with our **hands**.

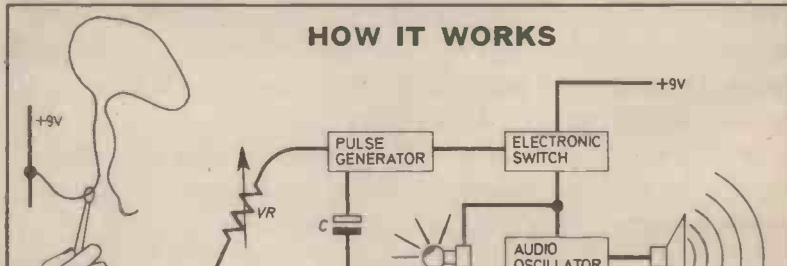
Although the novelty value of the unit will appeal to the younger members of the family as a game, it can have more serious applications.

CIRCUIT DESCRIPTION

The circuit for the unit is shown in Fig. 1; this consists of a unijunction transistor oscillator, and a thyristor which is used as a switch. The multivibrator formed by TR2 and TR3 is optional to the unit, and may be omitted if the audible alarm causes annoyance to other people.

If the ring and wire touch, C1 will charge up via R1 and VR1, since the ring and wire only touch briefly, the capacitor is charged up in short bursts. It can be seen that a certain number of touches in a certain time will charge the capacitor up fully. This time is controlled by the

HOW IT WORKS



The object of the "game" is to move the ring from one end of the bending wire to the other without causing the lamp to light or the audible alarm to sound. Each time the ring touches the wire, capacitor *C* is charged up a little bit more. After a certain number of contacts, depending on contact time, the generator will emit a pulse which triggers the electronic switch. When this happens power is supplied to the audible frequency oscillator resulting in a tone being emitted from the speaker and the lamp illuminated.

The number of contacts required before the switch is triggered is controllable by means of *VR*.

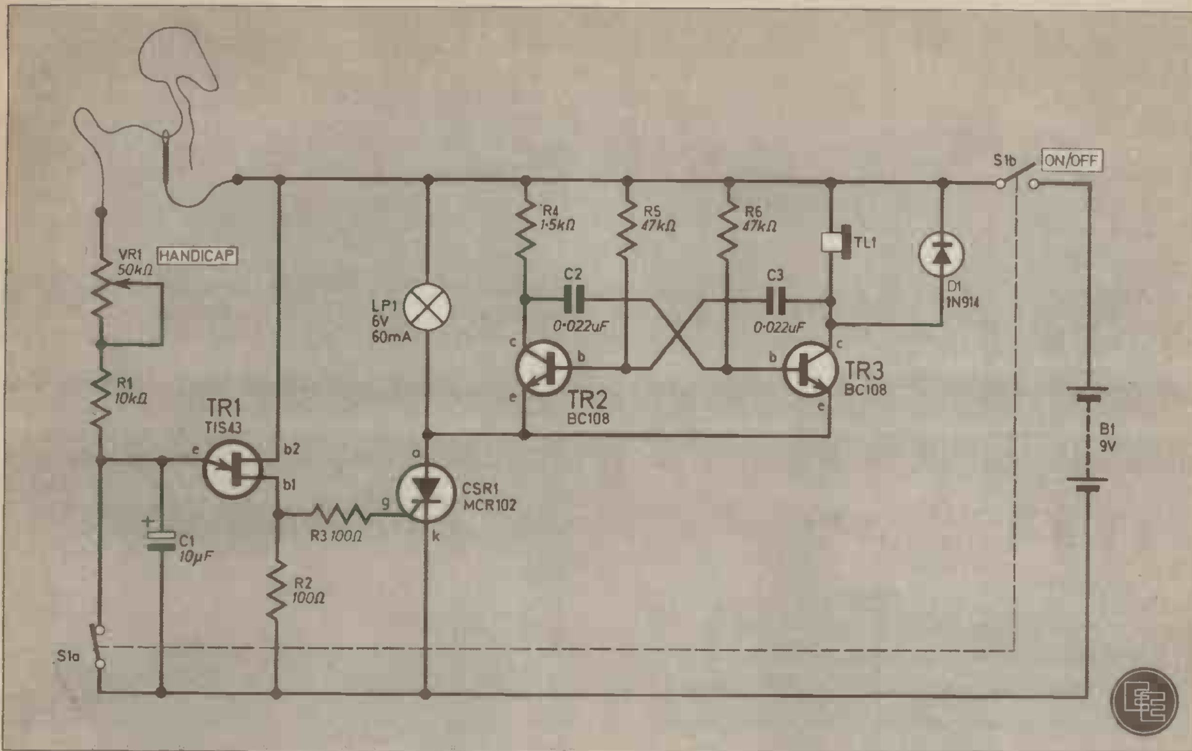


Fig. 1. Circuit diagram of the Steady Hand Tester.

resistance of VR1 (the "handicap" control), which controls the amount of current passing to the capacitor.

When the charge on C1 reaches a certain level, this will cause TR1 to conduct and the emitter /b1 junction to be forward biased. At this point the capacitor will discharge via this junction, through R2 to ground.

THYRISTOR ACTION

A thyristor normally blocks current flow in both directions, but it can be triggered so that it allows current to flow in the forward direction, while blocking current in the reverse direction. It thus behaves as a conventional silicon rectifier. In its conducting state it will allow current to flow until the current through it and the load has been reduced to zero.

To make the thyristor conduct, a positive pulse is applied to the gate terminal. In the present circuit this is obtained from the b1 connection of TR1, the pulse being present when the capacitor is discharging.

The lamp LP1 is then illuminated, the anode to cathode path of CSR1 being effectively a short circuit, connects the lamp between the positive rail and the negative rail.

Since the anode of the thyristor is now effectively at ground potential, it completes a path between the emitters of TR2 and TR3 and earth, the multivibrator is then free to operate.

Photograph showing the components mounted on the stripboard.

MULTIVIBRATOR ACTION

Briefly the action of the multivibrator is as follows: when power is applied to the circuit, one transistor will draw current faster than the other, this happens because one transistor has a slightly higher gain than the other.

Say that the current in TR2 will increase faster. The collector voltage will fall, this change being fed back to the base of TR3 via C2. The collector voltage of TR3 will now tend to increase, this increase being fed back to the base of TR2.

This action will continue until TR2 is fully conducting, and TR3 cut off. Capacitor C2 now charges up via R6, until the base of TR3 becomes sufficiently negative, that TR3 starts to conduct. This transistor now turns fully on, and turns off TR2. Capacitor C3 now charges up via R5 and the cycle repeats.

The square wave produced by the action of TR3 switching on and off is the audible tone heard from the magnetic transducer TL1. Diode D1 is connected

STEADY HAND TESTER

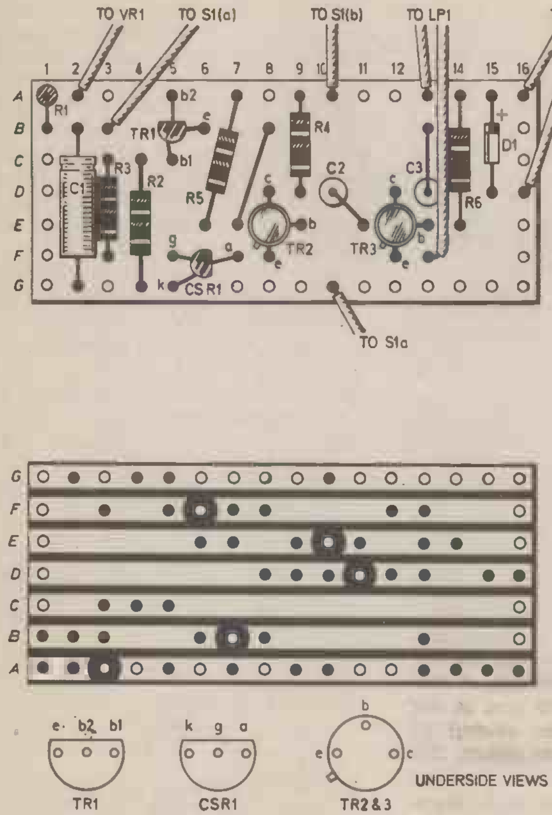
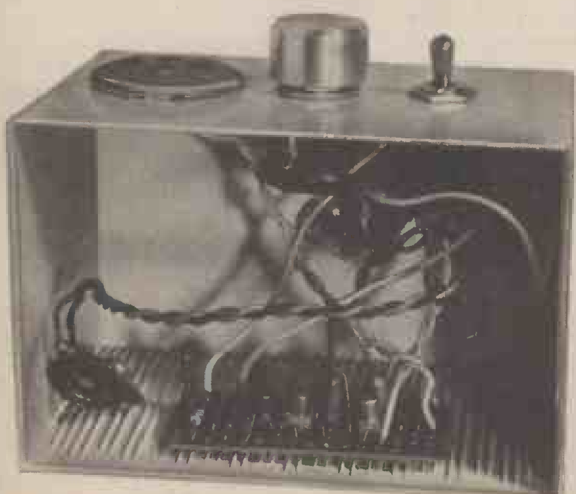


Fig. 2. Component layout on the stripboard, also showing the breaks required on the underside.



Internal photograph showing the position taken up by the stripboard.

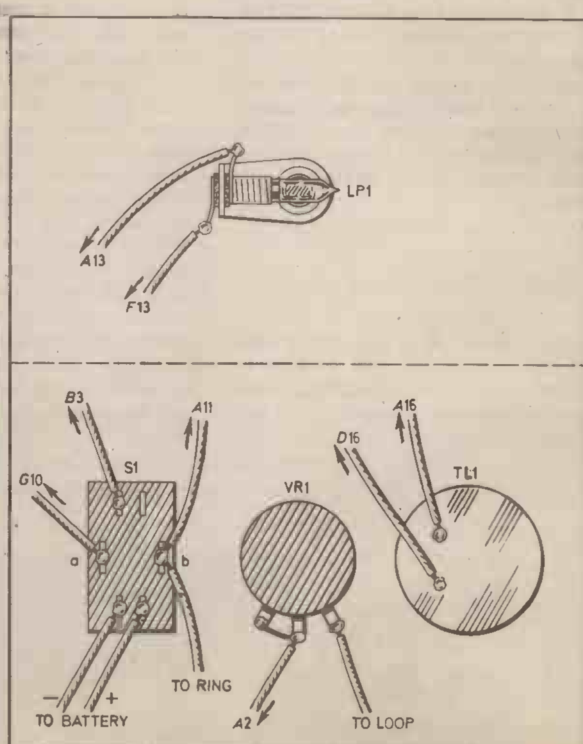


Fig. 3. Wiring diagram for the various controls. Note the top of the box has been opened out for clarity.

Components

Resistors

R1	10kΩ
R2	100Ω
R3	100Ω
R4	1·5kΩ
R5	47kΩ
R6	47kΩ

All resistors ¼W ± 10%

Potentiometer

VR1	50 kilohm carbon lin.

Capacitors

C1	10μF 16V elect.
C2	0·022μF plastic or ceramic
C3	0·022μF plastic or ceramic

Semiconductors

TR1	TIS43 unijunction transistor
TR2	BC108 *npn* silicon
TR3	BC108 *npn* silicon
CSR1	MCR102 or any 1A 30V thyristor

Miscellaneous

TL1	magnetic insert or telephone earpiece
S1	double pole double throw toggle switch
B1	9V battery
LP1	6V 100mA (m.e.s.) bulb

Stripboard, 0·1 inch matrix size 16 holes × 7 strips; battery clip to suit B1; wood beading; stiff wire for ring; metal coathanger for loop; plastic case; small knob; connecting wire; sleeving; long plastic rawlplug; solder.

SEE SHOP TALK page 311

across the transducer to prevent a back e.m.f. from damaging TR3.

Each time the alarm circuitry operates, the unit has to be switched off and back on again ready for the next attempt. This is because CSR1, which latches on, must have its supply removed before it will reset to the original state. This is made possible by the on/off switch S1; when in the off position, it short circuits C1 and discharges it so as to have a clean start when switched on again.

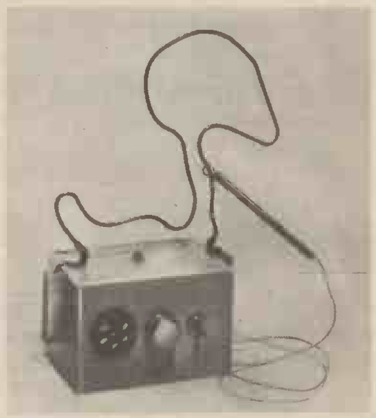
CONSTRUCTION

Most of the components are mounted on a piece of 0·1 inch matrix stripboard 16 holes by 7 strips. The layout is given in Fig. 2, which also shows the breaks required on the underside of the board. The layout is not at all critical, so it can be altered to suit the box used to house the components used.

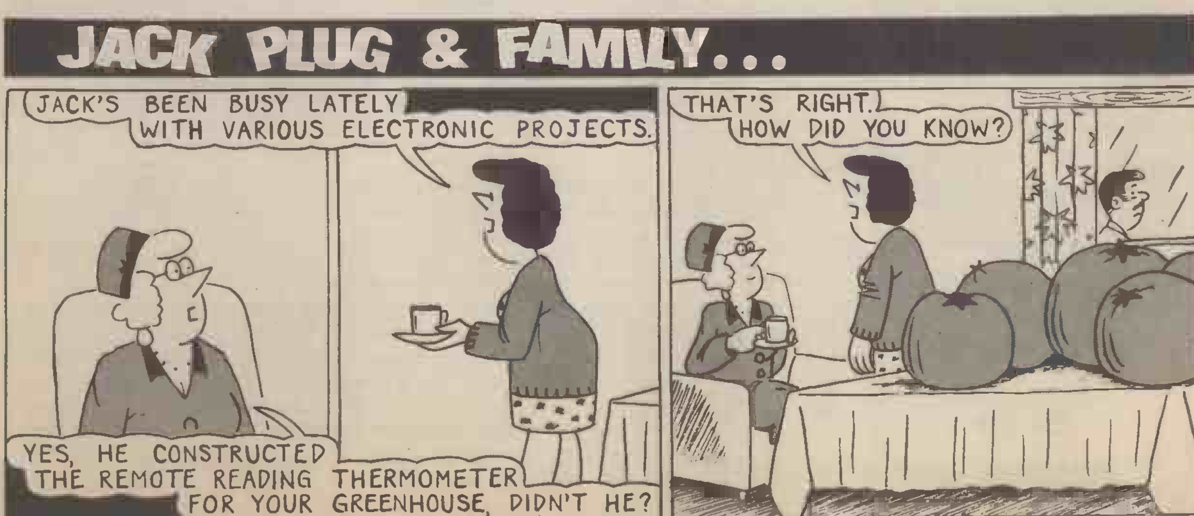
The wire loop was made from a coathanger which was bent into a convenient shape, and fixed into two pieces of wood which were glued to the sides of the box. Each end of the loop is sleeved to allow the ring to be rested while the contestant is getting ready. The probe containing the ring was made from a long piece of plastic rawlplug with a stiff wire fed through it and formed into a ring at one end.

The other end is soldered to a flexible wire and connected to the unit. The shape of the loop is up to the constructor's imagination, and there is no reason why sockets of a suitable size cannot be fitted to allow different shaped loops to be plugged in. This will add to the interest and skill required by the contestants. The shape used by the author (with a little imagination) was in the form of a duck!

As was said at the beginning the use of this unit has many serious applications, one idea is to measure the co-ordination of, say, people at a party to see if they are in a fit state to drive, if they are not, then taxis are called for! ⌑

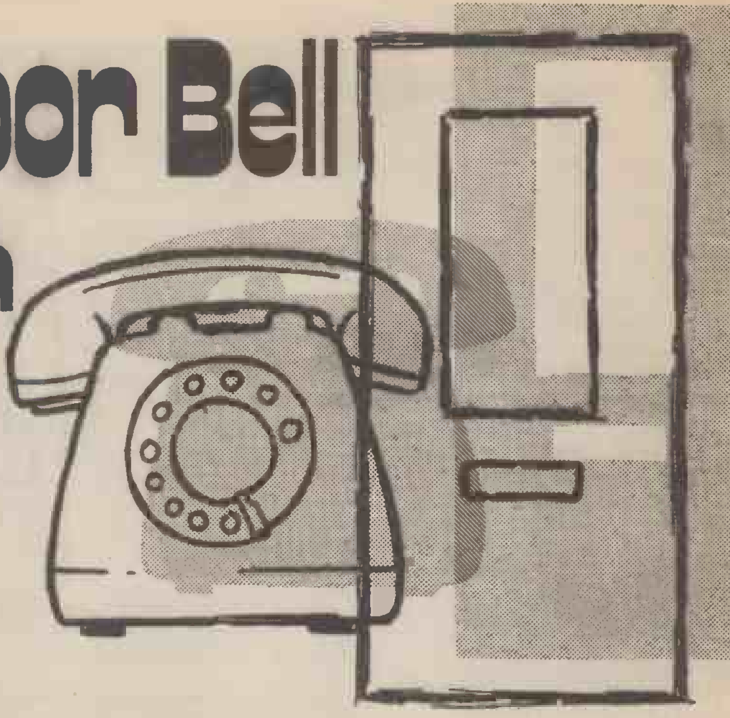


Photograph of the complete Steady Hand Tester.



Phone/Door Bell Repeater

By R. A. PENFOLD



WHEN one is working in a shed or other outbuilding, in the garden, or perhaps even listening to loud music actually inside the house, it is very easy to miss the ringing of a telephone or a doorbell. The simple device described here overcomes this problem by using a microphone to pick up the sound of the bell, and the resultant electrical signals are used to trigger an alarm circuit situated near the user. The prototype has been tested using connecting cable of 10 metres in length between the microphone and the alarm, but it should operate over an even greater distance if required.

Although the circuit could be easily simplified if a direct connection were made to the telephone or doorbell, Post Office regulations forbid this in the case of the former, and so the circuit has to be arranged so that it is triggered by the sound of the bell.

The circuit is extremely simple anyway, using only two active devices, and the fact that there is no direct connection to the monitored equipment obviously makes the unit more convenient to use. It also has the advantage that the device can be used to monitor an ordinary door knocker in cases where no doorbell is fitted, or the doorbell is inoperative.

Since the unit has a quiescent current consumption of only about 1 milliamp, it will provide many hours of service from an inexpensive PP3 battery.

CIRCUIT ACTION

Basically there are two main sections to the circuit. The first part amplifies the signals from the microphone, rectifies and smoothes them to a d.c. bias, and then amplifies this d.c. signal. This is then used to turn on the second part of the circuit which consists of an audio oscillator

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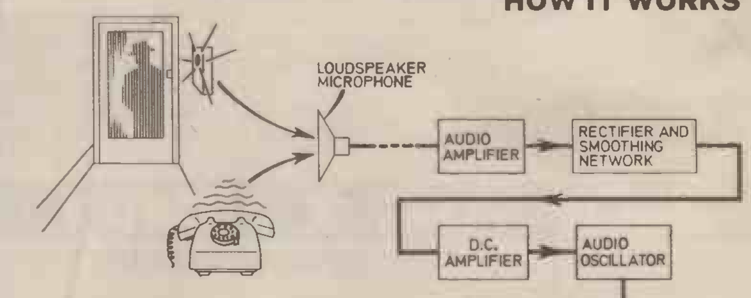
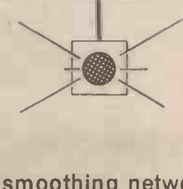
ESTIMATED COST OF COMPONENTS excluding V.A.T.

£4.50

excluding case

HOW IT WORKS





Sound from the telephone ringing or the doorbell chiming is received by the microphone and the resultant electrical signals are fed to an audio frequency amplifier. The output from this is coupled to a rectifiying and smoothing network and the d.c. potential this produces is fed to a d.c. amplifier. The audio oscillator is controlled by the large d.c. bias which is produced at the output of the d.c. amplifier. The oscillator is normally off but it is turned on by the d.c. bias generated in the presence of a suitable audio signal. If the microphone is sited near to the telephone, or near to the door chimes, a tone will be produced in the remote loudspeaker unit.

feeding a loudspeaker.

Referring to the circuit diagram of the unit, which is shown in Fig. 1, TR1 and associated components form the amplifiers and rectification circuit, while TR2 is the basis of the oscillator.

Looking at this in greater detail, signals from the microphone are fed to the base of TR1 via d.c. blocking capacitor C2. Transistor TR1 has a small forward bias provided by R1, and it operates as a high gain common emitter amplifier. The amplified signals appearing at TR1 collector are coupled via C3 to a rectifying and smoothing network utilising D1, D2, and C4. The d.c. potential this produces is fed to the base of TR1 through R3.

This d.c. signal is positive in polarity, and it causes TR1 to conduct much more heavily, causing its collector potential to fall. It will be apparent from this description that TR1 amplifies the signal twice, first at a.f. and then at d.c. In this way very good component economy is achieved.

