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SEPTEMBER 1989

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The Magazine for Electronic & Computer Projects

VOL 18 No 9 SEPTEMBER 1989

EVERYDAY ELECTRONICS

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The Magazine for Electronic & Computer Projects

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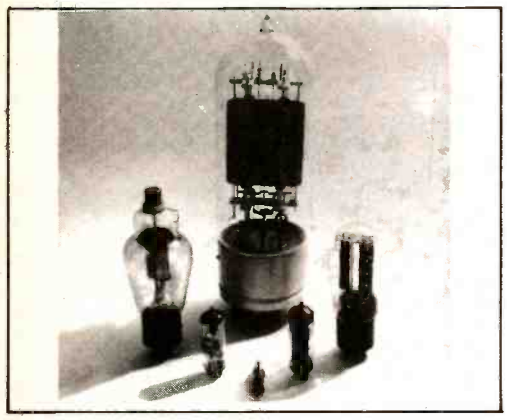

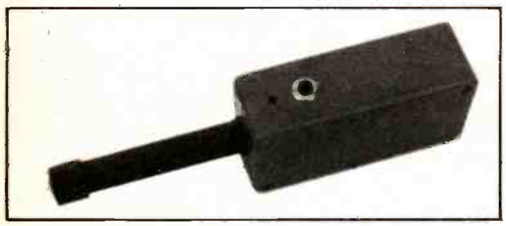

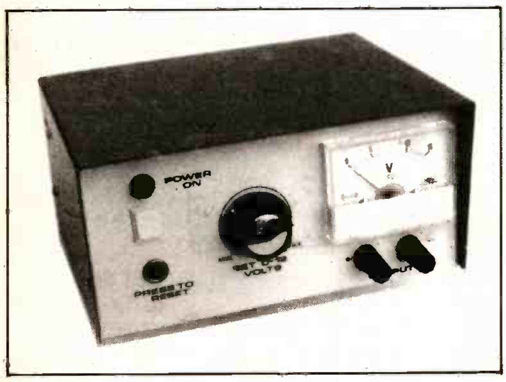

Our October '89 Issue will be published on Friday, 1 September 1989. See page 547 for details.

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Features

NEXT MONTH

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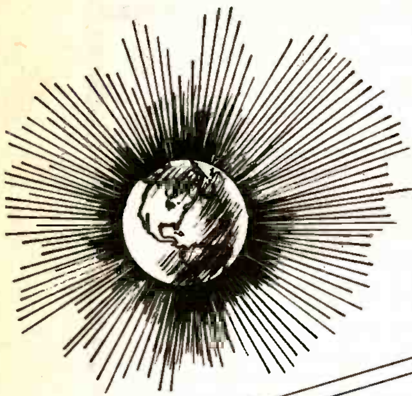

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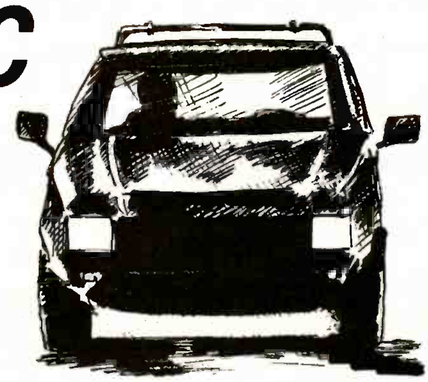
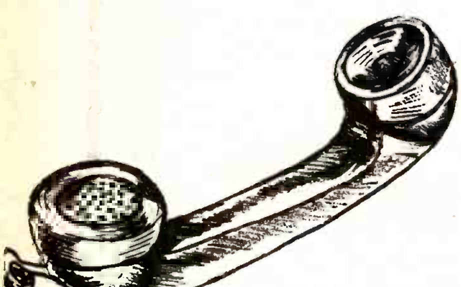


We investigate the various electronic ignition systems used in modern cars and explain how each one works and what all the technical terms mean.



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The Magazine for Electronic & Computer Projects

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TECHNOLOGY PROJECTS

School technology projects seem to be an on-going theme in our postbag. Just before the end of the summer term many schools ask students to decide on their project and hand in a basic description of the item. It is after this stage that we get the letters saying "*can you send me everything you have ever published on . . . .?*"

Well, frankly, no we cannot. If you need a specific article or a series we can supply back numbers or photostats (stats of **one** article or **one part** of a series cost the same as a back number) but you must tell us exactly what you need and what issue it was in.

To find all the articles we have published on, say, burglar alarms would involve someone in hours of work, followed by a letter to let you know what we have and then possibly the sale of one or two back numbers—at £1.50 each including postage and packing (see below for details). The end result, a net loss to us of possibly a few tens of pounds depending on how we value someone's time.

Obviously this is not on and we would soon go out of business if we offered such a service. Might I suggest a visit to the school library or a good local or college library will probably result in finding a few years' supply of *Everyday Electronics.* You can then do the research yourself—it is after all, part of the project—and contact us with your requirements once you have found the relevant articles.

OLD PROJECTS

This leads to another point; we cannot provide information on any article over five years old and frankly we would not suggest you try to build anything much older than that anyway. Even after a year or two make absolutely sure you can get all the parts you need for a project *before starting* it or buying anything.

We have no control over component manufacturers and i.c.'s, in particular, come and go with a fair degree of rapidity. We have no way of knowing if a particular component we use in this month's issue will be still in production in, say, three months' time. This does not mean such a project would be impossible to build after that time as wholesalers' and retailers' stocks would normally be expected to last for a year or two—but as I said please check **before** you commit yourself and your cash.

TIME!

One further word of advice; not every project anyone builds works first time, make an early start and plan to get your project working **two or three months** before the deadline. Misbehaving electronics have a habit of eating up time very rapidly indeed.

I know I have said most of the above before but each new year seems to throw up the same old problems—good luck.

Mike Kenward

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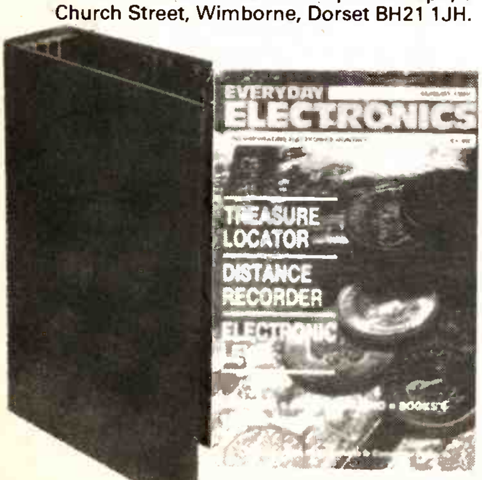

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XENON BEACON

CHRIS WALKER

A visual warning device that is self contained, compact, splash proof and rechargeable.

IF YOU wish to attract someone's attention to a scene, a flashing light is a good method to employ. This is because the human eye is very sensitive to sudden changes in light level, particularly towards the edge of the field of view. Flashing beacons are to be found wherever attention has to be promptly drawn to a hazard, warning sign or advertisement.

The beacon to be described here emits a powerful burst of light at a rate of approximately 1.5Hz and was initially designed for visibly locating portable amateur radio stations on hilltops. It has since found refuge in the car boot where it can be used to warn other motorists of accidents, breakdowns etc.

Xenon beacons can be bought quite cheaply but most of them have two main drawbacks: they are not designed as portable units and their light output is not very high. This design satisfies both these criteria and the light can be seen at a distance in excess of two miles under favourable conditions. Being moisture-proof it is ideal for outdoor use.

Other uses include mountain rescue, sea rescue (take it out with you in the fishing boat!) or just for fun at discos.

XENON TUBE

The light source consists of a glass tube containing xenon gas with an electrode at each end, see Fig. 1. When the xenon atoms are excited by passing a high current through the gas they emit an intense blue/white light. However, the gas is non-conducting at low voltages and in order to make it pass a current a potential difference of several thousand volts would be needed across the ends of the tube.

This is very inconvenient, and so a third "trigger" electrode is attached to the outside of the tube near the ends. In order to strike the gas (make it conduct) a p.d. of about 350V is applied across the ends of the tube and a brief 6,000V pulse is applied to the trigger electrode. This causes the gas at the ends of the tube to ionise and conduct; this ionisation very rapidly spreads along the tube and current flows from one end to the other causing the emission of light.

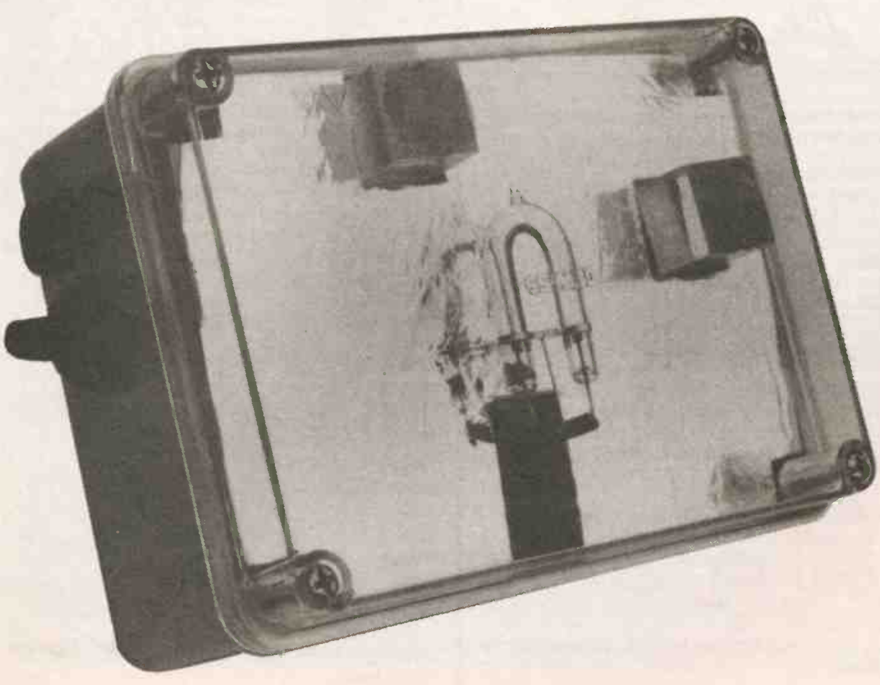
The tube used in the prototype is a long-life type with maximum energy input of 45 watt seconds per flash. The e.h.t. trigger pulse is obtained from a trigger transformer designed for use with this tube.

BLOCK DIAGRAM

The outline operation of the Xenon Beacon is shown in Fig. 2. The circuit uses an inverter to step up the 12V supply, producing several hundred volts required for the xenon tube; an ordinary mains transformer used "in reverse" acts as the voltage-increasing component. Since transformers only work on a.c. an oscillator is used to drive the primary winding.

The high voltage a.c. is rectified and used to charge up a high voltage storage capacitor. The voltage across the capacitor increases as the charge builds up and when it reaches about 350V a trigger circuit rapidly discharges the capacitor through the xenon tube thus producing a bright flash.

The inverter then proceeds to recharge the capacitor and the cycle repeats. The behaviour of the storage capacitor and trig-



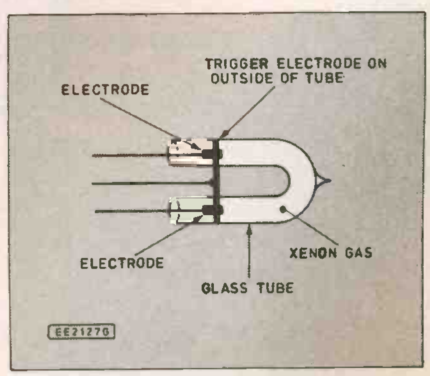


Fig. 1. The Xenon tube.

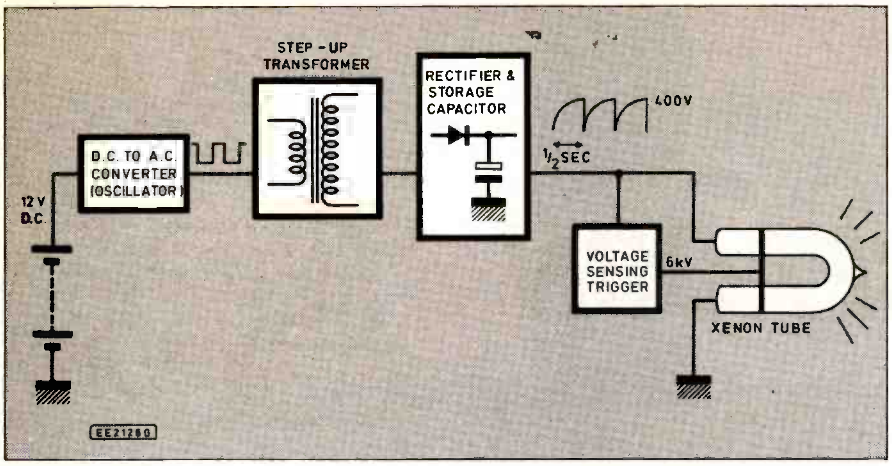


Fig. 2. Block diagram of the Xenon Beacon.

ger circuit is analagous to an automatic self-flushing lavatory cistern which fills up slowly to a certain level and then quickly empties its contents before refilling again.

CIRCUIT DIAGRAM

The circuit of the beacon, divided into three discrete sections is shown in Fig. 3. The inverter is driven from a 12V rechargeable battery, protected by fuse FS1. S1 is an on/off switch which connects B1 to sockets SK1 and SK2 when the unit is switched off, thus allowing the battery to be charged in situ. The power supply is decoupled by capacitor C1.

NAND gate IC1c is wired as a Schmitt trigger inverter, and together with R1, VR1 and C2 it forms a relaxation oscillator. The square wave output from the oscillator is buffered by gate IC1b and used to switch transistor TR2 which controls current through one half of the primary winding of transformer T1. (Note that in this circuit the *primary* is the *low voltage winding).*

An inverted version of the oscillator signal from gate IC1a switches TR1 so that when current flows through TR1, TR2 is switched off and vice-versa. TR1 and TR2 are Darlington devices having the high gain necessary to drive the transformer directly from CMOS gates.

Due to self induction in T1 primary, spikes of about 80V amplitude are produced each time TR1 and TR2 turn off. These spikes are stepped up in excess of 1,000V in T1 secondary, rectified by diodes D1 to D4 and used to charge capacitors C3 and C4.

TRIGGER

As the voltage across C3 and C4 increases, capacitor C5 is charged via R4. R5, VR2 and R6 form a potential divider which feeds a fraction of the voltage across C5 to neon LP1 via R7. Thus the voltage across the neon increases to about 70V upon which the neon conducts and a positive voltage is applied to the gate of thyristor CSR1.

The thyristor triggers and conducts from anode to cathode, discharging C5 through the primary winding of trigger transformer T2. This induces a very high voltage pulse in the secondary of T2 which is used to strike the zenon tube X1; C3 and C4 then deposit their charge through the tube in a fast, high current surge.

Following this, thyristor CSR1 resets to its high impedance state and the process repeats as C3 and C4 charge again.

Notice that if, as may occasionally happen, the tube fails to strike upon the discharge of C5 through CSR1 then the thyristor will reset and C5 will recharge until neon LP1 conducts and the tube is triggered again: this process is repeated rapidly until the xenon tube fires.

ENERGY

The energy dissipated in the xenon tube per flash is determined by two variables, namely the total capacitance of C3/C4 and the voltage across them. The trigger voltage is adjustable from about 220V to 340V by altering VR2; setting this to a high value results in one bright flash approximately every two seconds. Reducing the trigger voltage will give more rapid flashes of slightly lower intensity. Constructors may like to experiment with different values for the discharge capacitors C3 and C4; 32μ (22μ+10μ) was found to be a good value for this application. **It is very important that these capacitors are rated at 450V or higher.**

CONSTRUCTION

It is worth pointing out that while the circuit is driven by 12V it generates high voltages. These in themselves are not too dangerous due to the high output resistance of the inverter. However, when charged, capacitors C3 and C4 can deliver a very nasty shock or burn if shorted out by, for example, a ring or other piece of jewellery—take care when testing.

All the main components are mounted on a single sided printed circuit board, the full size foil pattern is given in Fig. 4. This board is available from the *EE PCB Service,* code EE 650 (see page 612). Notice that two 4BA holes need to be drilled to mount T1 and two 1cm square pieces have to be removed at the corners if the recommended case is used.

Using the layout diagram in Fig. 4 as a guide, solder the small components into place first: the resistors, presets, capacitor C2, neon and diodes, observing the polarity of the latter. Insert the trigger transformer T2—the recommended transformer will only fit the p.c.b. in the correct orientation. If a different type is used, check the connections before soldering.

Fit the remaining capacitors checking that C3 and C4 are inserted the correct way around and then bolt transformer T1 into place, nuts uppermost. Solder the transformer connections to the circuit board.