Transistor TR2 is used as a Hartly oscillator with the primary winding of T1 acting as a tuned winding. The necessary positive feedback is provided between TR2 base and the lower connection of T1 primary by C5. The output of the oscillator is coupled to the speaker by means of the secondary winding of T1.

The second transistor, TR2 is a silicon *pnp* transistor, and before it will begin to turn on and permit oscillation it must have its base biased about 0·65 volt negative with respect to its emitter. The bias current for TR2 is taken from TR1 collector by way of the potential divider formed by R4 and R5.

Under quiescent conditions the voltage at TR1 collector is little less than the positive supply rail voltage, and the base/emitter voltage of TR2 is far too low to produce oscillation. However, when an input signal activates the circuit and the collector voltage of TR1 falls, the bias on TR2 is increased to a level that enables the circuit to oscillate. This causes an audio tone to be emitted from the loudspeaker. This tone will continue for as long as an input signal is present, plus the few seconds that it takes C4 to discharge once the signal has ceased.

There is an on/off switch S1 and C1 is a supply decoupling capacitor.

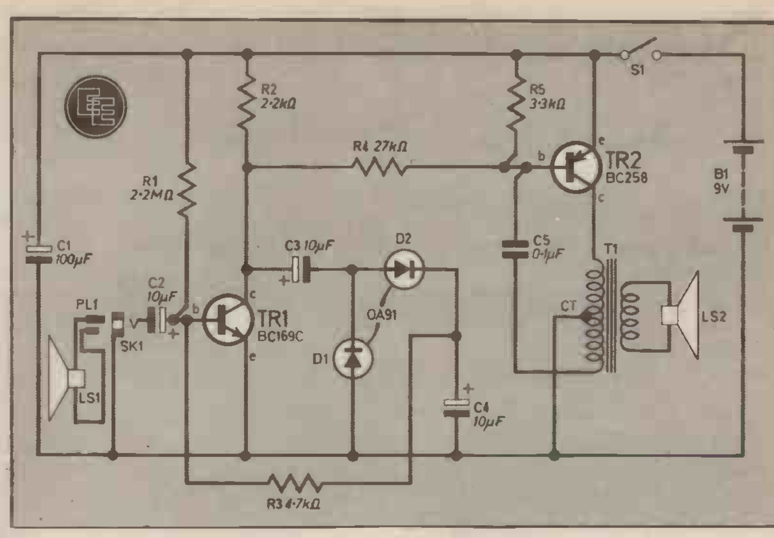


Fig. 1. The complete circuit diagram of the Phone/Door Bell Repeater including "loudspeaker" microphone.

CASE

The prototype device was housed in a ready made case type AB10, and this has approximate dimensions of 130 x 100 x 40mm. It has a removable lid, which in this application is used as the front panel with the case standing up on one of its long edges. Any case having similar dimensions should also be suitable.

A fretsaw is used to make a 63mm square cut out for the speaker in the left-hand side of the front panel. To the right of this and towards the top of the panel a 12·5mm diameter mounting hole for S1 is punched in the panel. A 6·5mm diameter hole for the input socket (a 3·5mm jack socket) is drilled beneath the hole for S1. The exact positioning of these is not critical, but they should be arranged so that they give a reasonably neat finish.

A piece of speaker fret or cloth about 90mm square is glued behind the speaker cut-out, and

Photograph of the prototype unit showing layout of components and board on the rear face of the lid.

Components

Resistors

R1	2·2MΩ
R2	2·2kΩ
R3	4·7kΩ
R4	27kΩ
R5	3·3kΩ

All ¼W carbon ± 5%

Capacitors

C1	100μF 10V elect.
C2	10μF 10V elect.
C3	10μF 10V elect.
C4	10μF 10V elect.
C5	0·1μF plastic or ceramic

See **Shop Talk** page 311

Semiconductors

TR1	BC169C silicon *npn*
TR2	BC258 silicon *pnp*
D1, 2	OA91 germanium diode (2 off)

Miscellaneous

B1	9 volts type PP3
S1	s.p.s.t. toggle switch
SK1	3·5mm jack socket
PL1	3·5mm jack plug
LS1	miniature loudspeaker coil impedance 40 to 80 ohms
LS2	miniature loudspeaker (75mm diameter) coil resistance 3 ohms
T1	transistor output transformer type LT700 (Eagle)

Stripboard: 0·15 inch matrix 9 strips by 21 holes; battery clip for B1; length of cable to run from microphone to unit; case type AB10 size 130 × 100 × 40mm approx.; connecting wire; solder.

then the speaker is carefully glued onto this. The speaker should be about 70mm or more in diameter. Smaller speakers will work in the unit, but will not, in general, produce as much volume as slightly larger types.

COMPONENT PANEL

Most of the circuitry is constructed on a 0·15 inch matrix stripboard panel having 21 holes by 9 copper strips. The component layout of the board together with details of the positions of the four breaks in the copper strips are shown in Fig. 2. Cut out a panel of the required size using a hacksaw, and make the breaks in the copper strips before connecting any of the components.

Commence assembly of the panel by soldering into position the single link wire plus the resistors and capacitors. Then mount and connect T1. This has two mounting lugs which serve no useful purpose here, and they are either broken off or bent out at right angles so that they do not get in the way. The specified transformer is intended for printed circuit mounting, and it is plugged into the board and soldered into place in the same way as the other components.

The transistors and diodes are connected last of all, and a heat-shunt is used on each lead out as it is soldered into circuit, to prevent these components from being damaged due to overheating.

Finally, the component panel is wired up to the rest of the unit using p.v.c. covered single core connecting wire. Details of this wiring are shown in Fig. 2. Keep the leads as short as possible as these provide the support for the panel.

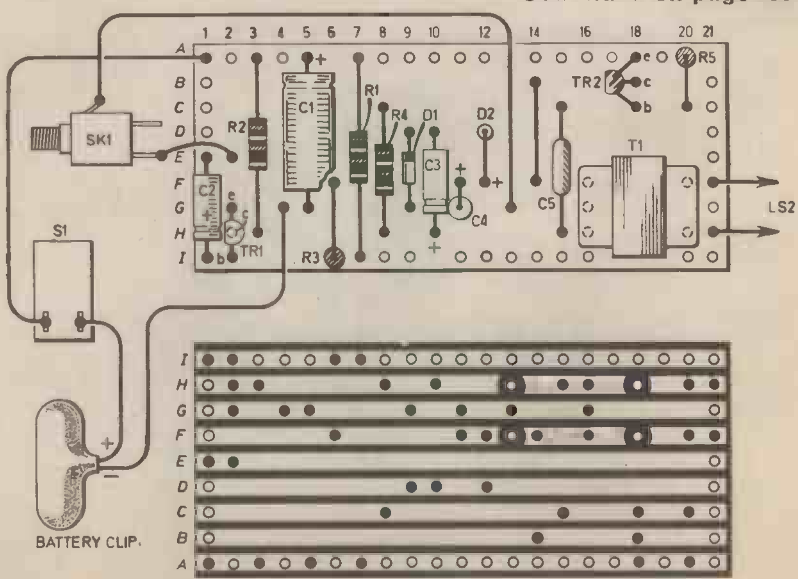
The component panel is situated above and behind the speaker magnet with the coppered side of the board facing the rear of the case. It is a good idea to place a layer of insulation tape over the inside of the rear of the case, behind the component panel, so that the copper strips cannot be accidentally short circuited through the metal casing.

MICROPHONE

The microphone consists of a miniature high impedance loudspeaker, a 63mm diameter 64 ohm component being employed with the prototype. Any speaker having an impedance in the range 40 to 80 ohms is quite suitable.

It is not essential for this to be connected to the unit via a screened cable unless these connecting wires pass close to a mains lead, or some other source of electrical interference. Twin speaker lead or two lengths of ordinary insulated hook up wire twisted together make ideal connecting leads. They are terminated in a 3·5mm jack plug which fits into the socket on the front of the repeater.

Continued on page 336



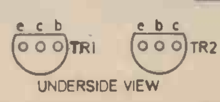
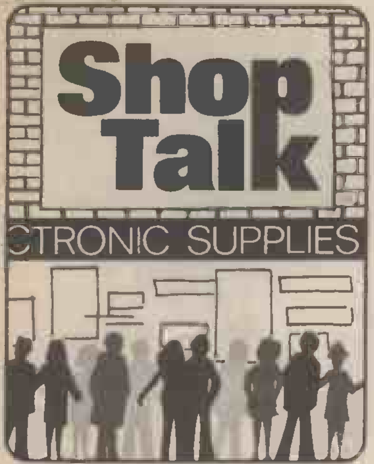


Fig. 2. The layout of the components on the stripboard, the breaks on the underside and wiring up details.



Shop Talk

By Brian Terrell

New products and component buying for constructional projects.

EACH month we receive many enquiries concerning the purchase of components for constructional projects, current and past. They are not the components expected to cause buying problems which are dealt with on this page, but commonplace components. In many cases these components are offered for sale by advertisers in EVERYDAY ELECTRONICS, but escape the notice of some constructors, as does this page on occasions.

To assist constructors we search through catalogues we have and inform them of a supplier. This takes quite a lot of time (something we have little of) and could be avoided if the constructor purchased a few of the catalogues available.

The cost of a catalogue is about 50 pence which will prove a saving even in the short term, because you may be able to order all the parts required from one supplier—effecting a saving on postage and incurring no minimum order charge. Whether you can order all the components from a single supplier can only be found out with the aid of catalogues!!

Many, if not all of the components used in E.E. constructional projects are part of the stock carried by many advertisers. It is surprising that none of them offer a complete kit of parts for our projects. I am sure this service would be more than welcome and appreciated by many constructors.

We would be interested to hear readers, and advertisers comments on this subject.

Amplifier Module

An audio amplifier module known as the AL-30A has recently been added to the range of modules available from Bi-Pak, The Maltings, 63a High Street, Ware, Herts. The cost is £3·60. The module measures only 90 × 64 × 27mm and can provide up to 10 watts r.m.s. into 8 ohms with an input of 90 millivolts into 50 kilohms. The power supply requirement is 28V 1A. A suitable power supply is available from Bi-Pak. Distortion (t.h.d.) is low, quoted typically 0·3 per cent.

It should find many applications in record players, tape recorders, cassette and cartridge players. Many constructors who made the *Multi-Band Tuner* featured recently will now be looking for an amplifier. This module together with its power supply could well fit the bill.

The AL-30A 10 watt amplifier module.

Soldering Iron

Recently we received details and a model of a miniature lightweight soldering iron from a new soldering iron manufacturer/distributor, S & R Brewster Limited, 86-88 Union Street, Plymouth PL1 3HG. The iron known as SRB1, complies with BS 3456 2/14.

It is mains powered and rated at 18 watts which makes it ideal for the constructor of EVERYDAY ELECTRONICS projects. There are four interchangeable bit sizes to choose from: No. 19 1·5mm tip, No. 20 3mm, No. 21 4·5mm, No. 22 6mm.

For maximum efficiency the bit fully encloses the heating element due to a new bit-fixing method. The body is constructed of robust plastic with a built-in hook for hanging the iron during use. The cost of the SRB1 is £3·50 including V.A.T. plus 20p postage and packing, direct from S & R Brewster.

Constructional Projects

Now to deal with components required for constructional projects this month. We foresee no buying problems for any of the components for the *Fuzz Tone Unit* although the footswitch may not be available from your local supplier and may need to be ordered by post. We have been unsuccessful in locating a supplier of the exact switch used in the prototype. A suitable s.p.d.t. type is available from Maplin and Home Radio who also supply a d.p.d.t. version along with Bi-Pak and Doram.

Although the designers of the *Touch Operated Power Switch* employed TAG 1/100 thyristors, virtually any thyristor will be suitable as long as it can pass the current required to energise the relay. With the relay specified the contacts can switch up to 3 amps at mains voltage i.e. 750 watts. Investigate your appliance requirements before purchasing the relay.

The transformer listed and used by the authors is more than adequate for the job and could be replaced by a mains/12V 100mA type if the relay to be used is rated 12V with a coil resistance greater than 185 ohms.

In the *Phone/Door Bell Repeater*, the only component likely to cause concern is the LT700 transformer. We have found this listed in the Bi-Pak, Maplin and Home Radio catalogues. One transistor in this project carries an unfamiliar type number BC258. This is a silicon *pnp* transistor rated at 300mW, I_{cmax} equal to 100mA and a gain of 180 to 460. Any similar type at hand may be substituted.

A thyristor is called for in the *Steady Hand Tester*. Don't break your back trying to get the type specified (used by the author) as any thyristor will do. No difficulty should be encountered in getting the rest of the components.

Apology

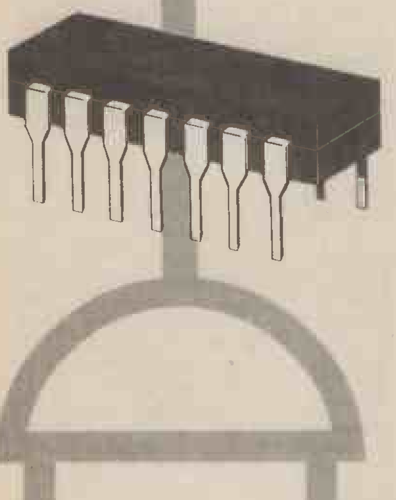
We wish to apologise to our readers and J. Bull for publishing an incorrect address in *Shop Talk* last month. J. Bull are at 103 Tamworth Road, Croydon CR9 1SG.

The 18 watt miniature soldering iron type SRB-1.

Doing it Digitally...

Part 10

By O. N. Bishop



IN THE series so far, the examples have been fairly simple, the complexity of the circuit being in the timing rather than the actual logic function which the circuit performs. This month one of the circuits examined, Noughts And Crosses is static but the logic involved is quite complicated.

DIGITAL THERMOMETER

The thermometer described below displays a number to indicate temperature. The simple version needs only two i.c.s (7400 and 7493) and shows how this kind of instrument works.

The essential parts of the circuit are a clock and a counter. This clock uses a special type of resistor called a thermistor as one of its timing components. A thermistor alters its resistance with temperature, becoming lower as temperature rises.

The clock circuit will oscillate faster if the resistance is lowered. Thus its frequency is proportional to temperature.

The counter is set to count how many pulses the clock circuit produces in a fixed short period of time (about one second) so the higher the temperature the higher the count displayed.

The circuit is shown in Fig. 10.1. and the wiring up in Fig. 10.2. Several types of thermistor are available. The circuit requires one with a resistance of about 1 kilohm at room temperature such as the Mullard VA1038 or Siemens K164/1K.

The cheaper thermistors such as the type quoted are in the form of discs or rods. Tiny bead thermistors are also available though these are much more expensive. They respond quickly to changing temperatures and are ideal for a permanent circuit with extra counting range (see later). It is not worthwhile using them for the first simple circuit.

When the clock is completed as in Fig. 10.2, connect its output to a lamp or loudspeaker unit to see how it is behaving. Place the

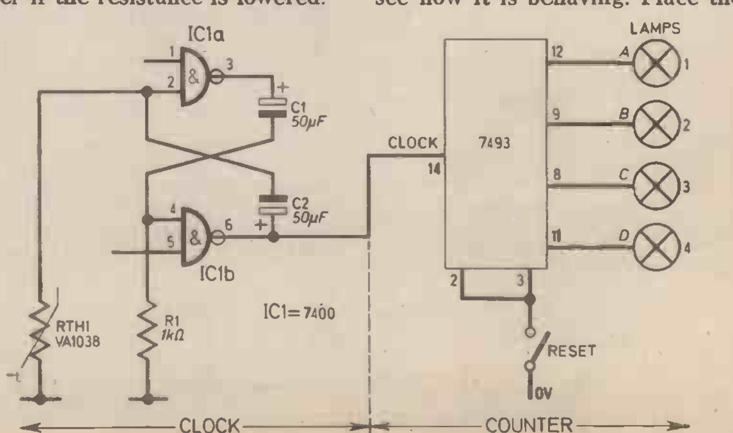


Fig. 10.1. Circuit diagram of the digital thermometer.

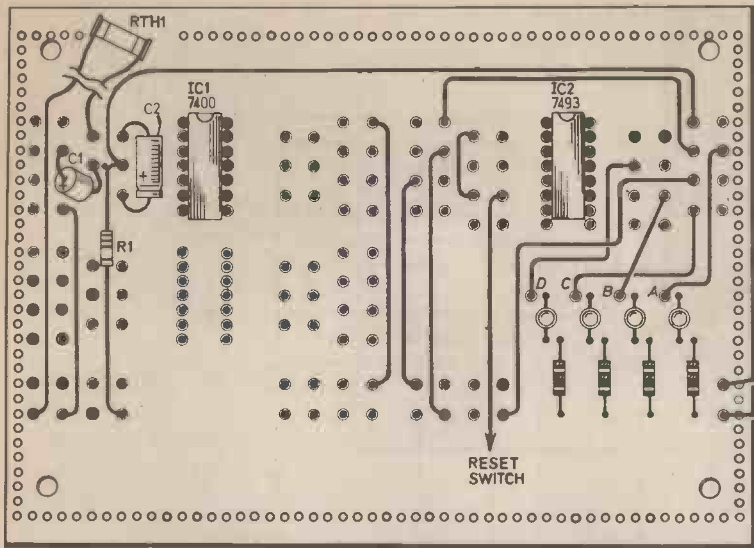


Fig. 10.2. Layout of the components on the experimental board for the digital thermometer. The gating circuit to make the counter count for one second is not shown.

thermistor in different situations—on the bench, close to a light bulb, on a lump of ice—and notice the frequency of oscillation changing. The clock should oscillate at about 15Hz when warm and slow down to zero when cold. If this effect is not noticeable try varying the capacitors or resistor values to increase or decrease the rates of oscillation.

Connect the output of the clock to the 7493 counter. If the counter is switched on for one second different counts will be obtained for different temperatures.

To reset the counter disconnect the reset wire from negative. It is convenient to use one of the card reader switches as a push-to-break switch for resetting.

To switch on the counter for a short time the circuit in **Fig. 10.3.** may be used. With the switch open the capacitor is charged through the 5·6 kilohm resistor. When the switch is closed the capacitor discharges through the 560 ohm resistor. So, on the instant of switch-on, the input to the NAND is made to go high and gradually falls low as the charge leaks away. As long as it is high (about one second) pulses from the clock can pass to the counter. For the switch it is best to have one of the keys from the keyboard which are push-to-make.

The NAND gate is one of the spare gates of the 7400. The 0·47 microfarad capacitors are to stop any fast pulses caused by bouncing of the switch getting through to the 7493. Even the capacitors shown may not be sufficient to stop all contact bounce pulses (indicated by a sudden change in count of the 7493) so try 1 or 2 microfarads if necessary.

This thermometer has the advantage that it can measure temperatures remotely. The thermistor can be placed outdoors and the rest of the circuit can be placed in any handy spot. To read the temperature just press the reset button, press and hold the start button then take the reading.

By the way, for repeat readings release the start button and allow half a minute for the capacitor to recharge before taking the next reading.

The simple thermometer has several drawbacks owing to the fact that it uses only two i.c.s. It does not tell the temperature in degrees—just scale readings from 0 to 15. To know what these mean in degrees Celsius the thermistor must be placed at several known temperatures and the scale reading noted for each.

INCREASED RANGE

The thermometer could be given greater range by feeding the *D* output of the 7493 into the *A* input of another 7493 then it would read up to 255. In fact if this was done then there would be some advantage in doubling the counting rate by using 22 microfarad or 25 microfarad capacitors in the clock.

To increase the length of time during which counting takes place the value of the discharging resistor can be increased from 560 ohms up to about 1·5 kilohms. This would be an advantage if the thermometer were to be used at low temperatures such as outdoors in winter for it would give a greater sensitivity over a smaller range.

A variable resistor of about 1 kilohm placed in series with the discharging resistors allows the counting time to be varied. This could also be used to adjust counting time so that a whole number of degrees corresponds to the whole numbers on the thermometer scale so making it easier to convert scale readings into degrees Celsius.

The rate at which the clock works depends on the voltage supplied to it so take care that

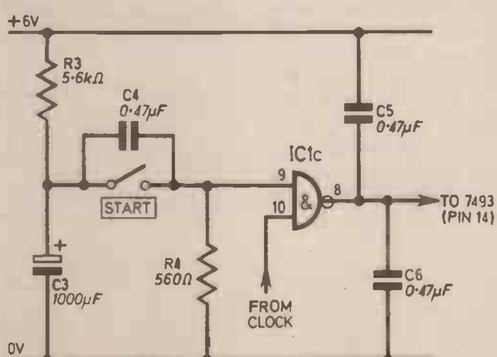


Fig. 10.3. A simple circuit to make the counter in the digital thermometer count for about one second.

the battery does not get flat. As a refinement (only worthwhile if the instrument is to be made permanent) a reasonably constant voltage can be obtained using a device known as a Zener diode. It is connected as shown in Fig. 10.4.