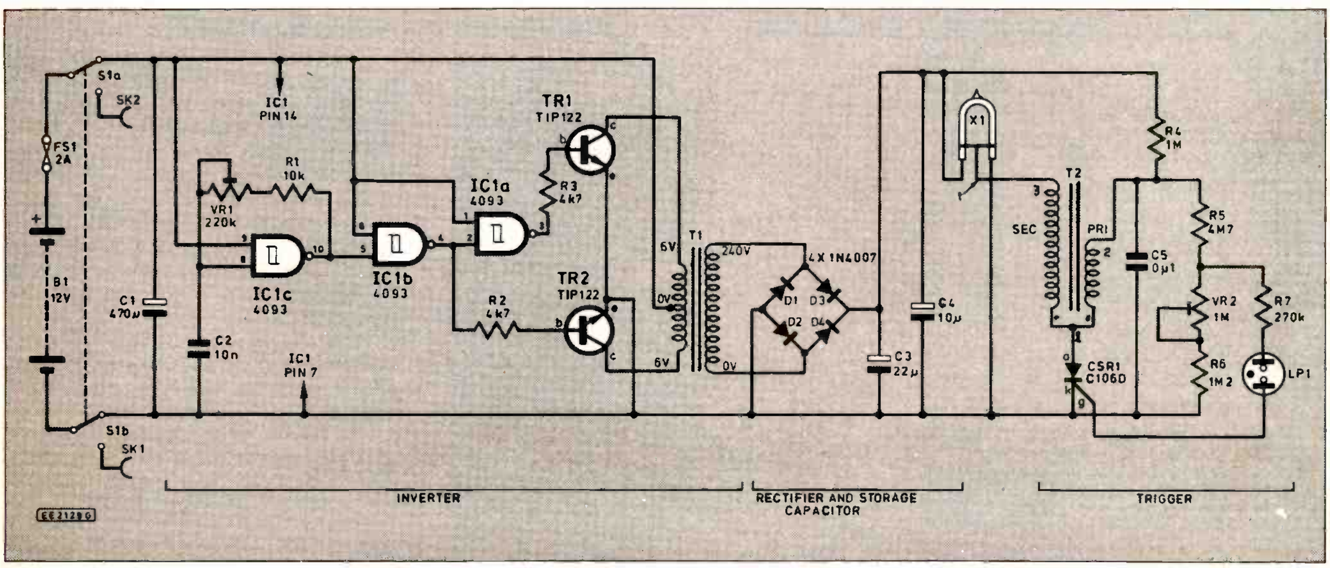


*Fig. 3. Circuit diagram of the Xenon Beacon. Note that voltage figures on the transformer T1 **only** refer to "physical" points or tags. Also the secondary winding has become the "primary" and vice versa.*

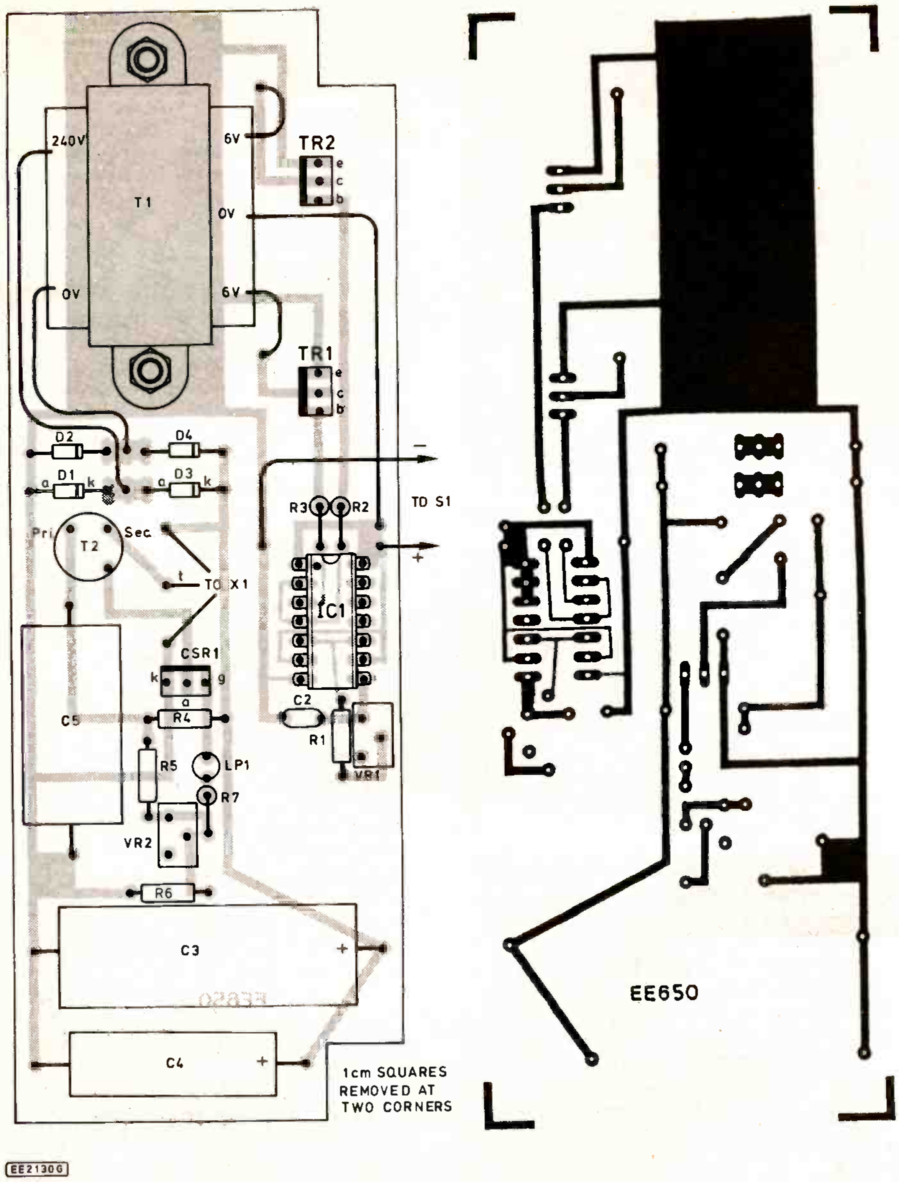


Fig. 4. P.C.B. layout and wiring for the Xenon Beacon.

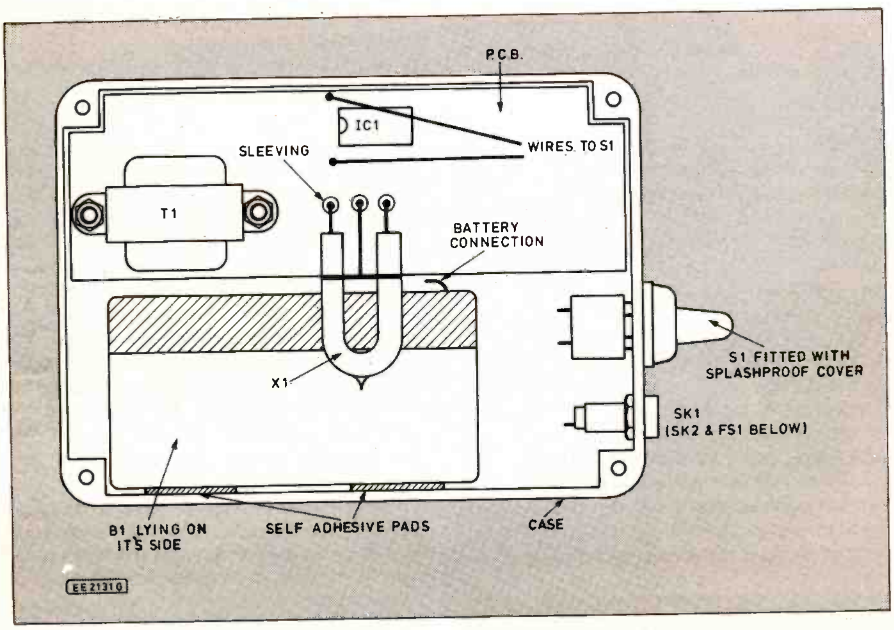


Fig. 5. Case layout from the top.

The transistors should be fitted with small clip-on heatsinks and these are probably best attached before the devices are soldered into place. Insert the transistors with their tabs facing T1 and fit the thyristor with its *front* facing the neon bulb.

Three pieces of stout wire about 8cm long need to be soldered in place to support the xenon tube X1. 20 s.w.g. tinned copper is ideal for the purpose. Do not fit the xenon tube at this stage.

Solder two insulated wires for connection to the switch and then fit IC1 into its socket, observing the usual CMOS handling precautions.

CASE

The prototype unit is housed in a waterproof plastic case measuring 150 × 110 × 70mm and having a transparent top. Fig. 5 and Fig. 6 show the layout of components within the case.

Four holes need to be drilled to mount the switch, sockets and fuse holder. Wire these according to Fig. 7. The capacitor C1 is mounted on the back of switch S1. The battery terminals will accept slide-on connectors (the type used for car electrics)—these should be insulated with rubber sleeves.

The battery lies on its side and is held in place with double-sided self adhesive pads as shown. In the prototype the battery is further anchored by two clear perspex blocks glued into the lid, which press onto the battery when the lid is screwed in place.

The xenon tube is sited in the transparent lid above a reflector made from a piece of cardboard covered with aluminium cooking foil. The reflector is shaped to fit in the case and a slot needs to be cut to pass the wires to X1. It can be fastened to the side of B1 with "Blue-Tak" or similar, allowing it to be removed for servicing.

Using pliers, and being careful not to strain the glass, bend the wires of the xenon tube at right angles to the plane of the tube about 1cm from its ends. Slip three 3cm lengths of sleeving over the tube support wires on the p.c.b. and solder X1 to these wires so that the tube is positioned mid-way between the reflector and the lid of the box, trimming off surplus wire as necessary. Slide the sleeving up to the top of the vertical section of the wires and hold it in place with glue.

ADJUSTMENTS

Set both VR1 and VR2 at mid-position and apply power. Transformer T1 should be heard to whine and the xenon tube should flash at approximately 1.5Hz.

If a frequency counter or oscilloscope is available, connect it between 0V and pin 3 of IC1 and adjust VR1 until the inverter oscillator runs at a frequency of about 1.5kHz. If such equipment is not to hand leave VR1 set at mid-position. The trigger voltage/flash rate is set as required by adjusting VR2.

The p.c.b. can now be fastened into the case with adhesive pads and the lid screwed into place. Four rubber feet will improve the durability of the unit.

BATTERY

The battery used in the prototype is a rechargeable 12V 1.2Ah sealed lead-acid type. It has a mass of 600g and fits snugly into the recommended case along with the p.c.b. It will give over three hours of continuous use.

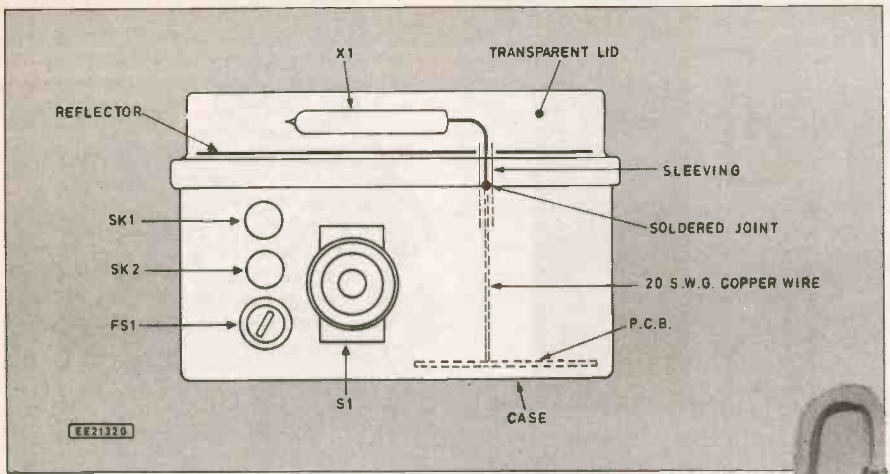


Fig. 6. Case layout from the side.

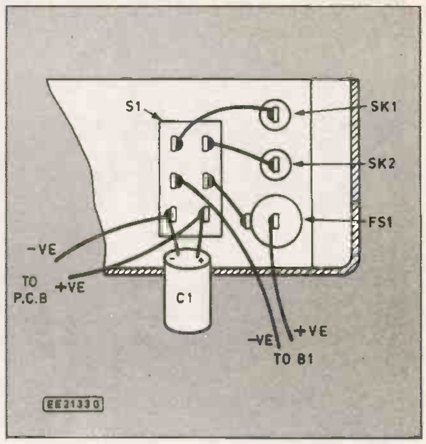
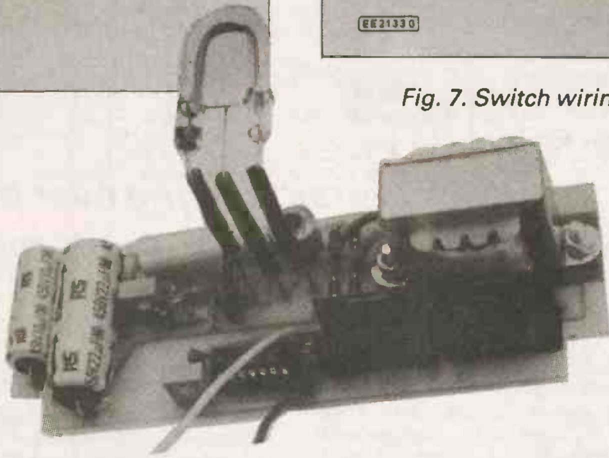


Fig. 7. Switch wiring.



These batteries are available in a variety of sizes/capacities and constructors wishing to leave the beacon runing for long periods may like to consider using a battery with a higher capacity although size and weight must be taken into account if the unit is to remain portable.

Indeed, the xenon beacon could be very successfully run from a car battery, via the cigar-lighter for instance.

It is possible to operate the unit from a 6V supply, the only modification being to replace transformer T1 for a type having a 3-0-3V "secondary" winding. The current consumption is increased and, due to inefficiencies in the transformer, the highest flash rate will probably be around 1Hz. The benefit of using a 6V supply is that smaller and lighter batteries may be used.

Finally, 12V sealed lead-acid batteries should be charged at a constant voltage of 13.5V although the maximum charging current should be restricted to 1A. (The *Bench Power Supply* featured in *Everyday Electronics*, February 1988 is ideal for this application—back issues are available for £1.50 each including postage, see the Editorial page for details; or see the *Stabilised Power Supplies* series. month).

Failure to keep to these limits will cause the battery to expel excess hydrogen gas inside the box. In any case, the box should not be entirely sealed—a small vent hole around the sockets will prevent a pressure build up without affecting the moisture-proof characteristics. Ideally, the box lid should be removed when charging. □

COMPONENTS

Resistors

R1	10k
R2, R3	4k7 (2 off)
R4	1M
R5	4M7
R6	1M2
R7	270k

All 0.25W carbon

Shop Talk
See page 578

Potentiometers

VR1	220k
VR2	1M

Both sub-miniature vertical mounting presets

Capacitors

C1	470µ 16V elec.
C2	10n ceramic
C3	22µ 450V elec.
C4	10µ 450V elec.
C5	0µ1 450V polypropylene or similar

Semiconductors

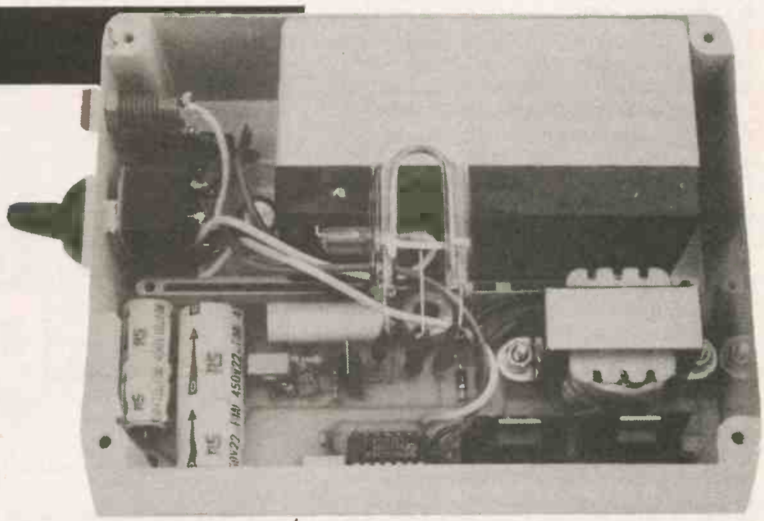
TR1, TR2	TIP122 *npn* Darlington (2 off)
D1 to D4	1N4007 1000V p.i.v. silicon diodes (4 off)
IC1	4093 CMOS quad 2-input NAND Schmitt trigger
CSR1	C106D thyristor

Miscellaneous

T1	Miniature transformer: 240V/6-0-6V at 250mA
T2	6kV xenon tube trigger transformer
X1	45Ws xenon tube
LP1	miniature wire ended neon bulb
B1	12V 1.2Ah sealed lead-acid battery
FS1	20mm 2A fuse with panel mounting holder
S1	d.p.d.t. toggle switch with splashproof cover

P.C.B. available from the *EE* PCB Service order code *EE 650;* 14-pin d.i.l. socket; clip-on heatsinks for TR1 and TR2 (TO220 case); waterproof plastic case internal dimensions 150×110×70mm with transparent lid; 4mm wander sockets (2 off); slide-on connectors and insulating boots for B1; rubber feet; 20 s.w.g. tinned copper wire; sleeving; materials for reflector.