If the voltage across the diode exceeds 5·1 volts a current passes through the diode (in the reverse direction to the arrowhead in the symbol) so the voltage falls to 5·1V again. This circuit will reduce though not entirely eliminate, voltage reductions due to battery ageing.

The Zener diode can be one of the cheap types such as BZY88C5V1 which is rated at 400 milliwatts.

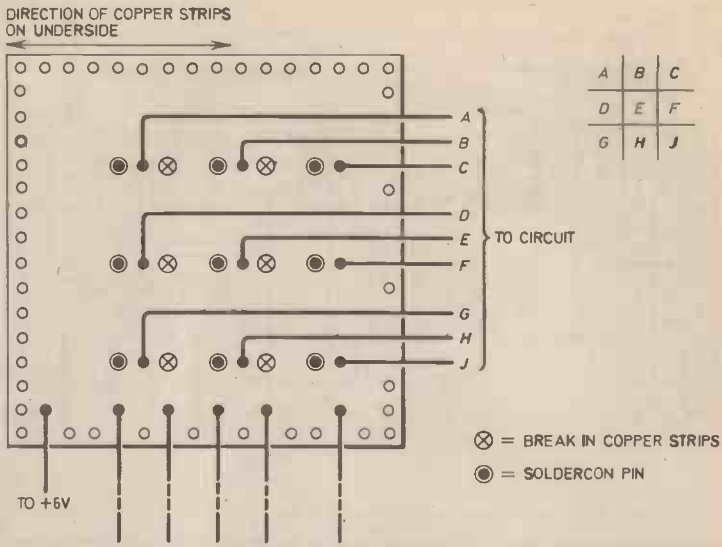


Fig. 10.5. Construction of a "pin board" using a piece of stripboard. The lettering of the squares is shown in the inset. The wires at the bottom of the board are used to make the moves by pushing onto the pins.

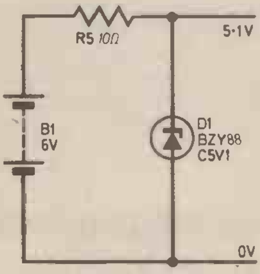


Fig. 10.4. A voltage stabiliser using a Zener diode to counteract fluctuations in battery voltage.

NOUGHTS AND CROSSES

The "noughts and crosses" circuit to be described is fairly complicated but providing the constructor is capable of putting the components together and wiring up the circuit then he should be capable of beating it. But do not think that the circuit is easy to beat—one slip and the circuit will take advantage.

With the limit of three i.c.s that can be accommodated on the experimental board, it is not possible to make a device that will play faultlessly: the best that can be done is to design a circuit which will recognise certain positions and make appropriate moves. With positions it does not recognise it will act at random. Thus it will play somewhat like an absent-minded player.

When the circuit has been built, it should be possible to work out a better circuit and, if noughts and crosses has not become boring, to go on and build it.

In the game to be described, the circuit is "crosses" and its opponent "noughts". It does not matter who plays first. Let us look at the strategy involved in a game.

STRATEGY

A good first move is to capture the centre square. The circuit is thus programmed to do this if it has not already been taken at a previous move. The game is actually played on paper in the normal way but to inform the circuit what moves its opponent has made a "pin board" is required. Construction of the pin board is shown in Fig. 10.5.

As a move is made, one of the wires is pushed onto the appropiate pin. These wires are all connected to logic high so a high signal to the circuit tells it what move has been made. Note that the circuit does not get any information about what it has done itself—it is just too complicated to do this with only three i.c.s.

If a wire is connected from pin *E* to the circuit then lamp *E* will light. This happens when a nought is put in square *E*. If there is no nought in square *E* then the lamp will be out, indicating that the circuit wishes to play a cross in Square *E* at its first available turn.

The circuit has four other moves it can make. Let us consider when it would want to put a cross in square *A*.

(1) If its opponent plays first into square *E*

(2) Later in the game when its opponent is in squares *B* and *C*, or in *D* and *G*, or in *E* and *J*.

These situations are illustrated in Fig. 10.6. We can write the required move in logical form: lamp *A* must go off when *E* OR (*B* AND *C*) OR (*D* AND *G*) OR (*E* AND *J*) are high.

The logic could be translated into hardware using four AND gates and a NOR (NOR because the lamp goes low when one of the ORed terms goes high). If an AND i.c. (type 7408) and a 7402 are available this circuit can be built, but it is not recommended for there is a special i.c. which will form this function.

AND-OR-NOT GATE

The special i.c. is the AND-OR-NOT gate whose circuit is shown in Fig. 10.7. This i.c. is the same price as a 7402 and allows more circuits to be accommodated on

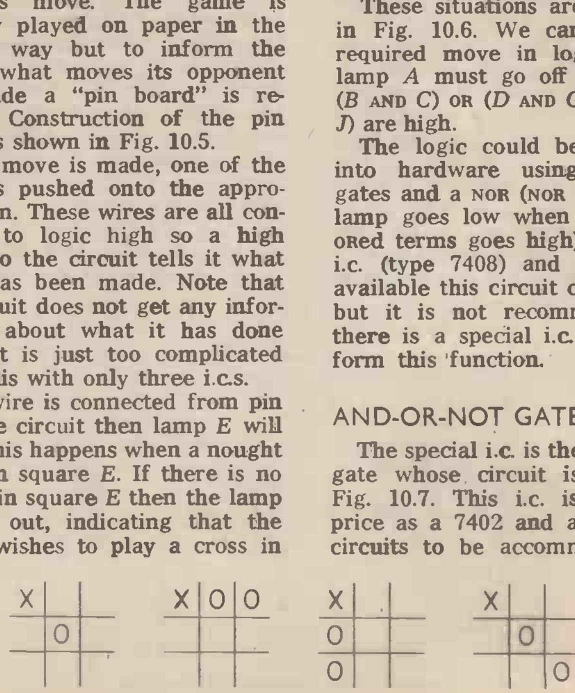


Fig. 10.6. If any of the four combinations of noughts occurs in the game then the circuit will reply with a cross on square *A* as shown.

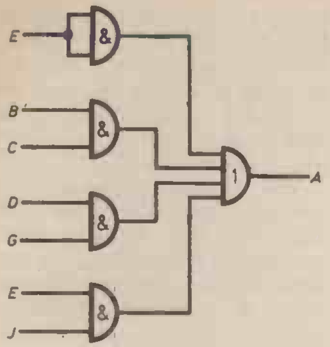


Fig. 10.7. A logic circuit which will respond as required in Fig. 10.6.

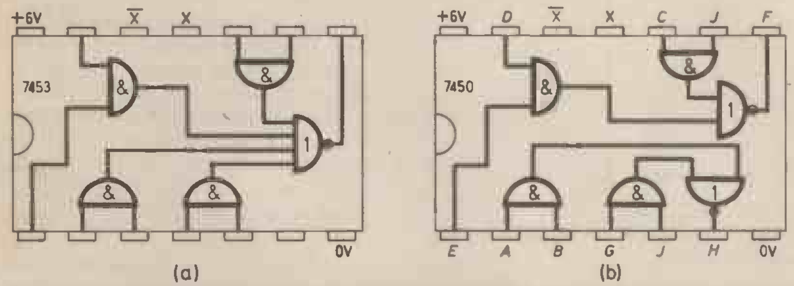


Fig. 10.8(a). Pin connections of the 7453 AND-OR-NOT gate. (b) pin connections of the 7450 dual AND-OR-NOT gate. The 7453 is used to control the *A* lamp and the 7450 the *F* and *H* lamps.

the experimental board.

There are two types of AND-OR-NOT needed for this circuit. For controlling the *A* lamp a 7453 is used (Fig. 10.8a). The other sort of AND-OR-NOT gate needed is the 7450. This has only two pairs of inputs per gate but has two of these gates in a single package (Fig. 10.8b). This type is used to control lamps *F* and *H*.

The circuit will want to play *F* when crosses are in *D* and *E*, or *C* and *J*. It will want to play *H* when crosses are in *B* and *E* or *G* and *J*. The connections are shown on the i.c. diagram in Fig. 10.8b.

There is still one vacant socket on the board. This could be used for another 7450 to control two more squares but the circuit can be made a little more sophisticated so that it is more difficult for the opponent to see how the circuit operates.

The third i.c. is a 7453. It is used to play *G* when there are noughts in *D* and *H* or *D* and *E* or *E* and *H* or *E* and *C* (see Fig. 10.9). The first three prevent "noughts" from establishing two possible lines simultaneously to make sure of winning. Whether this is good strategy for "crosses" depends on whether other squares in the lines are already occupied and by whom. Anyway it is a variation on the style of play. The connections to the 7453 are shown in Fig. 10.10.

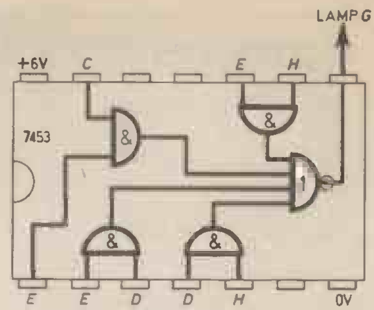


Fig. 10.10. Connections to the 7453 to give the *G* output as in Fig. 10.9.

BUILDING THE CIRCUIT

This completes the circuit which can be made up on the experimental board. With the circuit described, the only responses possible are *E*, *A*, *F*, *H* and *G*. This requires one more l.e.d. than is on the board but for the *E* lamp an ordinary 6V 40mA torch bulb can be used since no i.c.s are involved in the *E* circuit.

The i.c.s are the cheapest kind and there is no problem in working out other combinations of noughts to which the circuit can respond.

When play is begun there will be no connections to the pin board and all lamps will be lit except *E*. If it is the circuit's turn first, the fact that the *E* lamp is out signifies that the circuit should play a cross in the *E* square.

To make a move, connect one of the pins to positive to show where the nought should go. Nothing will happen since all the circuit's replies rely on there being two noughts on the board.

Choose a move for the circuit at random—say by throwing a dice. Now make a move in reply by connecting to another pin. If no lamp goes out make another random move for the circuit. If a lamp does go out then this is the move the circuit wishes to make. Thus the game continues.

If the circuit's opponent plays first and takes the middle square then the circuit will immediately respond by taking *A*. After that the game is as already described.

Sometimes the circuit will indicate that it wants to put its cross in a square already occupied by its opponent. If this happens choose a move for it at random. The circuit does not know everything that is happening in the game—it does not even know when it has won.

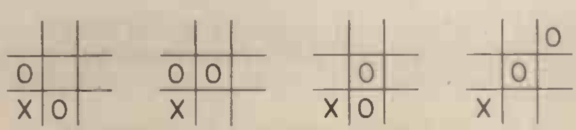


Fig. 10.9. The combinations of noughts for which the circuit will play a cross in square *G*.

ADDING COMPLEXITY

For those who want to build up the circuit permanently and perhaps make it more elaborate, there are some more points to consider. For more complex circuits use can be made of the inputs to the 7450 and 7453 which have not been mentioned so far. These are the "expander" inputs and they allow additional inputs to be added to the AND-OR-NOT gate.

The 7460 i.c. whose pin connections are shown in Fig. 10.11 contains two "expanders" each with four inputs so that by connecting

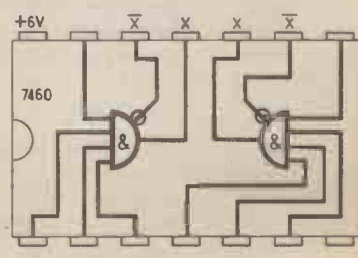


Fig. 10.11. Pin connections of the 7460 dual four-input expander i.c.

Components

Digital Thermometer
Resistors
R1 1kΩ
R2 5·6kΩ
R3 560Ω
R4 10Ω
Thermistor RTH1 VA1038

Capacitors
C1, C2 50μF 10V elect. (2 off)
C3 1000μF 10V elect.
C4-6 0·47μF plastic or ceramic (3 off)

Semiconductors
IC1 7400
IC2 7493
D1 5·1V Zener diode 400mW type BZY88C5V1

Noughts And Crosses
Integrated Circuits
IC1, 2 7453 (2 off)
IC3 7450
IC4 7460
Miscellaneous
Experimental board; stripboard 16 strips by 16 holes; Soldercon pins (9 off).

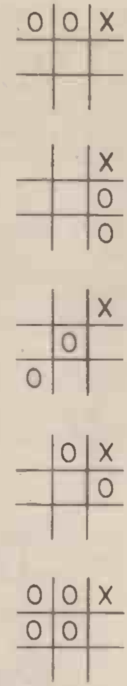


Fig. 10.12. By using the expander with the 7453 the circuit can be made to play square *C* when any of the five combinations shown occurs.

these to the 7453 (X to X and $\overline{X}$ to X) a lamp can be made to go low when any of five conditions is fulfilled. For instance lamp *C* can be made to go low when *A* and *B*, or *F* and *H*, or *E* and *G*, or *B* and *F*, or *A* and *B* and *D* and *E* are noughts (see Fig. 10.12).

The last arrangement would give a winning move for the circuit. The fact that the noughts are crowded together in a corner indicates that there is the possibility of a line of crosses elsewhere.

This logic is not certain to produce success but it does increase the chances of it. Whether it is worth an extra i.c. is a matter of opinion.

It is not necessary to use all four inputs to the expander gates—simply wire unused inputs to one or more of the used inputs.

The expanders have two inputs from each gate and both must be connected to the 7450 or 7453. Only one gate in the 7450 is capable of expansion.

To be continued

For Your Reference

a.c.	alternating current	oz	ounces (avoirdupois)
a.f.	audio frequency	p.i.v.	peak inverse voltage
a.f.c.	automatic frequency control	p.v.c.	polyvinyl chloride
a.g.c.	automatic gain control	r.f.	radio frequency
a.m.	amplitude modulation	r.m.s.	root mean square
BA	British Association (nut and bolt sizes)	s.p.s.t.	single-pole single-throw (switch)
cm	centimetre	s.r.b.p.	synthetic resin bonded paper
d.c.	direct current	s.w.g.	standard wire gauge
d.p.d.t.	double-pole double-throw	t.r.f.	tuned radio frequency
elect.	electrolytic	u.h.f.	ultra high frequency
e.h.t.	extra high tension	u.j.t.	unijunction transistor
e.m.f.	electromotive force	v.h.f.	very high frequency
f.e.t.	field effect transistor	%	per cent
f.s.d.	full scale deflection	X	reactance
f.m.	frequency modulation	Z	impedance
g.	gram	A	ampere (amp)
h.t.	high tension	dB	decibel
i.c.	integrated circuit	F	farad
l.e.d.	light emitting diode	H	henry
l.d.r.	light dependent resistor	Hz	hertz (cycles per second)
lin.	linear	Ω	ohm
log.	logarithmic	V	volt
m	metre (measurement of length)	W	watt
mm	millimetre	p	pico (÷ 1,000,000,000,000)
m.w.	medium wave	μ	micro (÷ 1,000,000)
npn	transistor structure	m	milli (÷ 1,000)
pnp	(two types)	k	kilo (× 1,000)
		M	Mega (× 1,000,000)

For your ENTERTAINMENT

By ADRIAN HOPE

EARLIER this year I visited Paris for the Audio Engineering Society spring convention and the Féstival du Son hi fi exhibition. These ran back-to-back and thus enabled foreign visitors to visit both exhibitions with a weekend off duty in between, a clever idea that exhibition organisers elsewhere should note for the future.

To make the event a hat trick, the dates were chosen to coincide (more or less) with the drafting of plans one hundred years ago, by French poet and thinker Charles Cros of a scheme to record sound using a combination of photographic and engraving techniques.

There is no record of Cros ever having made the system work, and Edison achieved success using a quite different system, six months later, in the winter of 1877.

But this has not deterred the French from officially regarding Cros as the originator of recorded sound. Both the Audio Engineering Society convention and the Féstival du Son included museum exhibitions of old recording equipment, but the Féstival show (which, unlike the AES, was open to the public) put on by far the more impressive display, which was reputedly insured for well over a million pounds. Amongst the treasures on view was an 1878 Edison phonograph and a 1910 stereo disc player. This used two separate mechanical, pick-up arms, both with its own horn, tracking a double groove on the same shellac disc.

The AES convention kicked off to a bad start. A recent hotel fire in Moscow had made the French authorities jittery, and they banned every working demonstration, presumably on the assumption that everything electric must be dangerous. Alternatively this may have been an official admission that even expensive French hotels are made of such inflammable material that one spark or overheated transistor will burn them to the ground. There were also problems, incidentally, at the British Spring hi fi show at the Heathrow hotel which followed a few weeks later. There, demonstrations were allowed but to drastically limited numbers.

Although sensible in their own right the Heathrow restrictions left queues of visitors waiting to get up to the first floor rooms and doubtless vowing never again. The limit on numbers was no more than 900 people at any one time and one estimate was that there were 500 exhibiting staff on that floor!

Cordless Headphones

In Paris, several exhibitors showed commendable ingenuity in the face of the ban on AES demonstrations. Sennheiser, for instance, simply loaned every visitor a pair of the company's new cordless headphones with built-in infra-red receiver and then transmitted the sound they wanted to demonstrate. In fact, infra-red cordless connections, either between an amplifier and a pair of headphones, must be the next domestic craze.

Infra-red links can provide very high audio quality in mono or stereo, are reasonably free from interference, and are legally acceptable because they are of a non-radio frequency nature which does not contravene any of the British Post Office Regulations.

The transmission technique used is an interesting combination of amplitude and frequency modulation. As it is impossible to frequency-modulate the fixed frequency transmitter diode, its output is amplitude-modulated with a carrier, and the carrier then frequency-modulated.

Power Boosters

Another interesting pointer to the future was the demonstration by the fairly new American firm, Setton, who had on show some amplifier boosters for use in cars and in domestic situations.

The idea is that anyone with a relatively low powered car sound system or domestic hi fi setup can buy a booster to increase its effective power. This will either make it better to cope with less efficient loudspeakers or produce more volume of sound. It's an alternative to junking everything and starting again with new, higher powered gear. But whether the whole exercise will prove cost effective is an open question.

Crosstalk

However efficiently and cleanly you boost the sound, you will also be boosting whatever distortion is contained in that sound at the same time. It follows that the system will only be useful when the original sound source is low powered but distortion-free and some audio equipment is low powered because it's cheap and because it is cheap it has a fairly high distortion factor.

From Nippon Columbia, in Japan (trade mark Denon), came signs of another new trend—crosstalk cancellers. Circuitry to cancel crosstalk is now being built into Denon amplifiers, and it is claimed to provide dramatically increased inter-channel separation. Figures of 70dB were bandied around!

Details are not yet available, but a prototype add-on unit may provide improvement in existing audio systems where crosstalk, for instance between left and right cartridge outputs, is not all it should be.

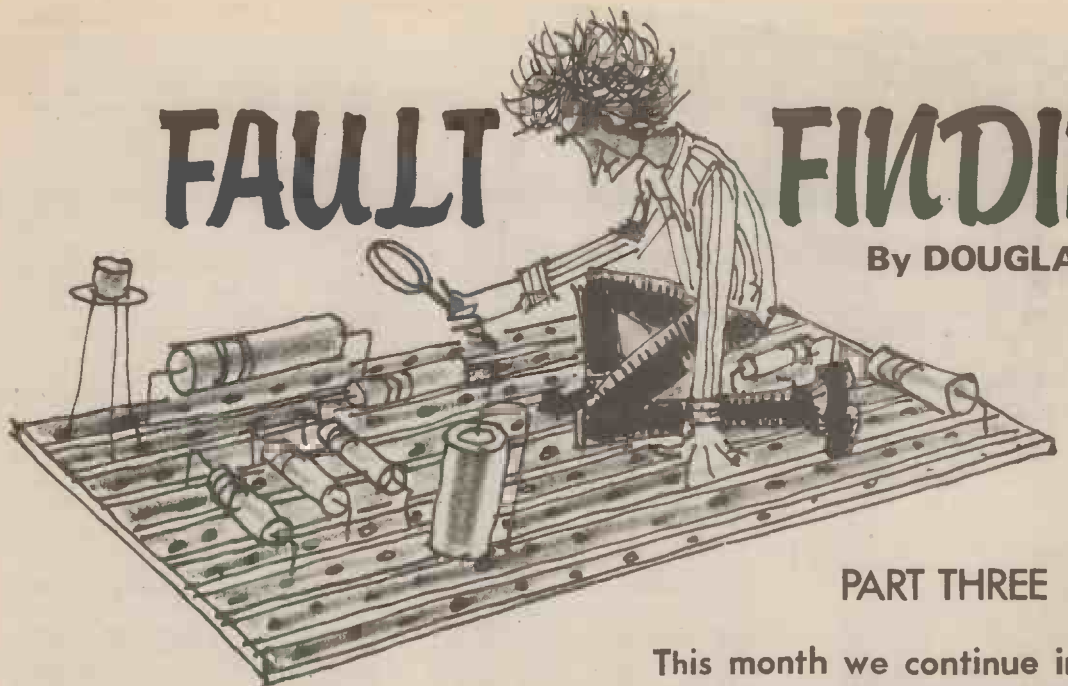
Dolby B

There were, of course, also some disappointments. High amongst these must rank the Beyer "black box" which is intended to make ordinary headphones sound like loudspeakers in a room. It's called the LSE I 'amplifier for loudspeaker simulation through headphones', but on demonstration in Paris it succeeded only in making music played through its headphones sound shrieky and unpleasant to the ear. Definitely a miss.