Approx. cost Guidance only **£20**



Pocket Money Project

FOUR-WAY CHASER

CHRIS BOWES

Using the CMOS version of the ever popular 555 timer chip to produce a simple l.e.d. "light chaser".

THIS month's pocket money project features a simple "chaser circuit" which can in fact be easily redesigned to give a number of chase patterns for between two and ten output circuits. It is a truly digital project and should provide an interesting introduction to digital electronics for anyone who has hitherto been unsure about using such i.c.s in projects.

The major advantage of digital circuitry over other forms of circuitry is that it operates on only two voltage levels. These are the power supply voltage (referred to as LOGIC 1) and 0 volts (referred to as LOGIC 0).

CIRCUIT DESCRIPTION

The full circuit diagram for the Four-Way Chaser is shown in Fig. 1. In effect this circuit consists of two basic "building blocks". These are the clock pulse generator, which is made up of preset VR1, resistors R1, R2, capacitor C1 and IC1. This is used to drive the chaser circuit which consists of IC2 and the output l.e.d.s D1 to D4.

The clock pulse uses a standard 555 timer circuit, a number of which will be featured in other projects in this series. However, in this project it is important that a CMOS 555 timer (such as the 7555) is used, because the cheaper, bipolar version, is not suitable for circuits which also include digital elements. The CMOS ICM 7555 timer does not require the connection of the capacitor between 0 volts and pin 5 that you may have noticed in some circuits using the bipolar device.

To produce the clock pulses the timer is configured as an astable, so that its output (at pin 3) will be switched off (logic 0 state) and on (logic 1 state) repeatedly. The duration of the ON state is set by the values of the preset VR1, resistor R1 and capacitor C1 and this can be calculated by using the formula:-

ON time = 0.7 × (VR1* + R1) × C1

[Time measured in seconds, resistance in ohms and capacitance in Farrads.]

The OFF time between each on period can also be calculated by using the formula:-

OFF time = 0.7 × (VR1* + R1 + R2) × C

The circuit shown incorporates a preset potentiometer wired as a variable resistor, VR1, which is included so that the actual speed of operation of the clock can be adjusted as desired by adjusting the wiper of VR1. Only the part of the resistance which is actually incorporated into the circuit is included in the two timing formulae given above.

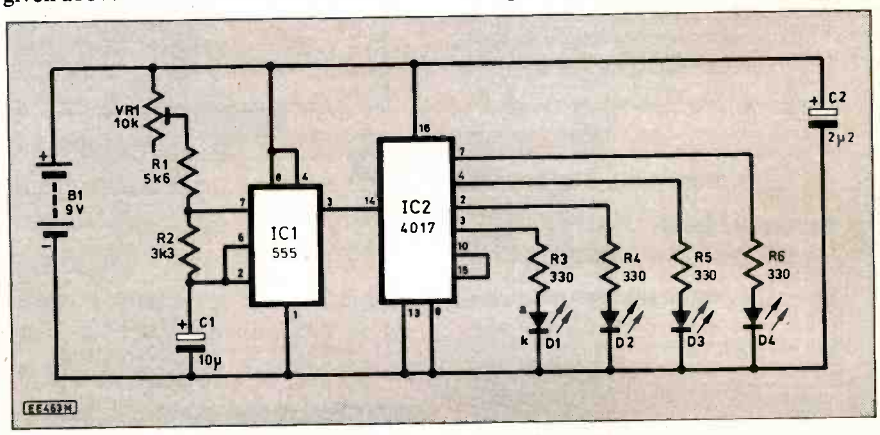


Fig. 1. Complete circuit diagram for the Four-Way Chaser.

CHASER CIRCUIT

The chaser circuit consists, very simply, of a 4017 Johnson Counter which is used to turn on the output l.e.d.s D1 to D4 in sequence. The 4017 has two clock inputs (at pins 13 and 14). These operate with opposite sense inputs and for the purposes of this circuit the clock pulse from pin 3 of IC1 is connected to pin 14 of IC2 with pin 13 of IC2 held at the logic 0 level by being connected to the 0 volts power supply rail.

In this arrangement each pulse from the output of IC1 causes the outputs of IC2 to go to the logic 1 state in sequence. As we only require four l.e.d.s to be driven by this circuit only outputs 0 (pin 3), 1 (pin 2), 2 (pin 4) and 3 (pin 7) are used to drive the l.e.d.s. The fifth output to be energised in sequence (4 — pin 10) is connected to the Master Reset input (pin 15). The effect of this is that whenever output four (pin 10) goes to the logic 1 state this immediately triggers the Master Reset circuit within IC2 which in turn resets the counter to zero with ouput 0 once more in the logic 1 state.

Each of the outputs 0 to 3 is connected to a l.e.d., via a 330 ohm series resistor (R3-R6). These resistors are necessary to restrict the current flowing through the l.e.d. to a safe level to prevent them burning out.

Capacitor C2 is included in the circuit to provide the decoupling necessary to prevent the rapid switching which occurs within the i.c.s. from scrambling the sequence generated by IC2.

CONSTRUCTION

The Four-way Chaser is easily made up using stripboard. The finished board is shown in the photographs and the component layout in Fig. 2 so you will probably find it helpful to look at those whilst you make up the circuit.

The first task is to cut a piece of stripboard to the correct size. You will need a piece which is at least 14 strips deep and 46 holes wide. You will need to drill the mounting holes as shown, using a 4mm drill, before starting to construct the circuit.

Before any components are mounted on the stripboard you will need to break the copper tracks as shown in Fig. 2 with a stripboard cutter or a small drill. It is important that these track breaks are made completely so that not even the merest sliver of copper remains to bridge across the track break.

Once the board has been prepared you can start the electronic construction. Although the operation of the circuit is not affected by the order in which you insert the components into the stripboard, you will find it easier to construct the circuit if the components are inserted in ascending order of size.

LINK WIRES

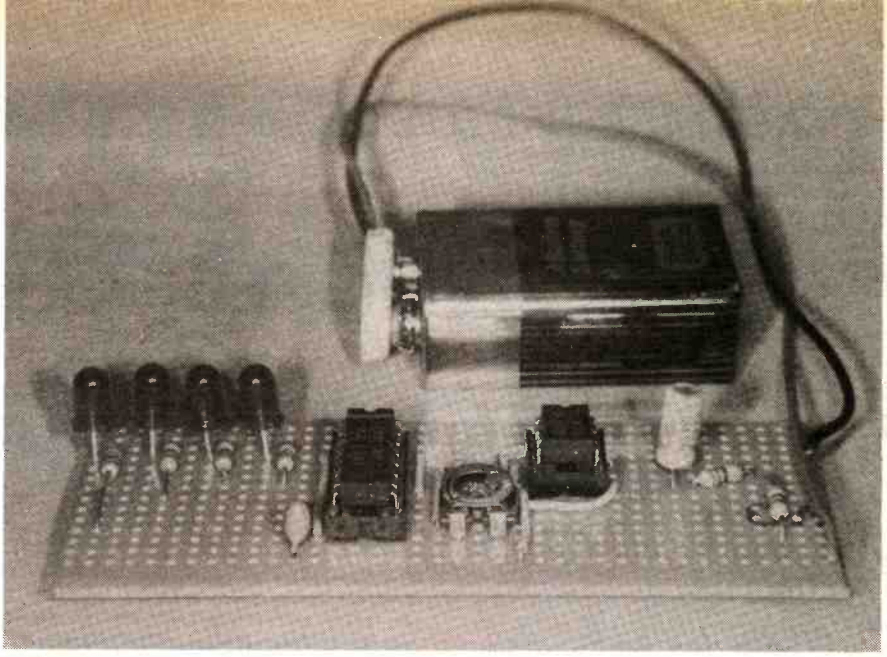
The first stage in constructing this circuit should be to insert the wire links into place. To do this you should place the stripboard so that the strips of copper on it are underneath the board and run from left to right and not up and down.

Starting at the top left hand corner of the board count across and then down the correct number of holes until you can place one end of the wire link in the position shown in Fig. 2. Turn the board over and solder the wire into place. Cut off any excess wire on the underside of the board with your cutters and turn the board over again for the other end of the linkwire.

The wire links are made with insulated single core wire but before connecting the wire you will need to strip off the insulation from one end with the cutters to leave about 3mm more of the conductor (wire) exposed than you expect to need. The stripped wire should then be tinned, by melting a little solder onto the bit of a soldering iron and then placing the wire onto the iron's tip with the solder on the opposite side of the wire to the iron.