If ever Dolby B broadcasts get under way in the UK there will be no shortage of receivers suitable for correct reception. Dr Ray Dolby, inventor of the Dolby noise reduction system, was present at the AES and confirmed that there are now forty six different Dolby B radio receivers available in the USA with well over a hundred American radio stations equipped with the necessary encoders to broadcast in this fashion.

Finally, it may surprise and please the British firm Garrard to know that their turntables are installed in the extraordinary new public library and art gallery, the Centre Georges Pompidou near Les Halles in the middle of Paris. This building can only be described as a real, live giant multi-coloured version of the Yellow Submarine. It has, amongst a wealth of other audio-visual equipment, a rest area where weary visitors can sit and relax in armchairs, while listening over hi fi headphones to jazz or classical records played in stereo from a central control desk—it was there that I counted upwards of eight Garrard direct-drive turntables.

FAULT FINDING



By DOUGLAS VERE

PART THREE

This month we continue increasing our knowledge of fault finding by looking at fairly complex circuits.

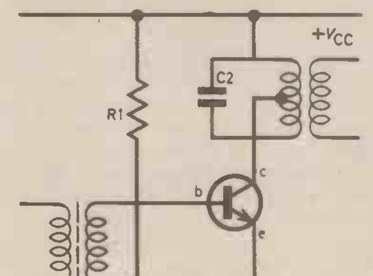
CONTINUING from last month, we now turn our attention to circuits used in transistor radios and audio amplifiers.

Referring to Fig. 3.1a, this circuit used to be very frequent in transistor radios using germanium transistors. You'll see that it's a variant on Fig. 2.1c, using the same method of biasing the transistor but different arrangements (transformers) for leading the signals in and out.

An experienced fault-finder will start by measuring the emitter voltage, because the emitter is earthed to signal frequencies by C3: connecting the meter is therefore unlikely to cause oscillation. If you try to measure the base voltage by connecting to the actual base lead-out you may provoke oscillation. A better step is to measure the voltage where R1 joins R2. This should be the same as the base voltage, since the input transformer connects this point to the base.

If the transformer base winding is open-circuited, the voltage at the R1-R2 junction will be what you expect but the emitter voltage will be zero.

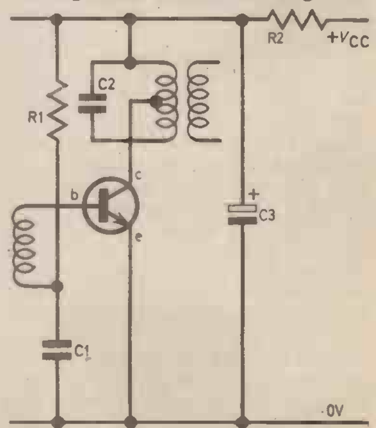
Practical radio circuits include an automatic gain control (a.g.c.) system which reduces the gain when signals are strong. It usually works by reducing the base voltage of the first i.f. amplifier transistor. So if you find that the biasing arrangement is not just R1 and R2, but more complex, you are probably dealing with an a.g.c. arrangement. Remember, in this case, that the voltages should be normal if there is no signal present. Remember also that if the whole circuit is oscillating, this corresponds to very strong signals, and the voltages will be peculiar.



(a)

Fig. 3.1a. A typical one transistor stage, used in transistor radios as an i.f. amplifier.

A modern i.f. amplifier stage, designed for component economy is shown in Fig. 3.1b. Here R2 is a decoupling resistance, which along with C3 keeps audio out of the radio part of the circuit and helps to keep radio-frequency currents inside the r.f. part. It also has a slight but useful d.c. stabilising effect, since an increase in collector current brings an increased voltage drop in R2 which reduces the voltage available for driving base current through R1.



(b)

Fig. 3.1b. This circuit is similar to Fig. 3.1a, but in this instance uses fewer components. A.g.c. in each circuit is usually connected to the junction of R1 and C1.

Again, a.g.c. arrangements may complicate the circuit, e.g. by connecting other components to R1, C1 junction. To avoid provoking oscillation, measure the base voltage across C1 and the collector voltage across C3 in the first instance.

CLASS A AUDIO AMPLIFIER

Now that you know how to swim, take a plunge into the deep end by estimating the d.c. voltages in Fig. 3.2. This is a class A audio amplifier of a type once popular in car radios. It is complicated, with three transistors all connected directly together. But don't worry. Your knowledge and common sense will see you through.

Starting with the easiest voltage: it can be assumed that the primary of T1 won't have enough resistance to drop much d.c. voltage, because that would reduce the audio power by reducing TR3 collector voltage. So TR3 collector must be at nearly the supply voltage, a nominal 14V. (Measure V_{CC}: maybe the battery is flat!)

Now look at the way one transistor is connected to another. The collector of TR1 to the base of TR2 means TR1 collector is 0·7V more positive than TR2 emitter. Similarly, TR2 emitter must be 0·7V more positive than TR3 emitter. And since TR3 emitter voltage drives base current through TR1 via R1 and R5, TR3 emitter must be at least 0·7V up on TR1 base.

Going back through this chain of voltages, adding them up on the way, you arrive at TR1 collector with 2·1V. Remember this is a *minimum* value. We neglected the voltage drops in R1 and R5 (typically about 0·2V). Also, TR3 is a power transistor operated at a high current (as you can see from the low valve of R6). This is one case where our carefree approximation that its V_{BE} equals 0·7V is likely to be wrong: with some power transistors it could be as high as 1·2V.

Never mind. We have still got a reasonable estimate of TR1 collector voltage (about 2V). This leaves 12V across R2 (22 kilohms) which puts the current in R2 at (14−2)V/22kΩ = 0·6mA approx. Not all this is TR1 collector current: a small portion supplies TR2 base current.

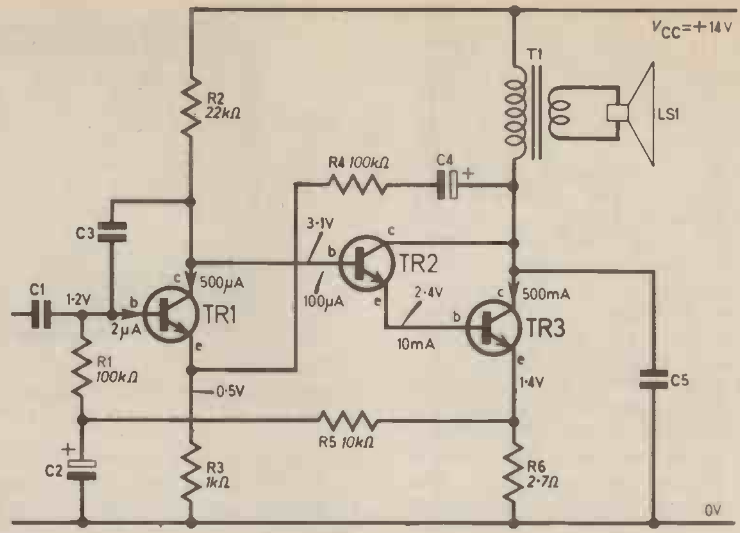


Fig. 3.2. Circuit of a typical class "A" audio amplifier as used in many car radios

In a well-designed circuit, the base current should be much less than the collector current. Allowing one-sixth of the 0·6mA for TR2 base current leaves 0·5mA for TR1 collector current. This immediately enables us to get a much better estimate of the voltages. Why? Because 0·5mA in R3 raises TR1 emitter voltage to 0·5V. So TR1 base is now at (0·5V + 0·7V) = 1·2V. Allowing 0·2V in (R1 + R5 gives 1·4V at TR3 emitter. The base of TR3 (using 1V for V_{BE}) is at 2·4V, and TR2 base (= TR1 collector) at 3·1V.

If you like, you can now recalculate the current in R2 and carry out the whole process again. But you'll find that the answer is not very different.

We've been carrying out what mathematicians call a process of successive approximation, which means that the more times you do it the closer you get to the truth. In electronic engineering, however, there are so many variables (such as resistor tolerances) that there's no point in going on.

We can now fault-find with the voltmeter with reasonable confidence. Before starting, just work out the current in TR3. With 1·4V across R3 (2·7Ω) it is 1·4V/2·7Ω = 0·5A approx.

Now, assuming no d.c. voltage drop in T1 primary, there is (14 − 1·4)V = 12·6V across TR3. The power (in watts, W) dissipated in TR3 is (collector to emitter volts *times* collector current) = (12·6 × 0·5) = 6·3W.

To get rid of this, TR3 needs a good big heat sink. If the bolts which clamp it to the sink work loose, TR3 can overheat and burn out. So if tests reveal that TR3 is no longer in the land of the living, make sure that its successor is clamped firmly in place.

Incidentally, the d.c. power dissipated by TR3 is roughly twice the maximum undistorted sine-wave r.m.s. power output. (This is true of class A amplifiers like this. Class A means that the transistors conduct the same d.c. current all the time, whether there's an a.c. signal or not.) So the audio power will be about 3W. This is useful to know because if it turns out that the loudspeaker is faulty you need to replace it with one which can take the full power.

LEAKY CAPACITOR

Let's put in a few plausible faults and see what happens. First, leaky electrolytic capacitors. If C2 leaks, TR1 is deprived of base current. So its collector current falls and its collector voltage rises. Transistors TR2 and TR3 base voltages rise and these transistors pass more current.

The d.c. negative feedback in the circuit (whereby the increased current produces an increased voltage across R6 which tends to turn on TR1 and remedy the error) can only work up to a point. If C2 leaks badly, TR3 passes a lot more collector current than it should. In a power transistor, this can easily spell disaster plus an internal burn-out.

Clearly, if TR3 *has* gone west, C2 must be carefully checked. This can be done, without removing it from circuit, by connecting a resistance from V_{CC} to TR3 emitter, low enough to pass about 0·5A. You haven't got such a resistance, of course (you need 25 ohms, rated at 6W or more) but perhaps you have a 12V, 6W car bulb? Connecting this will put something like the normal voltage at TR3 emitter. If C2 is all right there should be very little voltage lost in R5, so the voltage across C2 should be practically the same as at TR3 emitter (which you measure, of course, since your car bulb probably passes a current different from the nominal 0·5A).

VOLTMETERS—OHMS PER VOLT

This is a very convenient point for raising one of the great bogeymen of voltage measurements. I have a test meter which, if used on its 10V range to measure the voltage across C2, would register just half the voltage of TR3 emitter, *even if C2 were perfect and not leaking at all.*

The reason is that the meter itself takes so much current that it produces a significant voltage drop in R5. Look at it this way: the meter takes current, so it has resistance. This resistance is connected across C2. Current flowing through the meter resistance via R5 reduces the very voltage you are trying to measure.

My meter (on its d.c. voltage ranges) has a resistance which is given by its makers by the mysterious formula "1,000 ohms per volt d.c.". This means quite simply that when switched to its 1V range, its resistance is 1000 ohms (1 kilohm). On its 10V range, 10 kilohms; on 100V, 100 kilohms and so on. When switched to the 10V range and connected across C2, it puts 10 kilohms across C2. This, being the same as R5, must reduce the voltage to half what it should be. (In practice, some current passes through R1 also, and TR1 base, so the voltage is reduced a little further, but as it is only a few microamps the effect is negligible.)

One answer to this problem is to use a more sensitive meter. One rated at 20 kilohms per volt, on a 10V range, puts 200 kilohms across C2 and the error is small (it reads about 5 per cent low).

A modern example of a multimeter, having excellent ranges. One attraction is the use of a "mirror" scale.

If you haven't got a more sensitive meter, switch to a higher range. On "100V d.c." my 1000 ohms per volt meter is 100 kilohms, which is ten times R5 and so gives an error of about 10 per cent (actually 9 per cent, reading low, of course). The price you pay is that the meter needle hardly moves, and the voltage is hard to read. Even so, your meter may still be usable, since high accuracy is not required here.

If the capacitor does seem to be leaky, unsolder the positive lead, having first noted the voltage measurement carefully, then measure again. If it is leaky, the second voltage must be higher than the first. Note however that all electrolytics leak a little bit: but in this circuit a leak of a few microamps should have little effect on the voltage levels.

To return briefly to meter specifications, your meter should have a rating of at least 1000 ohms (1 kilohm) per volt d.c. In general, the higher the ohms per volt the less risk there is that the meter will read low when connected to a circuit with high resistances in it.

Mental arithmetic gives a quick check. The meter's resistance on a particular voltage range is the range voltage times the ohms per volt rating. This, for reasonable freedom from error, should be at least 10 times the resistance at the point where the voltage is measured.

For example, to measure the collector voltage of TR1 where the resistance must be something approaching 22 kilohms, you need at least 220 kilohms for the meter. Thus a 20kΩ/V meter on a 10V range, giving 200 kilohms is a little on the low side but the same meter on a 30V range (600 kilohms) is all right. The meter reads low by a fraction which is easily calculated:

$$\text{Error} = \frac{\text{Circuit resistance}}{\text{Circuit resistance} + \text{meter resistance}}$$

Example. A meter of 10kΩ/V on 10V (100 kilohms) connected to a point whose resistance is 20 kilohm gives an error (low reading), from above, of 20/120 = 1/6. In most cases it is all right to use an approximation:

$$\text{Error} = \frac{\text{Circuit resistance}}{\text{Meter resistance}}$$

This comes to 1/5 for the example just given. Not accurate, but near enough for most test purposes.

High accuracy is seldom needed in fault-finding on ordinary domestic equipment. It is seldom obtainable anyway, because the average cheap test meter is only accurate to about 3 per cent on its d.c. ranges: 5 per cent is usable and 1 per cent is very good. On the whole it's better to go for sensitivity (high ohms per volt) and handiness than accuracy. But on the other hand, it may pay to go for robustness (the ability to survive overloads, for example) rather than sensitivity.

To get back to our circuit. A leak in C4 passes extra current through R4 and R3, which tries to turn TR1 off and therefore TR2 and TR3 on, with possible damage to TR2 or TR3. A sustained high current here may well cause R6 to overheat (watch for charred paint) or burn out.

If R6 does burn out and go open, base current for TR1 can still flow to earth via R5, R6, so the circuit voltages may not change very much.

One circuit voltage, which we've ignored, so far, will change dramatically. This is the small voltage across T1 primary, due to the collector current flowing in the resistance of the winding. If the resistance is 0·1 ohm and the current 0·5A the voltage drop is 0·05V. To measure this it's necessary to depart from our usual practice of connecting one side of the meter (negative, for this circuit) to earth. We must instead connect meter negative to TR3 collector and meter positive to V_{CC} (+14V).

Always start with a voltage range high enough to take *any* voltage in the circuit i.e. up to 14V here, then switch to progressively lower ranges. Most meters have a 1V range on which 0·05V is easily measured.

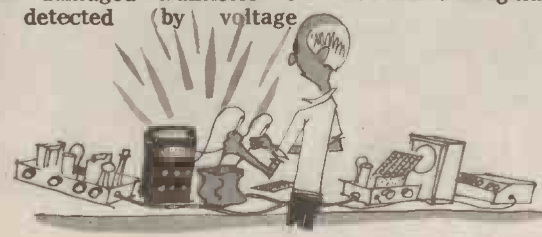
If R6 is open circuit, there is no collector current to speak of and the meter reads zero. Note that it does not follow that a reading of zero proves that R6 is burnt out. A damaged TR3 or TR2 could produce the same effect, for instance.

TRANSISTOR FAILURE

The commonest faults in amplifiers like this are transistor faults, especially damage to power transistors, which are often operated uncomfortably close to their maximum power dissipation ratings and are therefore vulnerable. A damaged transistor is easily detected (by voltage measurements discussed earlier in this article). But it is dangerous simply to replace a transistor without first trying to find out why it got damaged. If you don't find out, when you replace the faulty transistor the same fate may overtake it again, which can be expensive. So try to check resistances, capacitors, even things like ventilation of the equipment, before replacing the faulty component.

In fault finding you are seeking the abnormal: this calls for a non-electronic faculty which we all possess but don't always exercise. It's called imagination.

To be continued



Measure V_{cc}, maybe the battery is flat.

THE French have a saying, "The more things change, the more they remain the same" and I remember this point being very well illustrated by a cartoon film.

It showed a bunch of boffins working away to supply higher and higher octane petrol as the aircraft engineers kept raising the compression of their engines. Finally the boffins went to the engineers and said, here it is, the ultimate, 120 octane. The engineers raised their weary heads and said, "Oh! we do not need that, all we need is parafin".

Apparently while the boffins were prodigously working away, young master Whittle had invented the jet engine!

Even so I have always told myself this cannot happen to electronics. Wrong again! Just as I am about to consign my valve transformers and coils and chokes to the dustbin, someone invents the f.e.t. and we are back in business again. Full marks to the French.

Component Show

It is usually a pleasant break for me at this time of the year to go to the Paris Electronic Components Show, in fact I have urged readers to go at least once to see one of the largest international exhibitions of its kind, certainly in Europe and spend a night in Paris. I persuaded one of my young friends to go this year, and he said, yes I am going and I am coming back the same day. I told him that anyone who went to Paris and came back the same day is only fit for incarceration in a nut house. Last Saturday on his return, I eagerly asked him, "How did it go!" "It did not", he replied. "Those dear kind maintenance men at Heathrow airport went on strike, and I had a choice of returning the same day or not at all."

Words fail me!! Come to think of it I did not go either, although it is only the second time I have missed it in twelve years. This was because it clashed with the Easter school holidays and the last time this happened I could not get a seat on the boat let alone the trains!

Guide For Buyers

I was very impressed with the *Buyers Guide* which appeared in the April '77 issue. The only thing it cannot show is strengths and weaknesses of various suppliers. This implies no criticism because I think what I am suggesting is impossible.

For example, supplier *A* stocks three values of variable capacitor supplier *B* stocks thirty three values of the same item. When they filled in the questionaire, they both quite rightly put a tick against "variable capacitors".

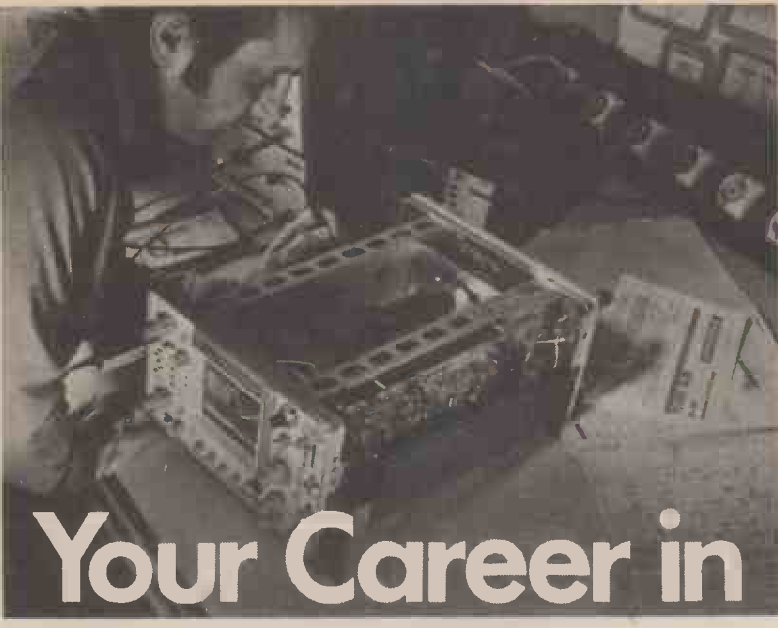
This *Buyers Guide* is a splendid quick, handy reference of who stocks what, but if you are a serious constructor, and I am sure you are one in the making, lay out some money on as many catalogues as you can afford and then compare them section by section.

Emergency Measures

The late Duke of Windsor had a motto which I have always liked "Adopt, Adapt, Improve". I did just this the other night when my wife said that she could hear water running. I opened the larder door and beheld Niagara Falls in miniature.

The trouble was quickly tracked down to a blocked overflow pipe in the main storage tank in the loft. This, combined with a sticking ball cock valve produced the deluge.

Unfortunately it will be several weeks before the plumber can replace the overflow pipe and all the while, we are at risk. My answer was to fix up a rain warning device in the tank, so if the water rises a little higher than it should, it wets the sensor, and rings a bell in the kitchen. So do not forget, in an emergency, *Adopt, Adapt, Improve!*



Checking out a Solartron/Schlumberger Type 5212 oscilloscope.