The solder is left there until it melts and flows evenly over the wire. When you remove the wire from the solder it will probably leave a little blob on the end of the wire, which you should then cut off. The tinned wire should now fit easily through the hole in the stripboard.

The next task is to put the resistors in their correct places by just bending the wires of the resistor at right angles to the body of the component, then fitting them through the holes shown in Fig. 2 and finally soldering them into place. Also, at this stage, fit the preset potentiometer into position and solder it into place.



I. C. SOCKETS

The i.c. holders should now be inserted and soldered into position as shown in Fig. 2. Although it is possible to solder the i.c.s directly into place using sockets will both make the construction simpler and make for easier replacement if a fault should occur. It is important that you take care to make sure that the notch on both of the i.c. holders is facing towards the bottom of the stripboard, as this will help you when inserting the timer and counter into place.

The capacitors C1 and C2 are the next items to be fitted. As these are both polarised types it is important that the positive and negative (−Ve) connections of both the capacitors (the negative(−) sign is usually marked on the component case) are connected to the correct holes marked in Fig.2. Failure to mount these components correctly will, at least, cause the risk of the circuit not working.

Both of the capacitors are easy to mount because they have leads which push into the board without needing to be bent. But, because the capacitor's connections are so close together, it is important that you take great care with the process of counting the holes when looking for the correct place to install these components.

The final components to be mounted are the l.e.d.s D1 to D4. These devices are also polarised but the result of not connecting them the correct way round is simply for the circuit not to work. The case of each l.e.d. has a small flat on one side of the otherwise circular body and the connection nearest to this (the cathode — k) should go to the negative power supply rail. If you

COMPONENTS

Shop Talk
See page 578

Resistors
R1 5k6
R2 3k3
R3-R6 330 (4 off)
All 0.25W 5% carbon

Potentiometer
VR1 10k min. skeleton preset, horizontal

Capacitors
C1 10µ p.c.b. elec. 10V
C2 2µ2 tantalum 10V

Semiconductors
D1-D4 Standard l.e.d. (4 off)
IC1 ICM7555 CMOS timer
IC2 4107 CMOS Johnson counter

Miscellaneous
B1 9V (PP9) battery
S1 s.p.s.t. toggle switch (optional)
Stripboard, 0.1in matrix 14 strips × 46 holes; case (optional); l.e.d. clips (optional); battery clips; connecting wire; solder etc.

Approx. cost Guidance only £5.50

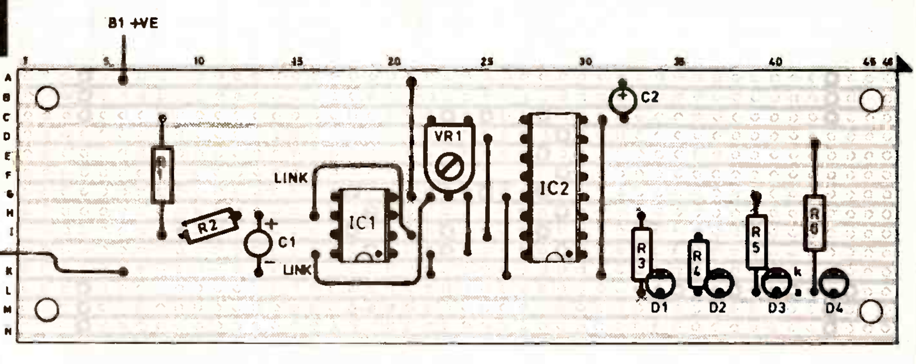
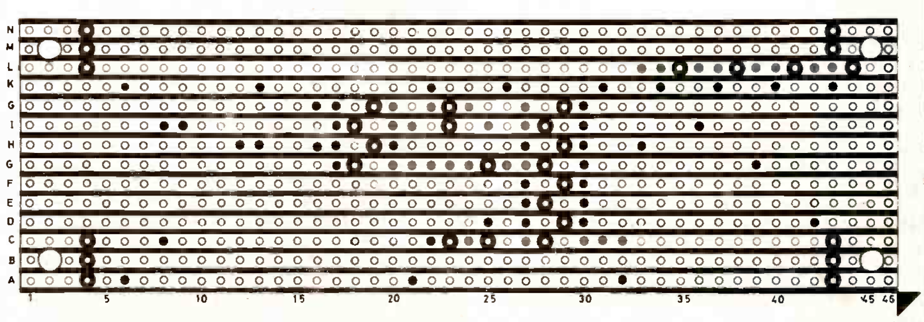


Fig. 2. Stripboard component layout and details of breaks required in the underside copper strips. The i.c.s should be inserted in i.c. sockets.



wish you may connect the l.e.d.s to the stripboard by long wires instead of mounting them directly on the stripboard.

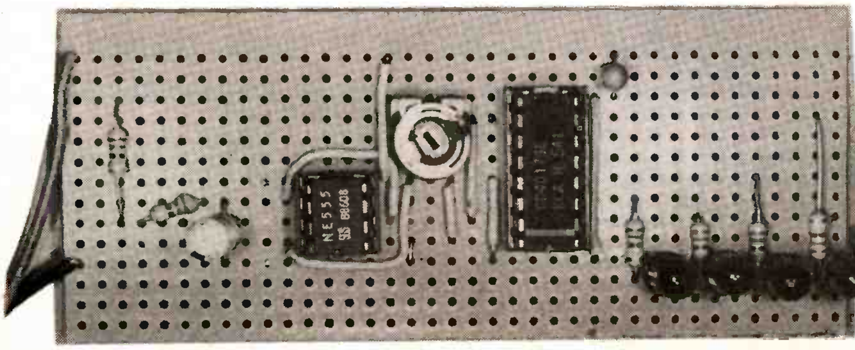
The wires connecting the battery B1 to the circuit board can now be tinned and soldered into place. The black wire from the battery connector goes to the point on the stripboard shown as B1−V and the red wire of the battery connector to the place marked B1+V, unless, of course, you wish to add an on/off switch. In which case the battery connector red wire will need to go to one of the switch terminals and another wire connected between the other switch terminal and the B1+V connection on the board.

The final step is to insert IC1 and IC2 into their respective holders, making sure that the notch on the i.c. corresponds with the notch on the i.c. holder. Some i.c.s do not have a notch in one end but have a slight, circular dent near one pin (pin 1), which goes nearest to the edge of the i.c. holder which has the notch.

duce the fault. The circuit description above will help you here.

The logical place to start is by checking that there is an output from the clock circuit. To check this simply place the multimeter so that the positive probe is connected to pin 3 of IC1 and the negative probe of the meter is connected to any 0V connection, such as pin 1 of IC1. If the clock circuit is operating correctly you should see the meter needle swing rapidly back and forth. If this is not happening you should investigate further by testing the voltages present at various points in the circuit.

Firstly you should measure the battery voltage with the battery disconnected from the circuit and then between any 0V connection and both pins eight and four of IC1 as well as between the battery positive connection to the board and pin 1. If there are no voltages present when a good battery is connected to the board this will obviously indicate faulty wiring up of the board.



Layout of components on the completed prototype board. Note that the timer i.c. is not the required CMOS version.

TESTING

Before connecting the battery and testing the circuit you should carefully examine the board to make sure all of the components are inserted into the correct places, are the correct way round and that there are no blobs of solder or slivers of wire shorting out the copper tracks. Once the board has been checked, the battery should be connected and you should be able to see the l.e.d.s flashing off and on in sequence and you should be able to adjust the rate of the "chase" by adjusting preset control VR1.

If the circuit does not operate correctly it will be necessary to check for faults. The first step in fault finding is to check carefully, once more, that all of the components are in the correct places and are the correct way round. In this project the components likely to cause faults if connected the wrong way round are the l.e.d.s, C1, C2 and IC1 and IC2.

The next stage is to check carefully that all of the soldered joints are good joints. This is probably best done by reheating the joint with a soldering iron.

If no mechanical problems of the sort mentioned above are found then it will be necessary to check the circuit through to see whether there is a faulty component or not. You will probably find that you will need to use a multimeter to perform this stage of the process.

FAULT FINDING

When fault finding it is important to adopt a logical approach to the problem, the first step being to look at the symptoms presented by the circuit and decide which is the most likely part of the circuit to produce the fault.

If the output voltage at pin three is locked permanently at a fixed voltage then you should remove IC1 from its socket and check the voltage at the pin three connection again. If the voltage persists with the i.c. removed then the fault does not lie with IC1 but most possibly with the wiring associated with the input to IC2. Similarly a permanent 0V at pin three of IC1 might be caused by a short between Pins 13 and 14 of IC2 or the 0V connection to pin 13 having been inadvertantly connected to pin 14.

The next step is to replace IC1 in its holder and check the voltages between 0V and pin two, pin six and pin seven. The voltage at pin seven should be fluctuating around a value which is roughly ⅔rds of the battery voltage. The voltages at pins two and six should be identical (because these two pins are connected together by a wire link) and these should also be fluctuating but at a voltage slightly less than that found at pin seven.

If both of these voltages are not present then the most likely cause is that the circuit from the positive voltage rail, through preset VR1 and resistors R1 and R2 is not correctly made. This is best checked by measuring the voltage present between 0V and each of the points in the component chain through VR1, R1, R2 and capacitor C1 and investigating at the point where no voltage is measured.

If a voltage is present between 0V and pin seven but no voltage, or only a very small voltage, is measured between the 0V rail and pins two or six of IC1, then you should check that the resistance between pins seven and six of IC1 is roughly equal to that of resistor R2. If this is correct then check the resistance of capacitor C1 with the resistance range of your meter.

If the resistance is very low (less than about 500 ohms) then you should replace capacitor C1. If there is no voltage measurable between pins six and two of IC1 then this could be caused by a short circuit between the connections of C1 or by a short circuit within C1 or its connections to the stripboard.

If voltage is present at pins two and six of IC1 but it does not fluctuate then the likely causes are that capacitor C1 is not correctly connected — which can be checked by reheating the joints of C1 on the stripboard — is faulty or that IC1 is faulty. To check C1 you should touch connect another capacitor of similar value across the connections to see if this cures the fault. If this does not cure the fault then you should check that the connection between the positive connection of C1 and pins two and six of IC1 is correctly made.

CHASER CIRCUIT

If voltage switching is occuring at pin three of IC1 then the clock circuit is working correctly and the fault must lie within the chaser circuit. Again a few voltage checks need to be made to help with the diagnosis of any chaser circuit faults.

Check that the signal from pin three of IC1 is repeated at pin 14 of IC2. There should be no wiring problem here as the connection is made by a direct copper strip.

If the signal is not reaching pin 14 of IC2 then the only real explanation is that there is a poor soldered joint either at the connection of the strip to pin three of IC1 or to pin 14 or IC2.

The next step is to check that the battery voltage is measureable between pins eight and 16 of IC2. If this is not measurable then the connections between the power supply rails and the i.c. should be investigated.

The battery voltage should be measurable when the positive meter probe is connected to pin 16 and the negative probe is connected to pin 13. If this does not occur the connection between the 0V power supply rail and pin 13 should be investigated.

The final input to be investigated is pin 15. This pin (and pin 10) should be at logic 0 (0V) for virtually all of the time. The very brief time for which these two pins are at logic 1, which occurs at the reset point, is so small as to be almost unmeasurable. If the voltage readings at pin 10 and pin 15 are not the same then the connecting link should be checked.

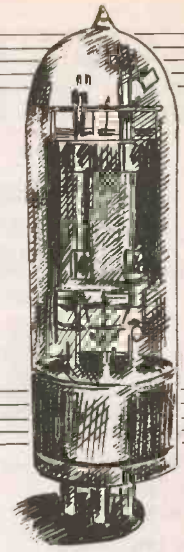
If the above tests reveal nothing untoward the final step is to check the outputs. If all of the other connections to IC2 are correct the outputs 0 to 3 must either then switching from Logic 0 to Logic 1 in sequence or the i.c. is faulty.

Whenever any of the outputs goes to the logic 1 state its associated l.e.d. (D1 to D4) should light. If this does not happen then the connections between the appropriate output pin and l.e.d. should be investigated. The most likely cause of this problem is that the l.e.d. is inserted into the board with the polarity reversed or that there is at least one dry joint in the series of connections from IC2 outputs, through the dropping resistor and l.e.d. to the 0V line.

IN USE

The project is simple to use. Once you have checked that it works correctly then you can simply set VR1 to give the correct speed of operation and place the LEDs in the desired position. □

Special Feature



THE MAGIC LAMP

PETE ROBERTS

No. the title is not a misnomer. It describes the derivative of the domestic light bulb that started the entire field of electronics at the turn of the century; the thermionic valve. Far from being obsolete, valves are still extensively used in high power applications, particularly in professional audio power amplifiers and radio and TV broadcast transmitters.

EDISON

Valve action was accidentally discovered by Thomas Edison, the inventor of the electric lamp. Light bulbs of the time used a tungsten filament sealed into a highly evacuated bulb, and suffered premature blackening of the inside of the glass.

In an attempt to find the cause Edison sealed a small metal plate into the bulb near the lamp's filament and subsequently found that a current could be made to flow between filament and plate when the plate was made positive with respect to the filament, but not when the polarities were reversed. A phenomenon that came to be known as the "Edison Effect".

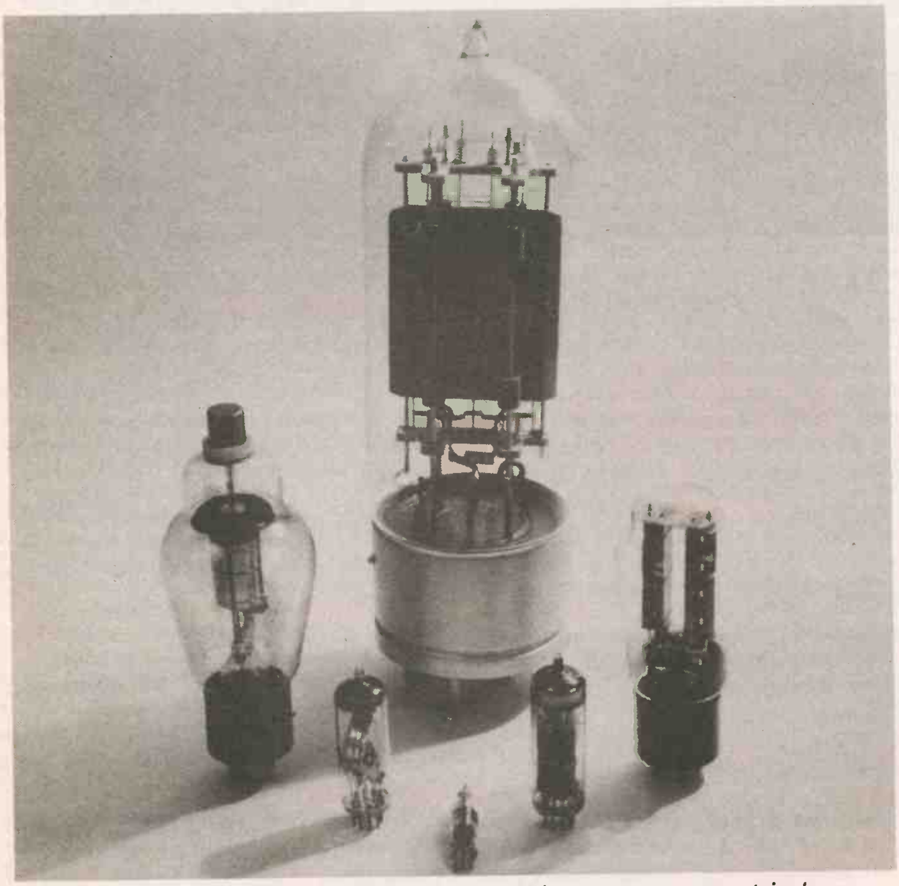
Soon after, J. A. Fleming developed the theory of thermionic emission, explaining the Edison Effect. Heating a conductor to a high temperature dislodges electrons from the surface. When surrounded by a vacuum these electrons can "boil off", forming a cloud of electrons. This cloud is known as the "space charge".

When a nearby plate is made positive, electrons from the fringes of the space charge are attracted across the intervening space, setting up a flow of current. Electrons lost from the space charge are replenished by fresh emission from the filament. Conversely a negatively charged plate repels electrons resulting in no current flow. This arrangement of filament and plate was called a "diode" — meaning two electrode. It was, and still is, used for demodulation of radio signals and power rectification. It was the one-way action of the diode that led to the generic term "valve".

TRIODE

Soon after the diode valve came the triode (three electrode), invented by Dr. Lee de Forest. He found that a metal mesh interposed between the filament and plate allowed control of the electron flow — charging the grid positively increased current flow, whilst a negative charge would reduce, or even cut off, the plate current, see Fig. 1. The important point to note is that a small change in grid voltage caused a large change in plate current, in other words amplification.