Your Career in Electronics

by Peter Verwig

WE ARE now half-way through 1977 so this is as good a time as any to review the electronics industry as a whole. Where is the industry going, how does it fit in with industry in general, what are its long-term prospects, is it really worthwhile as a career?

When I started my own career in electronics some 40 years ago the bulk of the business was in communications of one sort or another. Electronic capital goods was largely in broadcast equipment and professional quality transmitters and receivers for organisations like the Post Office and the armed services. Consumer goods were the traditional broadcast receivers and the first generation of TV receivers which were then an expensive but exciting luxury. It was much easier to identify what electronics was all about.

TECHNOLOGICAL EXPLOSION

In just two generations, electronics has enjoyed, perhaps suffered would be a more appropriate word, a technological explosion. Whole new sectors of electronics have come into being and spun themselves off as industries in their own right, the supreme example being the computer industry.

Very few sectors of general industry and commerce are now free from the influence of electronics. The old style copper pounding his beat never had a two-way radio in his pocket. The steel worker never imagined that his heavy and unpleasant job would one day be transformed into dial-watching and button-pushing. The small-time offshore fisherman used to get by with a magnetic compass, a good weather eye and a lot of instinct. Today he has an electronic fish-finder, two-way radio and radar. There are countless other examples.

And on top of all this the man or woman as an individual may well sport an electronic watch, have an electronic calculator in the pocket or handbag and go home to a whole range of electronic products, radio, TV, hi fi on disc or tape or both, push-button telephone with built-in memory, burglar alarm, TV games, electronic toys in the nursery, an electronically programmed washing machine. Again we have what appears to be a boom situation with industry and commerce using more and more electronics to stay in business and with the consumer hooked on electronic entertainment and household aids.

If we look at the penetration of electronics into our daily lives it is clear that we are becoming more and more dependent on electronic products in all their variety. This must be the best business in which to build a career. Or is it?

PARADOX

Paradoxically, this great modern industry called electronics, while creating new employment in itself, generates products which create unemployment elsewhere. Automation controlled by an electronic brain increases production and uses less people and that's what progress ought to be all about. In theory, automation promised less unpleasant repetitive work and shorter working hours, the abolition of drudgery for millions, and with a shorter working week it was thought there would be more leisure time for ordinary folk to indulge in activities of their own choice.

Well, it hasn't worked out like that. People lucky enough to be in full employment are generally still working as many hours a week as before and the unemployment figures tell their own story. But this sorry tale is not the fault of automation or electronics. It is because we have failed to take account of the impact of applied science on our social structure. Utopia is still a long way in the future and may never come.

REDUCED STAFFING

You would imagine that with the vast production of electronics which is displacing people in industry and commerce there would be a corresponding large influx of people into the electronics industry. To begin with, this had some truth. There was a rapid expansion of people in the electronics workforce when equipment still used valves and when every interconnecting wire had to be cut to length, stripped, tinned and hand-soldered point-to-point.

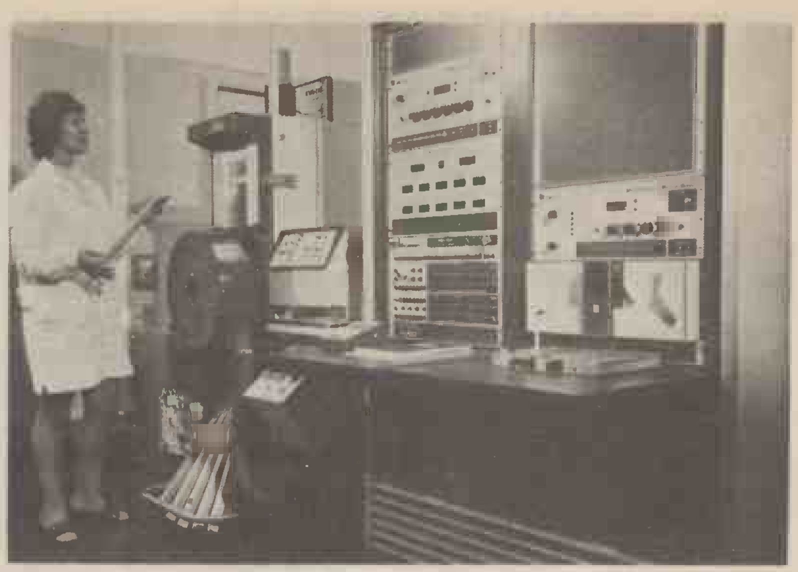
Electronics hardware is no longer built in this way. Today, the industry is geared to the printed circuit board, the integrated circuit and to flow soldering. As a consequence, although the value of production of electronics equipment rises year after year this is achieved with less people or, at most, the same number of people.

In short, electronics production has itself become automated except in those cases where the equipment is so specialised and is produced in such small quantities that automating the process would be uneconomic.

SKILLED OPERATORS

In some cases there is no option but automation. Let's take a simple example of testing a simple semiconductor memory of only 256 bits. If you gave one of these to a skilled tester equipped with power source, meters, notebook and pencil and told him or her to test completely all its possible combinations and functions it would take over 100 years at normal working rates to do the job. With modern automated test equipment an infinitely more complex 64,000 bit memory can be tested with a high level of confidence in 30 seconds.

Let's take another simple example. When a young person on Racal Instruments' production line inserts a 24-pin component into a printed circuit board of a 99 Series frequency meter or counter-timer, he or she needs no particular knowledge of electronics and only a little manual dexterity. The whole operation takes only a few seconds. And yet the equivalent of 5,000 discrete components of the old type are now in circuit, fully wired and already pre-tested.



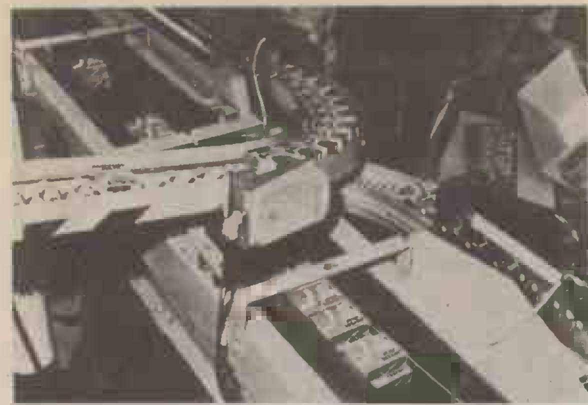
Automatic tester and grader for MOS semiconductor memories at the Mullard, Southampton, plant.

Using the old methods the finished instrument would be ten times the size and weight, would take months to wire up and test, would be less reliable in use, and would cost so much that it couldn't compete in the world market as the 99 Series does, and not least in the United States where it sells well.

Fine for Racal whose assembly costs are saved by this little miracle of Large Scale Integration (LSI). So you may now imagine that because a lot of the assembly time of the instrument has been saved by an LSI circuit the labour has been transferred to the semiconductor manufacturer, in this case Ferranti. Not so, because once you have mastered the art of semiconductor manufacture the automated process couldn't care less if a chip has one component, or a hundred or five thousand in it. The design of the circuit, the mask making and similar pre-production activities and the final mounting of the processed chip and its testing are a different matter and are related to electronic engineering rather than production.

The point is that with each jump in technology there is no corresponding jump in employment at production level. Good electronics manufacturers have doubled and trebled the value of their manufactured output, even after allowing for inflation, with no general increase in production staff during the past five years and in many cases with less production people.

Modern radio communications exemplified by this Marconi drive unit and I kilowatt fast tuning transmitter.



Herbert photo-electric control system on an automated packaging line for Chivers Jelly at Cadbury-Schweppes factory at Histon, Cambridgeshire.

Electronics in the office. Siemens keyboards and visual display units keep track on the availability and order processing of 36,000 different spare parts.

THE ENGINEER

What is being sold today from the electronics industry is technology, not labour. So if you want to build a career in electronics the best area is in technology because this is where the growth lies and where there is a long-term future. The good engineer will always be in demand as part of a design team, or as a test engineer, or an on-site commissioning engineer, or as a qualified service engineer.

To be an electronics engineer you don't need to work in the electronics manufacturing industry. As electronics has now penetrated most human activities an electronics engineer may easily find himself working on electronics in the gas industry, petrochemicals, in the aircraft industry or dozens of others which are users of electronic equipment. The field is very large and the opportunities are world-wide. Once you are qualified there is no reason why you shouldn't find work overseas.

MONEY MATTERS

But what about the rewards? Electronic engineers are a happy breed. It is fascinating work and most wouldn't want to do anything else. But the fact has to be faced that in the past three years the trend in wages policy in the UK has increased the earning power of the lower paid unskilled worker to a level where the skilled person with years of training is no better rewarded in cash terms than those who have never bothered to develop their talents. More recently, however, there has been pressure for the wages pendulum to swing back in favour of the skilled.

The levels of income of qualified engineers were recently revealed in the annual survey of the Institution of Electrical Engineers whose membership embraces a very large number of electronics engineers. The survey was based on a questionnaire sent to a representative sample of 16,000 members (40 per cent of the total membership) of which 9,623 gave details of their salaries as at January 1, 1977.

Taken right across the board of all grades of membership, i.e. Fellows, Members and Associate Members, the average member was getting £5,890 a year compared with £5,370 at the same time in 1976, a year-on-year increase of just under 10 per cent. This is lower than the average wage and salary increase for the nation as a whole and well below the rate of inflation. So the average qualified engineer started 1977 with a worse position than before and his relative position in the wages and salary league table continues to decline and with it his relative standard of living.

The overall average of £5,890 is arrived at by including all the senior people, managers, directors of research, production managers and in the academic scale those with second or third degrees, the sort of people with long experience commanding salaries up to £11,000. This may sound a lot but it is only reached by those over 35 years of age, often not untill 55, and reflects heavy managerial responsibility.

If we look at the lower end of the scale we find Associate Members of the IEE getting as little as £2,850 as development engineers in the under-24 age group and £3,500 in the 25 to 29 age group. The figures quoted are the lower quartile, the figures being those below which 25 per cent of the sample fall. This means that many development engineers are receiving less reward than the figures at first suggest. And they are the levels of incomes that are now scoffed at by unskilled workers in many other industries or even by unskilled workers in the electronics industry itself.

An interesting fact, once again highlighted by the present survey, is that earnings of those in the public sector of employment in the various age groups are generally about £1,000 a year ahead of those employed in the private sector of industry. And it comes as no surprise that the highest salary levels are obtained in Greater London and the South East.

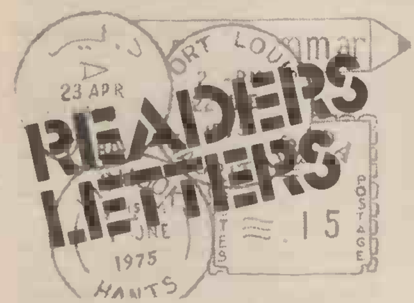
When looking at these salaries one has to remember that they refer to Associates, Members and Fellows of the IEE. Reaching the status of Chartered Engineer granted by the IEE takes a minimum of seven years during which time the would-be engineer has to acquire the right mix of academic qualifications, training and industrial experience. The requirements to achieve the status of Technician Engineer are less arduous but, naturally, the rewards in pay are proportionately less. There are plenty of unskilled and semi-skilled jobs going which pay just as well as the lower echelons of electronics engineers and for which the training required can be measured in days or weeks.

DEMAND

So is it all worth the effort? Let us for the moment forget the financial reward which, admittedly, is ridiculously poor at this time but has every hope of being adjusted in the near future. Let us instead look at the overall employment situation in the UK, in mainland Europe and in the United States. Every one of these areas has an unemployment problem and the great bulk of the unemployed are unskilled. A glance through the job advertisements in newspapers and technical journals shows that the demand for electronics engineers is entirely undiminished.

No qualified electronics engineer needs to be unemployed unless through his own fault, either through laziness or perhaps because of his reluctance to move to another area. What needs to be decided is whether you want just a job or an interesting career.. In the one you can be just a works number to be laid off in bad times, in the other a valued member of a team. Looked at in this light, the electronics engineer with his personal investment in sought-after skill is indeed fortunate.

Decca Radar's Airfield Surface Movement Indicator (ASMI) bright display, one of four, in the Visual Control Room at London Airport, Heathrow. Similar equipment, had it been installed at Tenerife, would probably have prevented the largest air disaster ever experienced last March.



Physics Is Fun

I was prompted to write on seeing the *Physics Is Fun* article in the May '77 issue concerning wave travel. I should like to point out that in our school the *ripple tank* is still used. This is a slight advance on the water tray shown in the article.

However in our experiments, one problem encountered was that the waves moved too fast to be seen. Nevertheless the waves can be made to appear stationary by moving a hand rapidly backwards and forwards in front of the eyes with the fingers spread slightly apart. Of course a better stroboscope can be made using a rotating disc with slits cut around the edge.

Another modification uses a motor instead of a bell to make the ripples.

Finally another experiment showing the principle of refraction can be set up by virtue of the fact that waves travel more slowly in shallow water than they do in deeper water.

A piece of glass or similar material is placed in the tank to make a shallow area. In order to obtain clear results "straight" waves must be made. These are made with the edge of a ruler instead of a point source.

The waves are bent over the shallow area. This is analogous to the bending of light when it enters glass or water.

Matthew Page,
Cheltenham,
Glos.

Wiper Delay Unit

I am a university graduate studying Electrical and Electronic Engineering. I therefore take an interest in your magazine. One article which particularly interested me, and one which I built was the *Wiper Delay Unit* in the Feb. '77 issue.

However, when the unit I made was tested the thyristor did not stop conducting when it should have, and the wipers continued to work as normal. This was due to a heavy back e.m.f. generated when the windscreen wiper was switched off, by the magnetic field collapsing. Switching transient voltages then occur keeping the thyristor conducting all the time.

I found a cure for this was to place a $1\mu F$ capacitor across the existing windscreen wiper switch. This capacitor limits the rate of rise of the anode voltage of the thyristor. My windscreen wiper motor is a field wound type.

I hope this information may be of use to other readers who might have experienced similar problems, and serve as a suitable remedy.

P. G. Long,
Pen-Y-Can,
Cardiff.

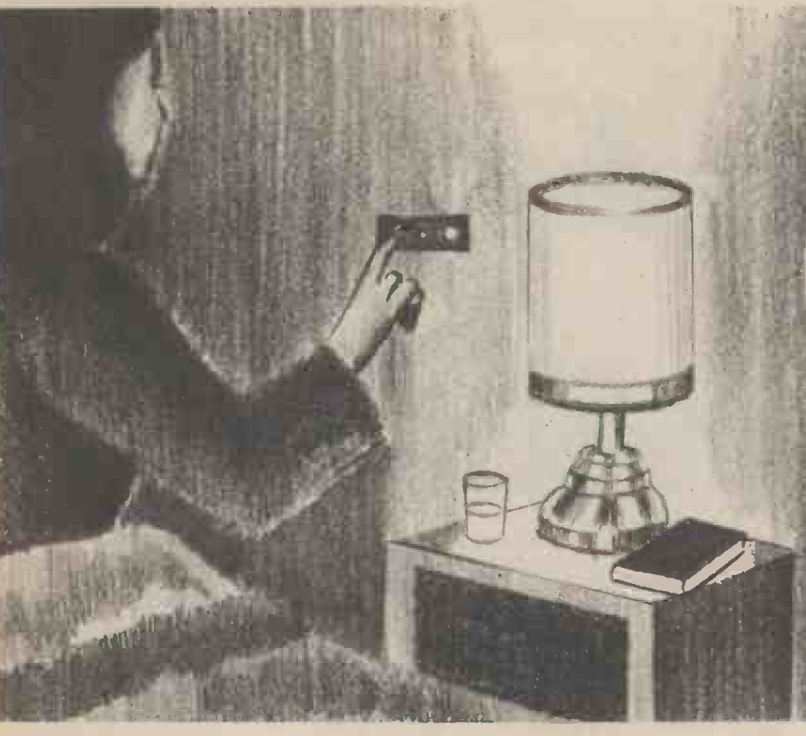
Thank you for taking the trouble to let us know of your fault and its cure. We are always pleased to receive such helpful information.

Electronics Club?

I have recently taken an interest in EVERYDAY ELECTRONICS magazine and would be pleased to know if there are any clubs or such-like in the Dublin area for beginners in electronics.

Charles Griffin,
25 Whitehall Park,
Terenure,
Dublin 12.

Unfortunately we know of no electronics clubs in the Dublin area, but hope that any readers who can supply this information will write to you at the address above. You may be interested to know that a Teach-In course aimed at the beginner will be starting in this magazine later this year.



TOUCH OPERATED POWER SWITCH

By R.W. COLES & B. CULLEN

A novel circuit which has the ability to control a wide variety of appliances.

THIS project is simple to build and operate, and can be used to control a wide variety of a.c. mains appliances in complete safety.

Switch operation is achieved by the lightest finger touch on the appropriate ON or OFF pad, and the state of the switch is indicated by an l.e.d. (light emitting diode) adjacent to the touch-sensitive areas. The active components are housed in a small plastic box, while the small laminated plastic control panel is on flying leads so that it may be mounted independently for a neat appearance.

FOR GUIDANCE ONLY

ESTIMATED COST OF COMPONENTS excluding V.A.T.

£7.00

excluding case

The touch switch principle is well known of course, but many designs published previously have been unable to handle worthwhile switch loads, or have been limited to specialist low voltage applications. By employing a heavy-duty relay in the design, the circuit is able to switch up to 3 amps a.c. or d.c. at up to 250 volts.

The need for such a design has become increasingly obvious to the writers but was prompted in the first place by a letter from a dairy farmer in Northern Ireland, who was having a lot of trouble with a mechanical switch installed in his milking parlour.

We cannot be certain that this switch will solve his problem, but it has already found lots of uses in the domestic environment with the prototype in constant use as a bedroom light switch, a job for which it is particularly well suited due to the "easy-find" l.e.d. indicator which is *on* when the load is *off*.

CIRCUIT OPERATION

The touch switch circuit shown in Fig. 1 is based on a design by Texas Instruments and uses junction field effect transistors (j.f.e.t.s) as the sensing devices and a thyristor bistable to provide the necessary latching control for the relay.

The touch pads are connected to the gates of a pair of f.e.t.s. which have 10 megohom resistors linking their gate and source so that the bias level is set under quiescent conditions. Field effect transistors have characteristics quite similar to thermionic valves including a very high input impedance, and with a resistor linking source and gate the sensing devices are normally on so that their drain terminals tend to fall to zero volts, and will remain in this condition until a negative gate voltage is applied.

Experienced constructors will remember the buzzing noise that resulted when the grid of a valve in an audio amplifier was touched with a finger, it is this principle, caused by the human body acting as an aerial and picking up induced voltages from the 50Hz mains supply, which is used here to energise the touch pads.

The induced voltage which is being picked up by the human body, is applied via, say the finger, to the touch pad. The f.e.t. associated with the particular touch pad is turned off at a rate of 50 hertz as this voltage swings

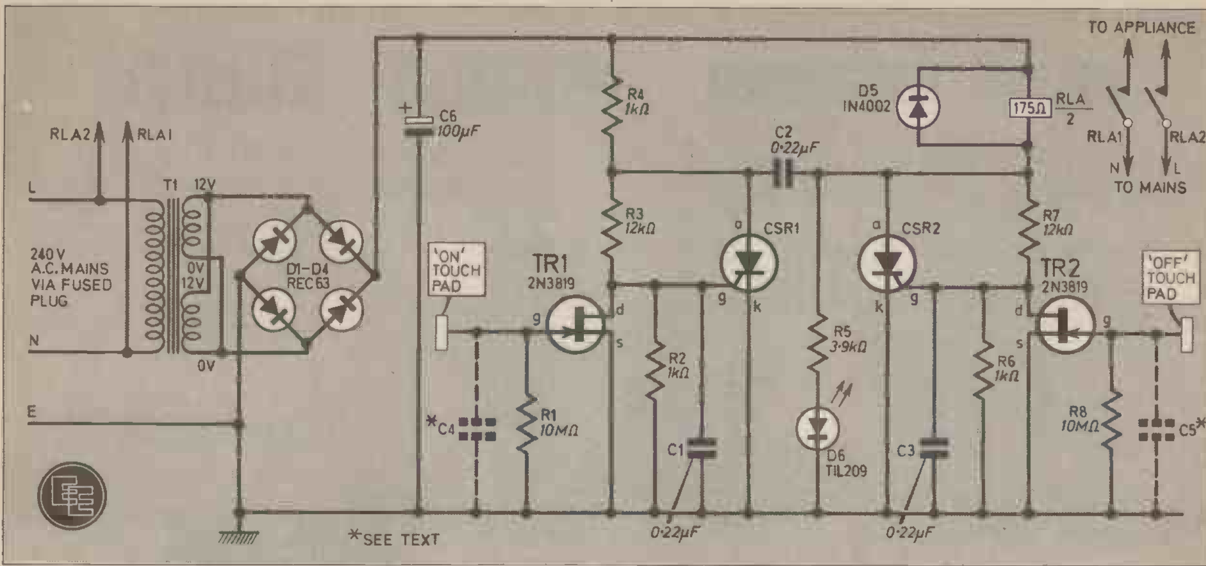


Fig. 1. Circuit diagram of the Touch Operated Power Switch.

negative. This results in a 50 hertz square wave appearing at the drain terminal of the f.e.t., this in turn triggers one side of the thyristor latch. Once the thyristor has been triggered it will turn on and behave like a forward biased diode, effectively connecting its anode load, either resistor R4 or relay RLA to zero volts.

This action also shorts out the supply voltage to its respective f.e.t. sensing circuit, which can then have no further effect on the operation of the circuit until the latch is reversed by operation of the other pad and its associated sensing circuit.

When a thyristor is made to conduct, it cannot be turned off again until the current through it has been reduced to zero, this can best be arranged by taking its anode voltage negative with respect to the cathode. With two thyristors connected as a bistable latch, it is necessary to make the "on" state of one device turn the other off, and this is made possible in this circuit by the coupling capacitor C2.

With thyristor CSR1 conducting, C2 becomes charged to the supply voltage with its left hand end negative at a voltage just above ground. If now thyristor CSR2 is triggered, the right hand end of capacitor C2 is shorted to ground and so the left hand end must momentarily move *below* ground, turning off CSR1 and allowing its anode voltage to return to a positive level, re-enabling the touch sensing circuit and recharging C2 with the opposite polarity.

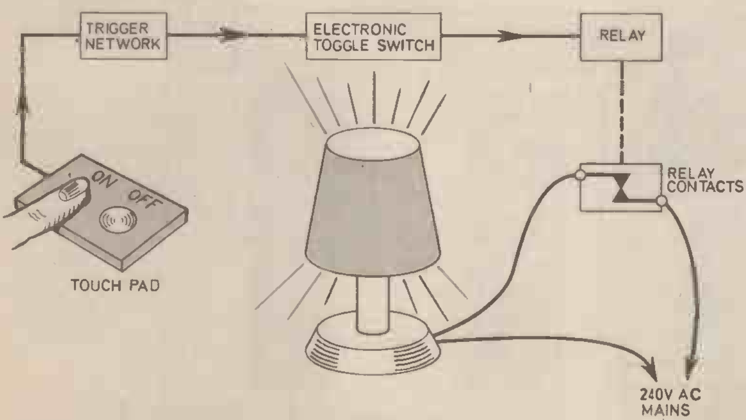
The circuit is of course symmetrical except that the thyristor load on one side is a resistor and on the other a relay, and that an l.e.d. with an associated current limiting resistor R5 has been connected on one side to give a positive indication that the relay is *off*.

SENSITIVITY ADJUSTMENT

In just the same way that a human body acts as an aerial to operate the circuit, so would long pieces of wire used to connect the touch pads to the main assembly, with unfortunate results such as random operation or *sticking*.

For this reason it is best to keep the distance between the touch pads and the sensing circuit fairly short, although the effect of long connections can be reduced by reducing the value of R1 and R8, which lowers the sensitivity. Adjustments of this kind should be made with the switch installed in its final position, since 50 cycle field strengths can vary

HOW IT WORKS



Mains hum picked up by the human body induces a voltage via the ON pad when touched, to the circuitry. A trigger voltage is produced and this is fed to the electronic switch which turns on and "latches" on. This causes the relay to be energised, and via its contacts the electrical appliance to be switched on.
Touching the OFF pad causes a similar action to take place and the relay to be de-energised thereby turning off the appliance.

TOUCH OPERATED POWER SWITCH

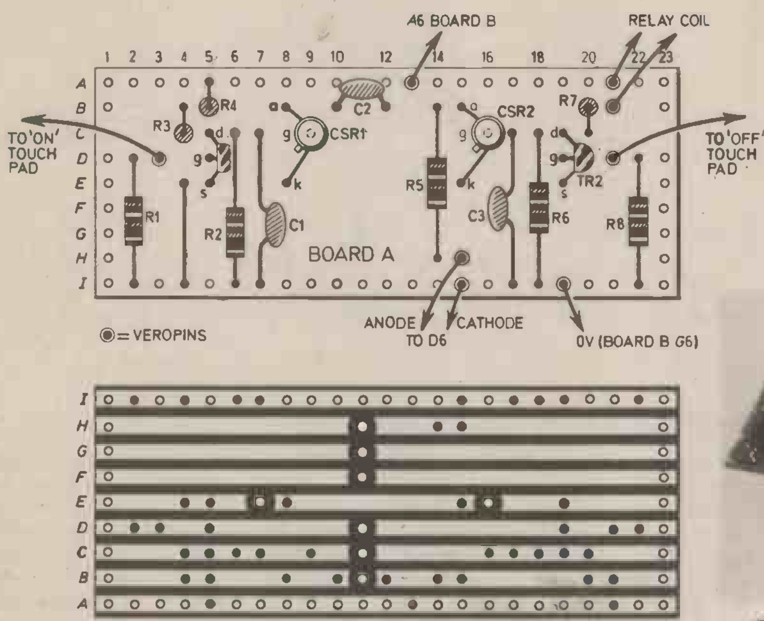
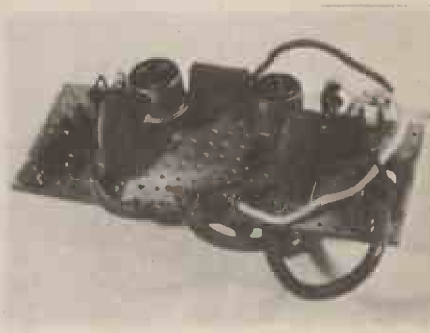


Fig. 2. Layout of the components on the stripboard, also showing the breaks required on the underside.

Photograph (below) showing the finished layout of board A (Fig. 2.).



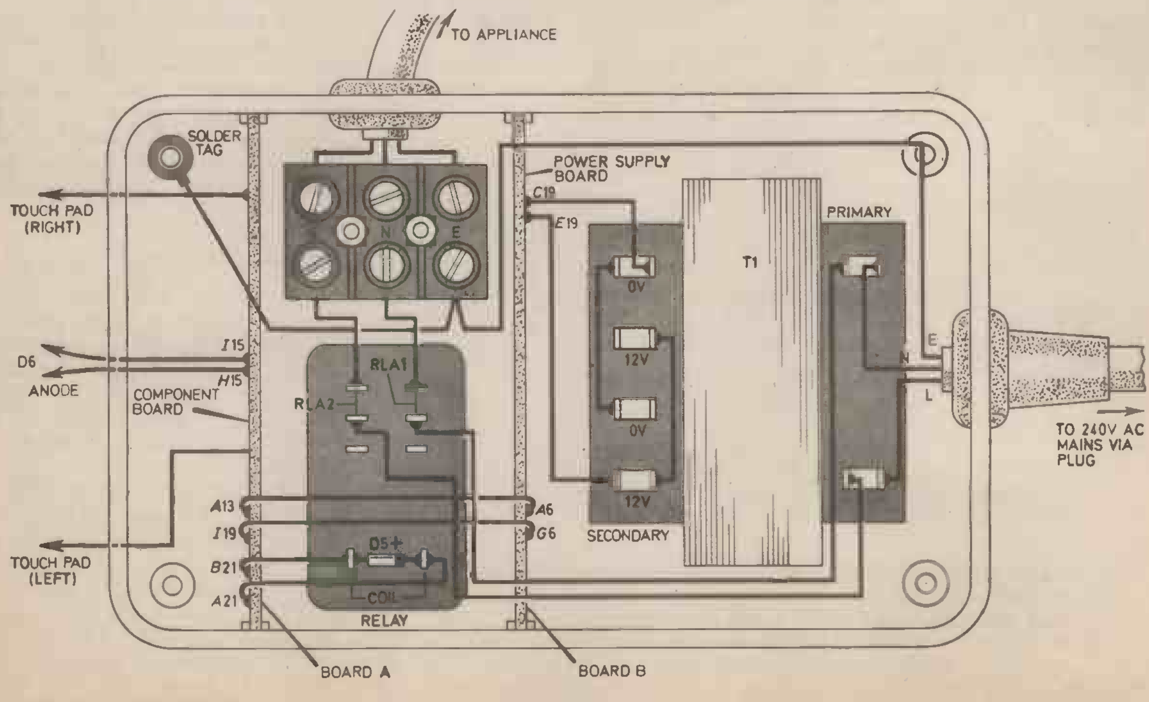


Fig. 4. Interconnections required between the two boards and transformer, etc. The wire from the E terminal on the connecting block goes to a solder tag which is trapped under the lid when fitted.

throughout a building, altering the apparent sensitivity.

Capacitors C1 and C3 are necessary to ensure that the thyristors are not triggered by noise spikes on the a.c. supply whereas capacitors C4 and C5 are not always necessary, but if included in the circuit can prevent false operation and over sensitivity in areas of high r.f. field strength, 500 pF being the maximum value normally required.

The d.c. power requirements for the circuit are not at all stringent and so a simple transformer, bridge rectifier, and capacitor combination is all that is required to produce the nominal 12V d.c. The transformer is necessary to provide complete isolation of the sensing circuitry from the mains supply for safety reasons, as well as to provide the low voltage a.c. input for the rectifier.

CONSTRUCTION

The entire circuitry is housed in a 130 x 100 x 50mm plastic box which has a steel front panel used here only as a lid. The chosen box is sturdy and yet easy to drill, and has the advantage of built in slots to accept circuit boards.

Two 0·1 inch matrix stripboards 9 strips by 23 holes are used to support the small electronic components used. These are fitted transversely into the slotted box. The mains transformer is by far the largest component, and this is fitted, tags uppermost, at one end of the case near the mains input lead.

The relay is installed between the two circuit boards, next to the output terminal block, and is secured with tags uppermost by means of a bolt which passes through its plastic cover and the bottom of the box. Layout of the main circuit board (board A) is fairly spacious and straightforward as can be seen from Fig. 2 which also shows the track breaks which must be made. Terminal pins were used on the prototype boards as anchor points for the wires, although this is not essential and can be omitted if desired.

The power supply board (board B), shown in Fig. 3, is empty apart from the bridge rectifier and the smoothing capacitor, but mounting these components in this way defines their position accurately and allows them to nestle alongside the transformer when installed in the case.

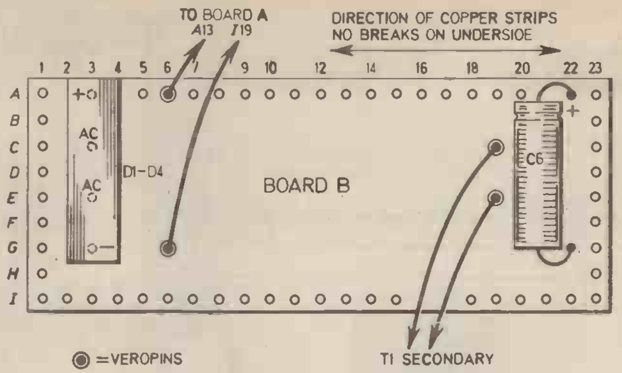


Fig. 3. Stripboard layout of the power supply, board B.

INTERCONNECTIONS

The number of interconnecting wires are small but because much of the circuit has lethal mains voltages, which are carried by some of these links, particular care must be taken that the wire is adequate for the job, and that joints are well made and protected with sleeving where necessary.

The pair of wires from the mains transformer primary to the relay contacts, and the pair from the relay contacts to the terminal block are the mains voltage links, and the best wire to use for this job is the blue and brown core wire stripped from a length of the main supply flex which should be good quality p.v.c. cable rated at 6 amps or more. The other links can be made with standard flexible hook-up wire, which can also be used to connect the touch pads and the l.e.d. lamp.

Because the lid of the box is made of steel, it is necessary to

Components

Resistors

R1 10MΩ
R2 1kΩ
R3 12kΩ
R4 1kΩ
R5 3·9kΩ
R6 1kΩ
R7 12kΩ
R8 10MΩ
All resistors ¼W ± 5%

Capacitors

C1, C2, C3 0·22μF disc ceramic (3 off)
C4, C5 500pF polystyrene (2 off) (see text)
C6 100μF 25V elect.

Semiconductors

TR1 2N3819 *n* channel field effect transistor
TR2 2N3819 *n* channel field effect transistor
CSR1 1A 100V TAG1/100 or similar rated thyristor
CSR2 1A 100V TAG1/100 or similar rated thyristor
D1-D4 (1·6A 50V) bridge rectifier REC63 or similar
D5 1N4002 (1A 100V) rectifier
D6 TIL209 or similar light emitting diode

Miscellaneous

RLA 2-pole change over, heavy duty contacts, 12V coil relay (Doram 348-920)
T1 mains primary/0-12V, 0-12V, ½A secondary (Doram type 196-303)
Stripboard 0·1 inch matrix, 9 strips by 23 holes (2 off); case 100mm × 130mm × 50mm; 3-way terminal block; mains cable; material for touch plate escutcheon; brass paper fasteners (2 off); rubber grommet; connecting wire; sleeving.

See Shop Talk page 311

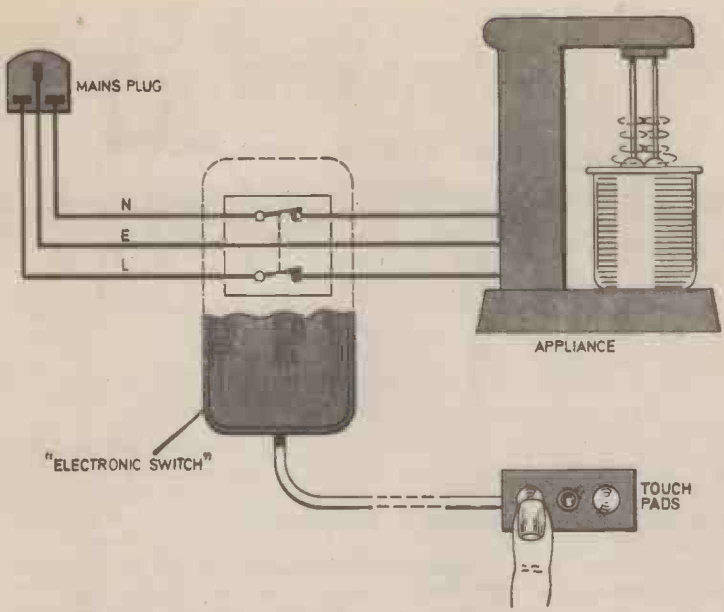
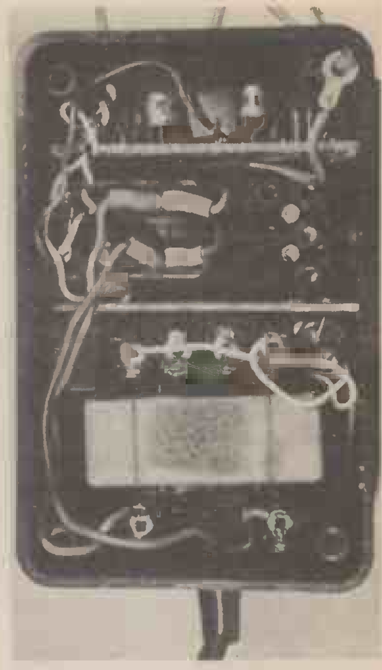


Fig. 6. Illustrating the way in which the Touch Switch is connected to the appliance.



Photograph showing the positions taken up by the two boards, relay and transformer.

connect this to mains earth by means of a wire link from the terminal block to a solder tag which is trapped under one of the panel fixing screws, when the box is assembled; Fig. 4 shows the connections required.

TOUCH PLATE CONSTRUCTION

The touch plate escutcheon detailed in Fig. 5 may be made from a variety of insulating materials, but in the prototype a laminated plastic material was used, and this proved to be an

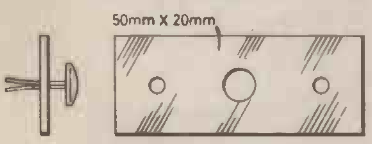


Fig. 5. Touch plate escutcheon. The holes are drilled to suit.

excellent choice. The touch pads themselves were formed from brass-stud paper fasteners with their legs trimmed to size and the wire soldered directly to them behind the escutcheon.

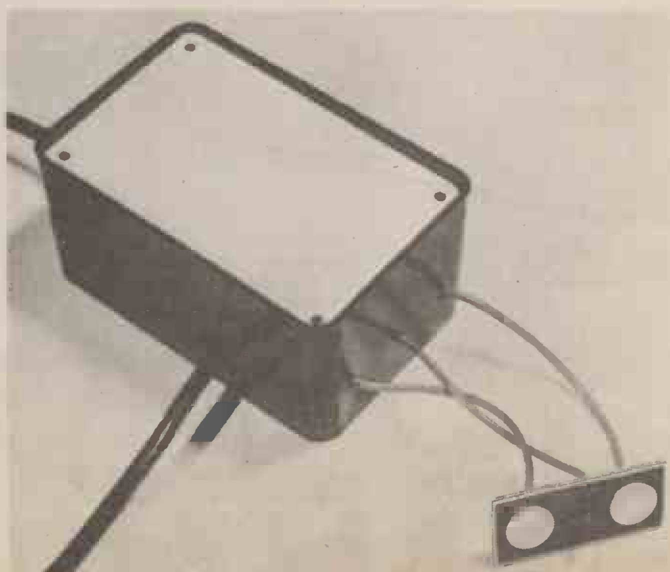
The l.e.d. was mounted in the simple plastic holder which is usually sold with these devices, and it is necessary to ensure that one of these will be supplied with the l.e.d. when ordering. The completed escutcheon can be mounted in a convenient place according to the constructors own personal choice.

METHOD OF USE

The ease of use of the touch switch is demonstrated in Fig. 6 where you can see that it is simply a matter of inserting the unit in series with the mains lead to the appliance to be controlled in the same way that you would with a conventional mechanical switch.

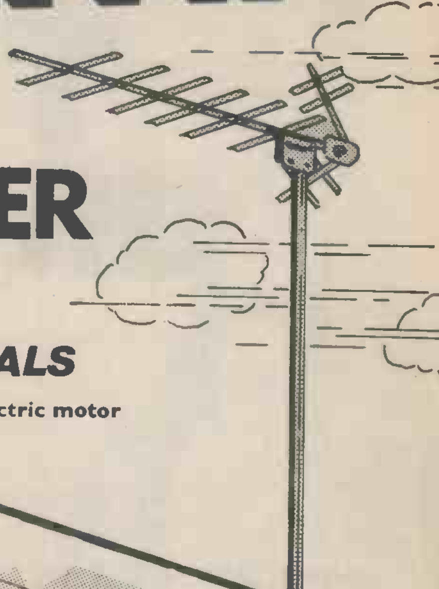
The mains supply arrives via a three-core cable which would normally be terminated with a 13 amp three-pin plug, and the switched supply together with an earth is available on a three-connection terminal block housed inside the units' main case. Two-pole switching is employed to provide complete isolation for the switched appliance when off.

A further point to note is that the touch pads are completely isolated from the mains supply thereby ensuring complete safety, especially where the younger members of the family are involved. ⌘



General view of the completed unit.

NEXT MONTH



MOTOR CONTROLLER

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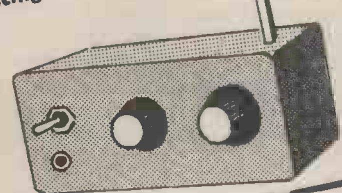
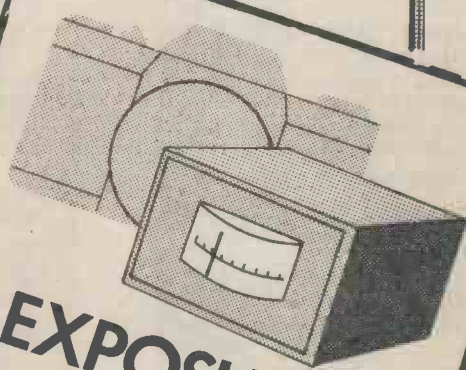
Explore the airwaves and listen to many interesting broadcasts.





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AUGUST ISSUE ON SALE FRIDAY JULY 15

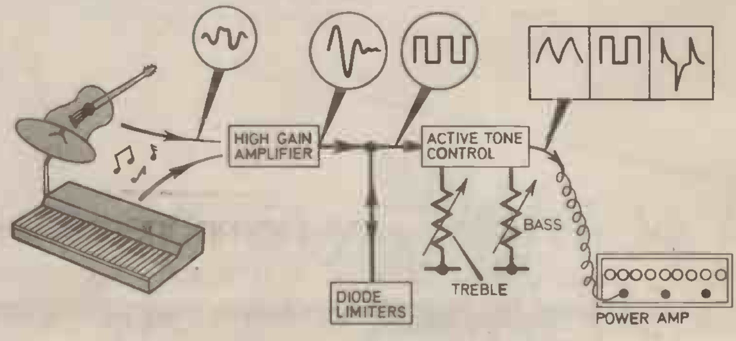
FUZZ TONE UNIT

By E. LYNDSELL

STILL high on the popularity list of musical effects units is that old campaigner the "fuzz box". There have been many designs published in this and other magazines to produce the "fuzz sound" but most have little or no control over the tone of the sound produced. Admittedly, there have been "tone" or "effect" controls on some of these designs but these merely control the amount of fuzz or the sustain.

This design differs from the rest by adding the facilities of bass and treble boost and cut to the "fuzzed" signal thereby allowing a whole range of tonal qualities to choose from.

HOW IT WORKS



Electrical signals from a musical instrument, usually electric guitar or organ, are first fed into a high impedance high gain amplifier. The output signal is modified by the diode limiters allowing a maximum peak signal of about 200mV to pass, resulting in a severely distorted waveform. It is this kind of distortion that produces the well known fuzz sound.

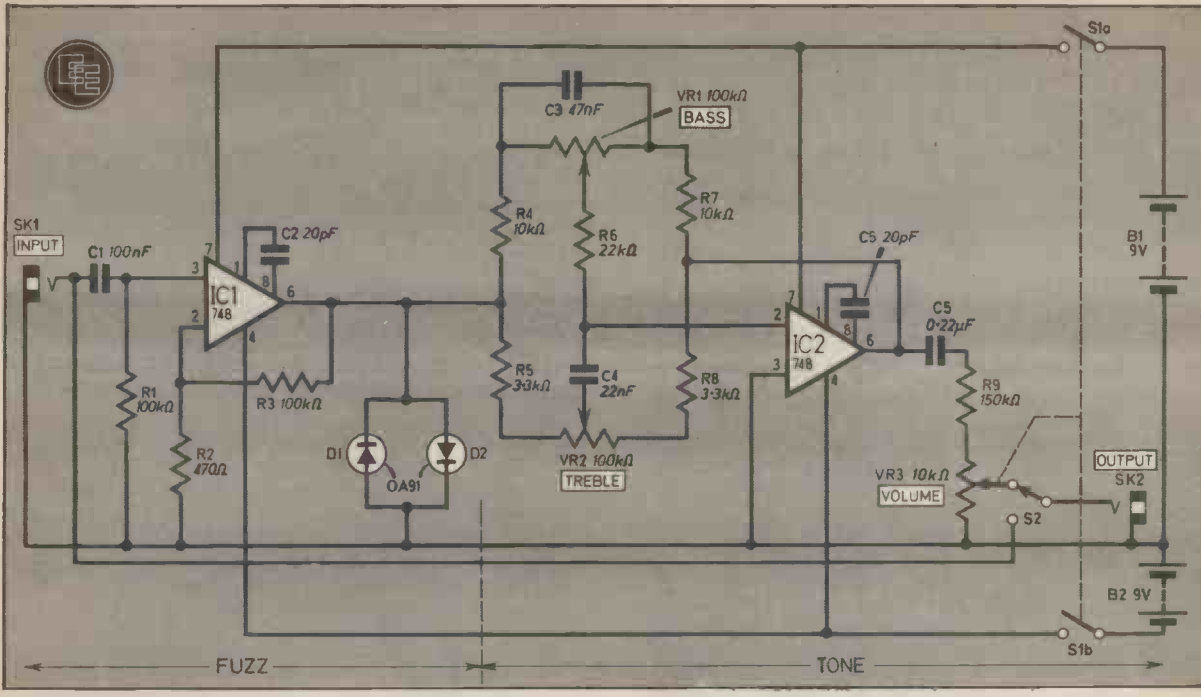
The clipped signal is next fed to an active tone control section which allows the bass and treble frequencies to be boosted or cut as required. The resulting signal is then passed to the power amplifier.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Fuzz Tone is shown in Fig. 1. It can be seen to consist of two distinct sections: (a) a high gain non-inverting amplifier IC1 with diode limiters across its output feeding (b) an active tone control of the Baxandall type constructed around IC2.

Input to the unit is at SK1 via d.c. blocking capacitor C1. Resistor R1 sets the input impedance of the unit at 100 kilohms making it suitable for almost all electronic guitars, organs, etc.

The gain of the first stage is set by the ratio R3 to R2 being



The complete circuit diagram of the Fuzz Tone Unit.

equal to (1+R3/R2) which with the values chosen is seen to be approximately 200.

Because diodes, D1 and D2 are germanium types, they start conducting heavily when the voltage appearing across them exceeds about 200 millivolts, so signals with an amplitude greater than about 200 millivolts reaching the diode limiter will produce a clipped waveform and therefore produce the fuzz sound. In other words, all *input* signals greater than about 1 millivolt will produce the fuzz sound, accompanied by sustain. The latter is proportional to the input level.

The tone section of the Fuzz Tone is a variety of the well known Baxandall arrangement which provides both boost and cut of the treble and bass frequencies keeping mid-band gain constant.

The feedback around IC2 is frequency dependent producing maximum gains and cut at about 100Hz (bass) and 10kHz (treble). The amount of gain or (cut) depends on the settings of VR1 and VR2. The input signal to the tone section is unaffected for midway settings of VR1 and VR2.

Resistor R9 and potentiometer VR3 form a variable attenuator allowing an output signal up to about 550 millivolts peak which

Components

FOR GUIDANCE ONLY

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

£5.50
excluding case

Resistors

R1	100kΩ
R2	470kΩ
R3	100kΩ
R4	10kΩ
R5	3·3kΩ
R6	22kΩ
R7	10kΩ
R8	3·3kΩ
R9	150kΩ

All ¼W carbon ± 10%

Potentiometers

VR1, 2	100kΩ carbon lin. (2 off)
VR3/S1	10kΩ carbon log. with ganged d.p.d.t. switch

Capacitors

C1	100nF plastic or ceramic
C2	20pF ceramic or polystyrene
C3	47nF plastic or ceramic
C4	22nF plastic or ceramic
C5	20pF ceramic or polystyrene
C6	220nF plastic or ceramic

See **Shop Talk** page 311

Semiconductors

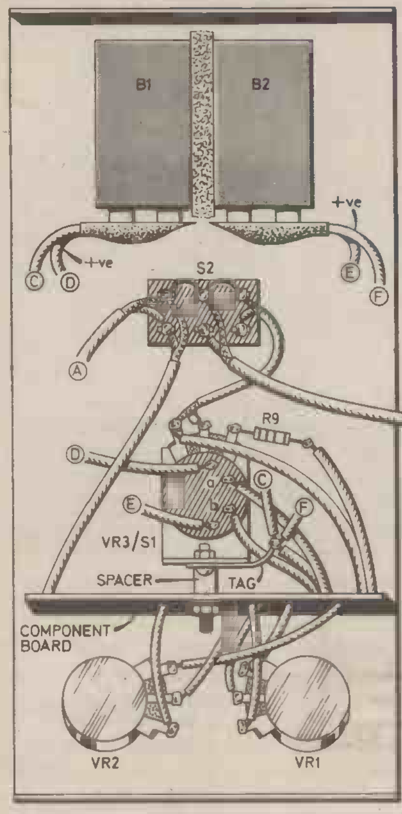
IC1, 2	748 operational amplifier 8 pin d.i.l. (2 off)
D1, 2	OA91 or similar germanium types (2 off)

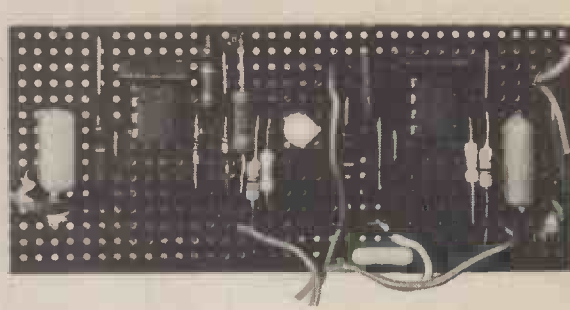
Miscellaneous

SK1, 2	standard jack socket (2 off)
S2	s.p.d.t. successional action footswitch
B1, 2	9V type PP3 (2 off)

Stripboard: 0·1 inch matrix 15 strips by 36 holes; control knobs (3 off); connectors for batteries (2 off); material for case; screened cable; mounting bracket material; connecting wire; solder; 6BA fixings.

FUZZ TONE UNIT





Photograph showing prototype component board removed from unit.

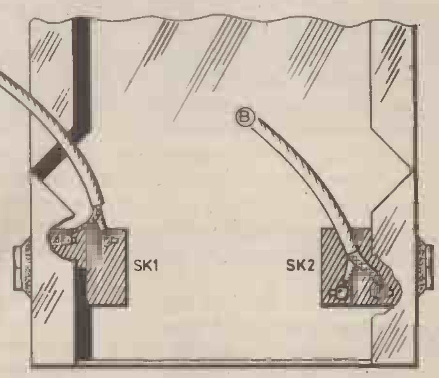


Fig. 4. Layout of the components within the case and on the lid with wiring up details.

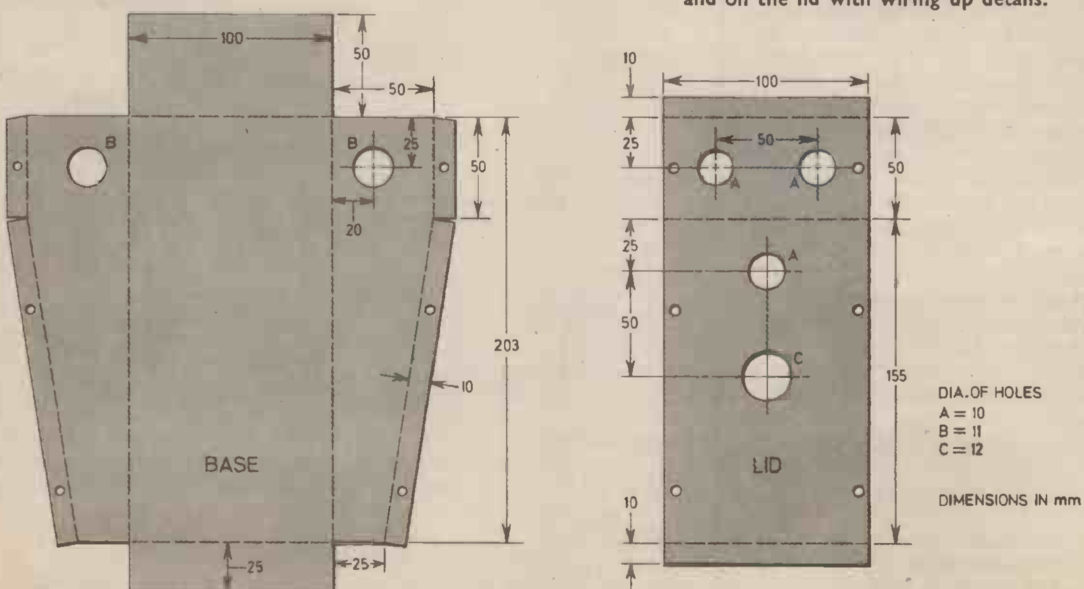


Fig. 3. Marking out details for the case. Both base and lid are shown. Note that the bend lines are shown dotted. The lid in the prototype was fitted to the base by self tapping screws.

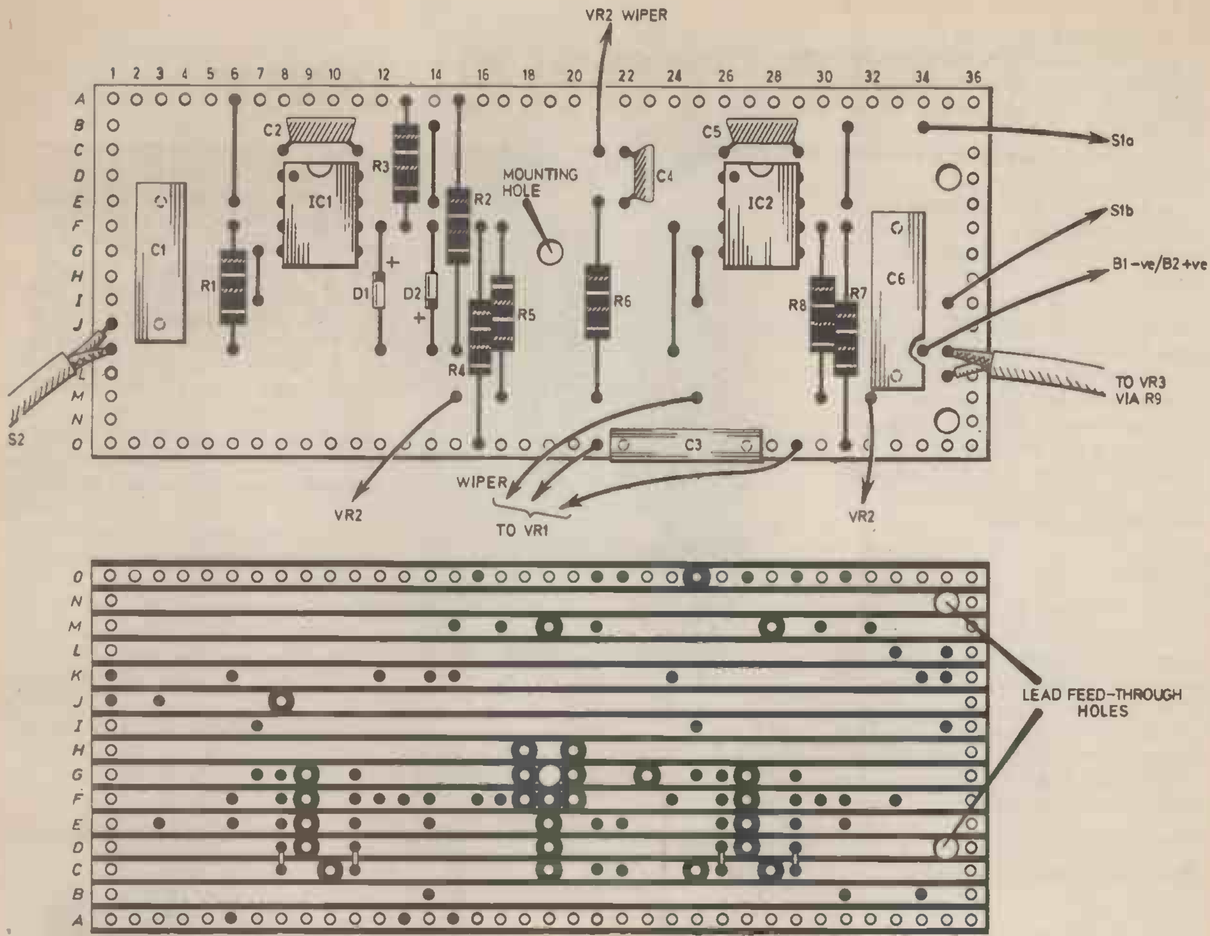


Fig. 2. The layout of the components on the stripboard and breaks to be made on the underside.

is more than sufficient for all amplifiers likely to be used.

A footswitch S2 has been incorporated in the design to allow the unit to be rapidly brought into effect or by-passed as required. The input impedance is high enough for the unit to be left connected to the instrument in the by-pass position thereby allowing S2 to be a s.p.d.t. footswitch which is more easily obtained than the d.p.d.t variety. The unit is switched on and off by a d.p.d.t. switch ganged to the volume control VR3. Remember to switch off the unit when not in use.

COMPONENT BOARD

The prototype Fuzz Tone was constructed on a piece of 0·1 inch matrix stripboard size 15 strips x 36 holes. Details of this board are shown in Fig. 2 which shows the layout of the components on the topside of the board, drilling details and the breaks to be made along the copper strips on the underside.

You will see from the photograph that i.c. sockets have not been used to hold IC1 and IC2, but the use of sockets (or Soldercon pins) is recommended to avoid damage to the devices through heat from the soldering iron. The use of sockets allows easy replacement should this prove necessary.

Begin construction by cutting the board to size, drilling the fixing hole and feed through holes and then making the breaks along the strips as indicated in Fig. 2. Position and solder, the sockets, resistors, capacitors and suitable lengths of flying leads to the board. Lastly, using a heat shunt on the diodes, D1 and D2, position and solder in place. It is advisable to use screened cable where shown. Place IC1 and IC2 in their respective sockets.

CASE AND WIRING UP

The case was made specifically for the job. It consists of two sections, lid and base, and dimensions and construction details are shown in Fig. 3. The prototype case was made from 18 gauge mild sheet with welded edges but this material is probably not suitable for the amateur constructor.

A suitable alternative would be 16 gauge aluminium folded as indicated, with Araldite fillets laid along the inside open-edge joints for strength. The external edges can later be filed round to improve the appearance of the case when the adhesive has set firm.

Begin by marking out the aluminium sheet and then drilling the holes for the jack sockets, potentiometers, footswitch and lid fixing holes. Next cut to shape and fold as indicated in Fig. 3 and photograph. The lid is held in position on the base by six small self-tapping screws.

A small bracket is required for holding the component board in place. The bracket is placed on the shank of VR3 and is held steady when the potentiometer fixing nut is tightened.

Next fix all the components in position including the component board, and wire up according to Fig. 4.

A further bracket can be made on the same principle as that used for the component board, to hold the batteries in place. It would be held steady under S2. Alternatively, Blu-Tak can be used as in the prototype.

When wiring up is complete, screw the lid in position and the unit is ready for use.

IN USE

An additional screened lead will need to be made up or purchased to connect the unit to the amplifier. The unit is placed in line between the musical instrument and the amplifier. The Fuzz Tone is switched on by rotating VR3 clockwise, further rotation increases the volume.

A view of the Fuzz Tone Unit from above showing importance of pointers on the knobs.

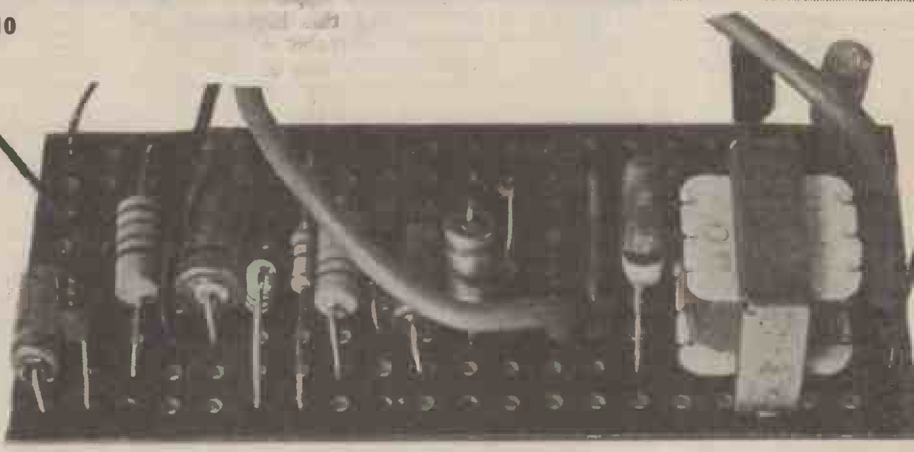
Switch S2 will either be in the by-pass position (no effect) or the fuzz position. With it in the latter position, set VR1 and VR2 and VR3 for the required tone and volume. Anti-clockwise rotation of VR1 and VR2 produces bass and treble cut whereas clockwise rotation produces boost. Press S2 and release, the unit should now be in the by-pass position. The level control (VR3) may need adjustment, to make the two levels comparable.

As the unit is to stand on the floor when in use, it is a good idea to fix some rubber feet on the case base to prevent it slipping about when being operated. Also, attention should be paid to selecting the knobs. Ideally these should have some form of pointer, be flat on top and of robust construction. A scale printed around the controls will be useful. The reason for these specifications is that the controls may be "foot-controlled" by the user during a performance.

The prototype unit was given a couple of coats of aerosol paint and Letraset used to label the unit and its controls. ⌑

Continued from page 310

Phone/Door Bell Repeater



Photograph of the prototype component board above, and the completed loudspeaker unit ready for use shown below.

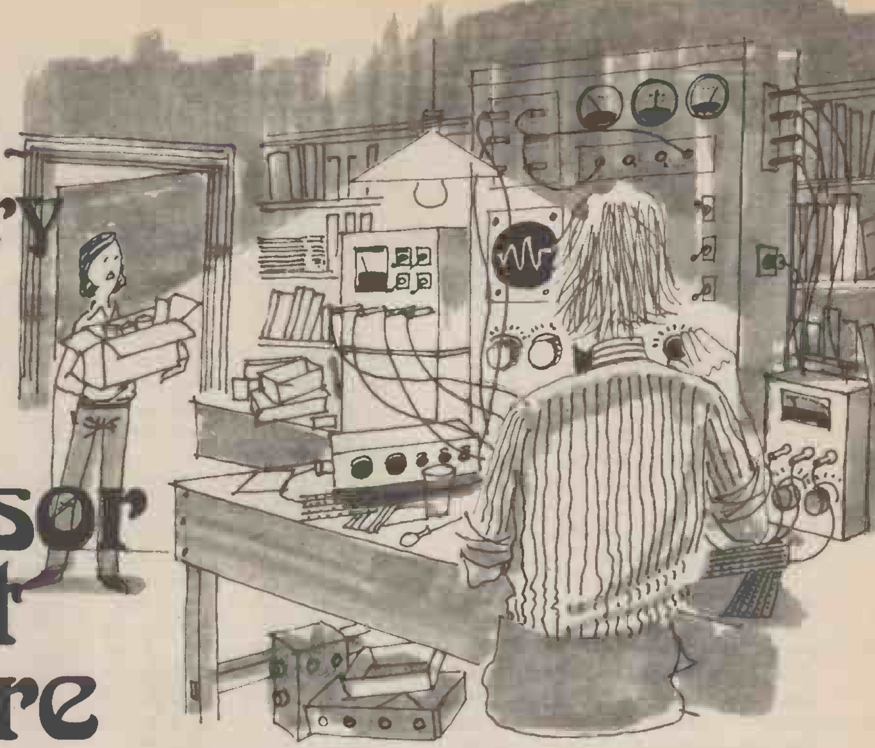
TESTING

After checking all the wiring thoroughly, connect a battery to unit and switch on. Incidentally, there is a space for the PP3 battery at the bottom of the case beneath the speaker.

Upon switching on, a tone should be produced by the unit for a few seconds while the capacitors in the circuit settle to their normal quiescent charges. Once this tone has died away, blowing into the microphone should cause the tone to return. Then it will slightly and gradually fall in pitch, and then after a few seconds it will cease.

The unit is then ready for use. It is not particularly sensitive and it is necessary to place the microphone close to the monitored equipment. This is not really a disadvantage though, as it ensures that extraneous noises do not trigger the unit and so mislead the user. ⌑

The Extra-ordinary Experi-ments of Professor Ernest Eversure



by Anthony John Bassett

THE Professor had just re-entered his laboratory to continue with some investigations on his latest top-secret super-project. Surrounded by futuristic and grandiose pieces of amazing apparatus which he was in the process of assembling with the aid of his latest experimental electronic robot, he was carefully planning the next stage of a complicated experiment when suddenly there was an unexpected interruption. A bleeper sounded, coloured lights flashed on a control-panel and a series of symbols lit up on a larger computer viewscreen.

"That's strange", thought the Prof. "the weather was fine a few moments ago, dry and sunny, not a cloud in the sky for a change! Maybe there is something wrong with my Electronic Weather Prognosticator, which is forecasting an immediate violent electrical tempest!"

HOME-MADE ELECTROPHORUS

Although the weather remained fine and the Prof.'s "Prognosticator" was functioning correctly, the tempest which it has forecast soon entered the laboratory itself in the form of the Prof.'s young friend Bob with his home-made electrophorus. Apparently he had been waving this highly-charged piece of apparatus about in the garden on his way to the laboratory, and had inadvertently waved it near the sensor of the Professor's electronic weather station.

"Hi, Prof., what's happened?" Bob greeted the Prof., viewing the various alarm signals.

"What's happened is that you've arrived and as usual we know all about it. You've just set off a few extra alarms this time by bringing in your electrophorus in a highly-charged state. But that's a rather unusual electrophorus, Bob. I can see that, during the course of over 200 years since it was originally invented by Alessandro Volta in 1775, the electrophorus has been modernised!"

"Yes, Prof., this is the latest super-slimline space-age electrophorus, made of materials from the local handyman's supermarket and every bit as good as the old resin, rubber and sulphur blocks! Here, let we show you!"

Bob's electrophorus consisted of two tiles which he had purchased at the decorators. One was a plain polystyrene tile. It was not the polystyrene foam type, but a solid glossy tile made of thin plastic sheet. The other was an aluminium tile which Bob had carefully filled and smoothed down, rounding the edges and corners to avoid loss of charge by corona action. So now the aluminium tile was slightly smaller than the other, and Bob had used a small piece of plastic rod a few inches long, carefully glued in place, to make an insulative handle, see Fig. 1.

Now he rubbed one side of the plastic tile vigorously on his hair, and almost immediately, loud crackling sounds indicated a build-up of static charges.

Bob placed the electrically-charged polystyrene tile on the nearest workbench and lowered the aluminium tile onto it. He placed his hand near to the aluminium tile, and a lively electric spark leapt from the tile into his knuckle.

"Ouch! Prof. that was a much bigger spark than I usually get!"

"That is because today the air in the laboratory is unusually dry, Bob, and experiments with static electricity usually work best in a dry atmosphere. In damp weather they often do not work at all!

"The robot had laid out a few trays of silica gel to absorb moisture from the air in the laboratory, as part of a test I am doing on new humidity sensors for my experimental Tempest Prognosticator."

SILICA GEL

Bob could see, on nearby workbenches, several trays of deep blue coloured silica gel, exposed to the air. The gel contained a cobalt indicator which was blue when dry, and as the gel absorbed moisture the colour would gradually fade until it was replaced by a pale pink when the gel was saturated with moisture. It could then be dried out again in an oven.

"Where did you get all that silica gel, Prof.?" Bob enquired.

"From one of my friends who is an electronics engineer, and regularly installs electronic equipment. Packaged in with each item of equipment is a a small bag of silica gel, and I found that he usually threw this away. But when he heard that I could make use of it, he saved some, and delivered a lot of it just in time for my experiments on atmospheric humidity!"

Bob once more placed his hand near the electrophorus and drew a few more, smaller sparks from it until he was touching the metal tile. He then placed a small object in the middle of the metal tile. The Prof. could see that this was a model of some strange vehicle of futuristic design, carefully constructed in lightweight materials such as polystyrene foam or pith, and tissue paper. Printed on it in tiny letters was the word ELECTROPHORCRAFT.

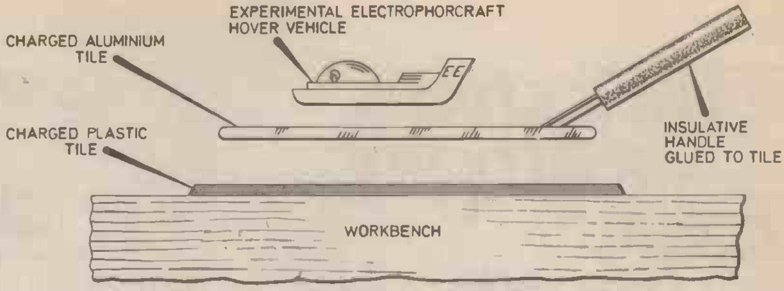


Fig. 1. Showing how the two tiles are positioned, in the experiment with the home made electrophorus.

Bob used the insulative handle raise the metal tile, gradually separating it from the plastic one, and as he did so, the Electrophorcraft took off, arose and hovered in mid air just above the tile. By tilting the tile slightly, Bob made the craft move from the centre towards one edge, and he then skilfully persuaded it to orbit around within the periphery of the tile, and then to perform figures of eight and other more complex manoeuvres.

He became absorbed in this fascinating occupation and sometimes lost control so that the craft flew over the edge of the tile. He would then pick up more charge by resting the metal tile back on the plastic one, touching it with his finger for a moment, place the Electrophorcraft back on the tile and raise the tile once again.

INCREASED HEIGHT

Suddenly to Bob's surprise the Electrophorcraft rose to almost twice its previous height.

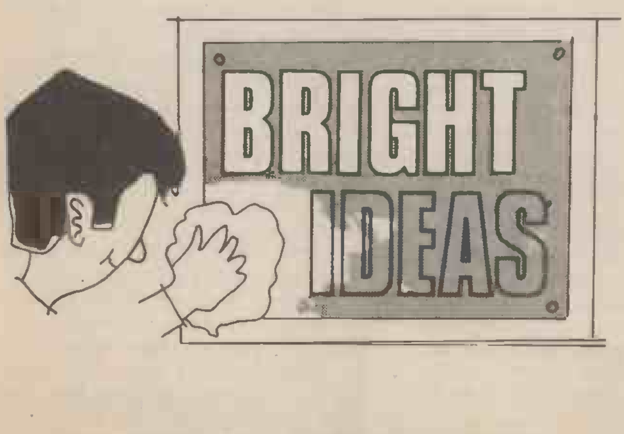
This was because the Prof. was holding the metal plate of another electrophorus in the air above Bob's.

"Hey, Prof.", Bob suddenly shouted as something suddenly dawned on him, "if your electrophorus were carrying the same charge as mine, it would neutralise the effect and cause the Electrophorcraft to sink back down again. But it has caused it to rise even higher, so you must have built an electrophorus which generates a charge opposite to mine. How on earth did you manage to do that?"

"Aha!" remarked the Prof. enigmatically, "you should have studied your books on electrostatics a little more thoroughly at school—then you would know the answer to that for yourself!"

Now Bob began to think. "If the Prof. could so easily almost double the height at which it hovers, maybe by a bit of investigation and experiment I could make it hover even higher, or carry a heavier load!"

To be continued



P.C.B. DRAWING AID

I recently completed my first printed circuit board and quite by accident discovered an aid to easy production.

After drawing the areas on a piece of paper on which the etch resistant was to be placed, I filled in the area with different coloured crayons. When transferring the pattern to the board it was a simple matter to follow the different outlines on the drawing. Even the most congested areas around i.c. sockets could be easily distinguished at a distance.

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

W.H. Gurney, Dudley, West Midlands.

Physics is FUN!

By DERRICK DAINES

A serviceable and sensitive galvanometer can be made easily and at little cost. Refering to Fig. 1, cut a piece of thick ply 200mm by 100mm and through this drill three small holes in line down the centre.

The middle hole should be exactly central and the other holes about 75mm from each end. Now wind fifteen turns of fairly thick copper wire round the edge of the base—that is, temporarily using the base as a former for the coil. When the coil is wound, slip it off the former and secure it with a few turns of Sellotape here and there. The two ends should be left about 150mm long.

Pass these two ends through the outer pair of holes previously drilled in the base and bend them across the bottom, thus holding the coil in position. If desired, a fillet of glue may be run along the bottom of the coil to secure it. For a nice touch, secure the wire ends to two brass screws for terminal posts. Pieces of Sellotape or masking tape keep the leadout wires safe from snagging.

The central hole already drilled will be totally or partly covered by the turns of the coil and it is now necessary gently to ease in a suitable steel wire or darning needle to act as a pivot. Adjust it so that the tip is exactly halfway between the top and bottom turns of the coil and bend over or cut off the excess underneath. Secure with Araldite or similar glue in the hole.

Armature

Attention may now be turned to the moving part—the armature. Refering to Fig. 1, take an old razor blade and magnetise it by stroking it with a powerful magnet such as that taken out of an old car magneto. The strokes must be taken in one direction only, lifting the magnet clear at each stroke.

When the blade has been magnetised as much as possible, mix a little Araldite and stick in the middle of the blade half of a press-stud mounted on a small metal bridge and a pointer of thin straight wire. The press-stud of course is to pivot on top of the needle and for stability should protrude through the razor blade.

Neutralisation of stray magnetic fields can be affected by securing a narrow strip of tinplate on the underside of the base, in line with the coil. The armature is now mounted on the needle support and the razor-blade will assume a position in line with the coil. Passing a direct current through the coil will deflect the magnetised blade (and hence the indicator wire) to one side or the other depending upon polarity.

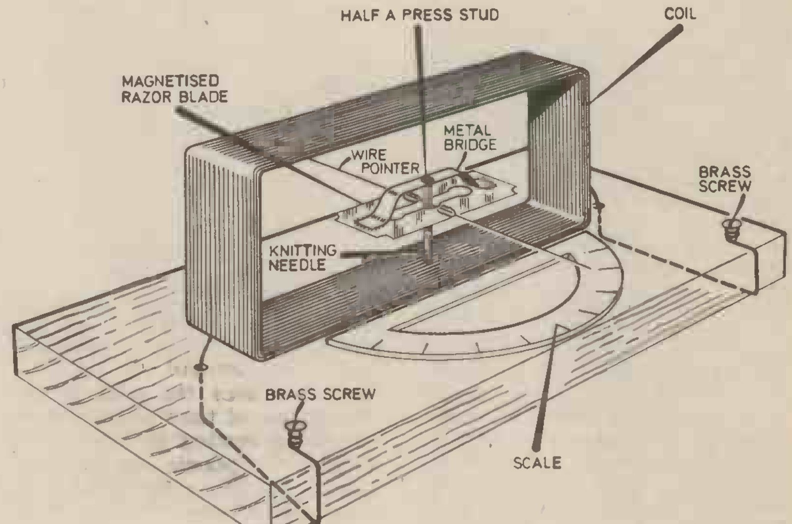
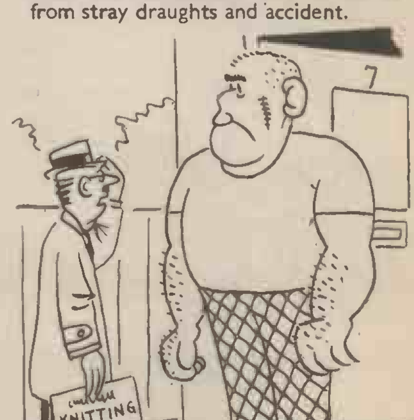


Fig. 1. Detailed contruction of the simple and low cost galvanometer. A piece of tin plate may be secured under the base, in line with the coil to reduce stray magnetic fields.

Calibration

Calibration is achieved by one of two methods. (a) screw a simple protractor into place beneath the indicator needle, or (b) stick a plain piece of card and mark it with a fine-nibbed pen. For both options put the galvanometer in series with a borrowed milliameter and an adjustable current source. For the protractor option, it will be necessary to work out the milliamps of current applicable to each degree of turn and to stick a small notice to this effect somewhere on the base.

It may be found that shaking may dislodge the press-stud support from its best position and the best cure is to make a small dent in the centre with a centre-punch. As an additional refinement, a large coffee jar upturned over the instrument will shield it from stray draughts and accident.



"Good morning, sir. Ever thought of constructing your own knitting machine?"

GEORGE HYLTON brings it down to earth

Oscilloscopes

A YOUNG reader from Wales writes to say that he has been given a second-hand oscilloscope. How is it used?

This article isn't long enough to go into detail. There's only enough room here to cover the basic principles.

Nowadays everybody is familiar with graphs. They appear on the TV screen, to show the rise in the cost of living, and so on. All these familiar graphs have one thing in common. They show how things change with *time*.

This is what the cathode-ray oscilloscope (c.r.o. for short) does. In electronics, we are constantly dealing with things that change with time. Sound waves are changes of air pressure with time. Radio transmissions are changes of electric and magnetic fields with time. All these changes can be turned into changes of voltage.

For example, a microphone can turn sound into a voltage. By drawing a graph of these voltages we can examine them with our eyes. In an audio system, for example, we can look at the audio waveforms at different points in an amplifier and see, just by the shape of them, where some form of serious distortion such as *peak clipping* is taking place.

It is also possible to make rough measurements of voltages from the size of the picture on the oscilloscope screen.

Moving the spot

So much for what a c.r.o. does. But how does it do it?

A spot of light moves steadily from one side of the screen to the other. (Usually from left to right, from the onlooker's point of view.) The controls on the oscilloscope enable you to select the speed. It can be set so that the spot moves quickly or slowly. But it always moves at a steady, even rate. If it moves very quickly, then it looks like a straight line rather than a moving spot.

If a voltage is applied to the normal input point of the oscilloscope the spot is deflected up or down, depending on the polarity of the voltage. (In modern oscilloscopes a positive input usually deflects the spot upwards.) So if the instrument is the kind that responds to d.c. and you connect a battery when the spot is halfway across, the movement will follow the path as in Fig. 1.

The size of the upward step depends on the sensitivity, which in turn depends on the setting of the *input attenuator*. Sensitivity settings are usually quoted as the input voltage needed to deflect the spot one centimetre. Common values are from 10 mV per cm to perhaps 50 V per cm.

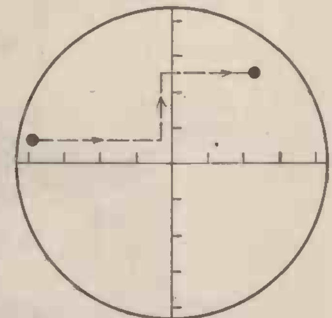


Fig. 1. The spot traces out a path similar to this, when deflected by a d.c. voltage.

Flyback

A trace which just goes across the screen once, then stops, has its uses, but if the speed is high the eye can't see much. Fortunately most of the voltages we are interested in repeat themselves again and again. This enables many traces across the screen to be superimposed, to give a clear, steady picture.

What happens is this. The spot, once it has traversed the screen, "whips" back very quickly and then does another traverse, and so on. Internal circuits ensure that the precise moment at which the trace starts to traverse is conditioned by the input signal. For example, if the trace always starts to sweep across at the positive peak of a sine wave the picture on the screen begins at that peak, as shown in Fig. 2.

In this example two cycles are shown. By adjusting the *sweep speed* a greater or smaller number of cycles can be displayed. You'll notice that the end of the trace doesn't match up with the beginning. A little bit is missing. This bit happens while the spot is moving back to its starting point. This *flyback* is not normally displayed on the screen, as it confuses the picture. (You may see it if you turn up the brightness too high, but this is **not** recommended as it may damage the screen.)

Adjustments

This is about as far as we can go here. To make a quick check on a 'scope, switch on and adjust the brightness and trace length (sweep length) controls to give a straight line which nearly goes right across the screen. Select a low sweep speed (time base speed). Put your finger on the input (Y amplifier, vertical input) terminal. This injects mains hum which produces a sine wave trace (usually rather distorted and whiskery). Adjust the input attenuator (Y gain) to give a reasonable deflection (say one third of the way across the screen, up and down).

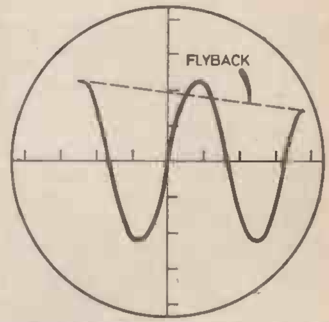


Fig. 2. Flyback causes the spot to follow a path as shown here.

If the picture is not steady, adjust the time base frequency or sync-control. You should be able to obtain a steady trace of a number of waves. The number depends on the time base speed.

To make tests with an oscilloscope calls for auxilliary equipment such as an audio oscillator. You also need guidance, either from someone who is used to working with oscilloscopes or from a book or magazine. A book which contains useful information is The Oscilloscope Book by E. N. Bradley. This deals with valve oscilloscopes, not transistor ones, but your secondhand 'scope is probably a valve one anyway.

PUBLISHERS ANNOUNCEMENT

The current 1977 Binders will now only hold 8 issues as the September 1977 issue format will be increased in size.

A larger Binder to accommodate 16 issues from September 1977 to December 1978 will be introduced.

Remittances with overseas orders for binders: please add 60p to cover dispatch and postage.

BOOK REVIEWS

50 PROJECTS USING IC CA3130
Author R. A. Penfold
Price 95p
Size 180 × 110mm, 96 pages paperback
Publisher Bernards (Publishers) Ltd.
ISBN 0 900162 65 1

A RECENTLY introduced device to the amateur market is the CA3130 CMOS operational amplifier. Similar in many respects to the "old faithful" 741 type, but has one major and useful difference; input impedance 1·5TΩ; 1·5 million million ohms is quite a bit different to the 1 megohm of the 741!

The book is divided into six chapters, the first containing basic information about the i.c., the remaining five are split up as follows:

Audio Projects, ranging from a magnetic cartridge preamp to a 500mW amplifier.

R.F. Projects, including a m.w. radio and a signal tracer.

Test equipment, which includes amongst others a high impedance voltmeter and a sinewave generator. The last two chapters detail many miscellaneous projects ranging from a metronome to a touch switch.

An interesting book which has been well written, and is sure to be useful to the amateur and professional alike.

T.J.J.

HOW TO BUILD YOUR OWN METAL AND TREASURE LOCATORS
Author F. G. Rayer, T.Eng. (CE), Assoc. IERE
Price 85p
Size 180 × 110mm, 90 pages paperback
Publisher Babani Press
ISBN 0 85934 035 X

ONE hobby which is fast gaining popularity in the world of electronics is treasure tracing, or to be more precise, metal locating. During the summer months, many people make their way out of doors in search of buried treasure. The chances of finding something along the lines of the Crown Jewels are pretty remote, nevertheless interesting finds can be made using simple equipment.

This book gives an excellent treatise of the subject, from the legal requirements, construction, and method of use. Part one gives very detailed information for the construction of the various sections, which when completed and connected together makes a complete metal locator. Part two gives details of alternative coils, oscillators etc, which may all be tried in different combinations to improve results.

The last section in the book gives general construction details, and changes which can be made if the locator is to be used in European countries.

A useful book to anyone interested in treasure tracing, and is sure to be a "mine" of information.

T.J.J.

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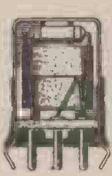

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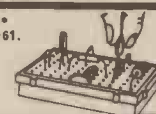

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