Triode valves could also be used as oscillators, allowing the generation of steady r.f. carriers, rather than bursts



Examples of valves in order of size: one very large anonymous triode, a 866 mercury vapour rectifier, 5Z4 type full wave rectifier, an EL84 output pentode, a EM87 magic eye, and a EA50 submin. detector diode.

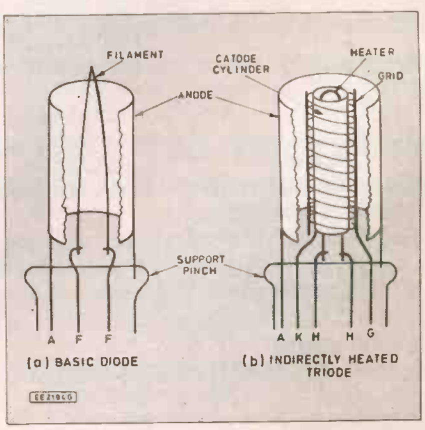


Fig. 1. Simplified diode and triode construction.

of r.f. energy produced by the spark transmitters in use at the time. In fact, the first broadcast station — 2LO — started only a few years after the invention of the triode.

Valves are voltage controlled devices. Also, in most cases they operate at fairly high voltages and correspondingly low currents compared with transistorised circuitry. Unlike transistors, valves can be made with any number of electrodes allowing some fairly unconventional circuits by today's standards.

HEATING

The circuit symbols for the diode and triode are shown in Fig.2. The plate is now known as the anode, with the filament becoming the cathode. In most cases filaments have given way to indirectly heated cathodes. Filament valves can only be used satisfactorily when a d.c. filament supply is available, i.e. from batteries. Where a.c. supplies are used a 100Hz hum is impressed upon any signal that the valve is handling.

The indirectly heated cathode comprises a tungsten cylinder into which an insulated tungsten heater is inserted. As hum in filament valves is caused by the filament temperature fluctuating in sympathy with the a.c voltage, the much larger thermal mass

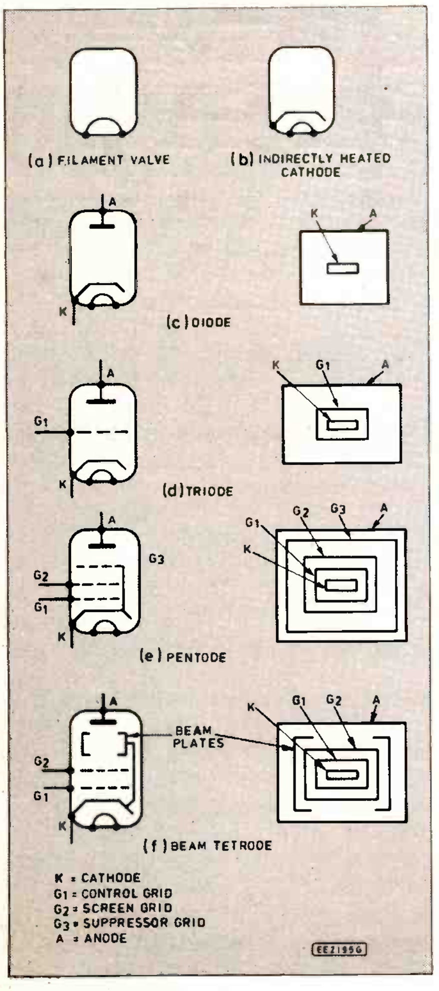


Fig. 2. Basic valve type with scematics.

of the indirectly heated arrangement eliminates the problem. As the cathode is also insulated from the heater, it is possible to design circuits where the cathode potential can be different from that of other valves in the equipment and independent of the (usually grounded) heater supply.

Valve manufacturers soon found that coating the cathode with a mixture of rare earth oxides (usually of strontium, caesium and calcium — each maker having his own secret recipe) allowed copious emission of electrons at a dull red heat and this, together with the larger surface area of the cylindrical cathode, allowed the design of valves capable of handling reasonable power.

DISADVANTAGES

It wasn't long before triodes were found to have certain disadvantages. When the grid is driven positive by the signal the anode current increases. With a resistive load (which is usual) this causes a drop in anode voltage, with a corresponding drop in anode current. Conversely during negative going portions of the signal, the anode current falls, increasing anode voltage which in turn tries to increase the anode current.

This is effectively a form of negative feedback which reduces the valve's gain (known as the amplification factor or μ). Also, at high frequencies, the fairly large parasitic capacity between anode and grid can cause circuit designers some headaches.

While these problems were overcome in multi-grid valves, of which more very shortly, modern triodes still give a good account of themselves, particularly in medium level audio amplifier circuits. Some of you may have come across the ECC83 double triode, a good example of modern valve design.

TETRODE

The next development was the tetrode valve, with two grids. The first (signal) grid is now called the control grid (G1) while the new grid (G2) is designated the screen. The screen grid is similar in construction to the control grid; a fairly tight spiral of fine wire. The screen is mounted concentrically, and close to, the control grid (Fig. 2). It is usually held at or close to the mean anode voltage.

The effect of the screen is to make the anode current almost completely independent of anode voltage, removing the degenerative feedback that triodes suffer from. The screen also breaks the capacitive coupling between the anode and control grid, simplifying the design of r.f. circuits. As usual though, Sod's law raised its head and curing one problem led to another.

SECONDARY EMISSION

In all valves, the electrons comprising the anode current don't just drift across from the cathode at a gentle walking pace. They whip across at speeds approaching that of light, literally smashing into the anode. Not surprisingly these high speed impacts knock electrons out of the anode; a phenomenon known as secondary emission.

At certain combinations of electrode voltages any increase in anode voltage caused more electrons to be knocked out of the anode than actually arrived from the cathode. Furthermore, most of these electrons were captured by the screen grid, resulting in a fall of anode current when the anode voltage increased. This, of course, is a negative resistance characteristic which in turn means instability. Tetrode valves would "take off" into oscillation quite happily with no warning. Obviously, something had to be done.

This problem was overcome in two ways. It was found that a third grid, with wide spacing, mounted near to the anode and maintained at cathode potential would repel any secondarily emitted electrons back to the anode, removing the negative resistance "kink".

This third grid, numbered G3, is known as the suppressor. The suppressor grid is usually connected to the cathode internally, although in some valves it is brought out to a separate pin. The new five electrode valve is called a pentode, and is the most commonly used type.

BEAMS AND MORE GRIDS

The other development used cathode ray tube technology where the tetrode electrode assembly was fitted with a pair of deflection plates, one each side of the screen grid (Fig.2). These plates, which are always connected to the cathode, form the electron stream into beams which repel any stray electrons back to the anode. The resulting valve type is known as a beam tetrode and finds service in high power audio work and r.f. power amplifiers in transmitters.

As a matter of interest, the two best known power output valves, the EL34 and KT88, are pentode and beam tetrode respectively.

There are valves made with even more grids for special applications; the heptode frequency changer springing to mind. Many modern valves are multiple types with two or more separate electrode assemblies in one bulb.

Some readers may also remember the magic eye, a cross between valve and CRT which indicates voltage levels by altering the area of the shadow on a fluorescent display. Magic eyes were extensively used as tuning indicators (by measuring the voltage on a receiver's a.g.c. line) and recording level indicators in tape recorders. An example of such a valve is the EM87.

NOMENCLATURE

As we hope to present the occasional valve project in the future, it would be a good idea to introduce the system of valve nomenclature. Like American transistors, American valves have an arbitrary numbering system. Usually, but not always, the first part of the valve number (usually comprising both letters and numbers) indicates the filament or heater voltage. The European Pro-Electron system is far easier to understand with each valve number having two or more letters and a number.

Referring to Fig.3 the first letter indicates the heater voltage, or current where the valve heaters are designed to be used in a series heater chain. Note that the "D" coding signifies a filament valve usually designed for battery operation.

The next letter denotes the valve type; extra letters here represent a multiple valve. The number indicates the valve base used (see Fig. 4) as well as the "family" to which the valve belongs.

For example, an EF80 is a signal pentode with 6.3 volt heater and a B9A base. An ECL86 is a triode output pentode again with a 6.3 volt heater and B9A base.

Fig. 3. European Pro-Electron valve coding.

First letter — heater type.

- D — 1.5 volt filament.
- E — 6.3 volt heater, undefined current.
- G — 5 volt heater.
- P — 300mA heater, undefined voltage.
- U — 100mA heater, undefined voltage.

Second and subsequent letters

- A — Signal diode, single.
- B — Signal diode, double.
- C — Triode.
- F — Pentode.
- H — Heptode.
- L — Power output, pentode or beam tetrode.
- M — Magic eye voltage indicator.
- Y — Single diode half wave power rectifier.
- Z — Double diode full wave power rectifier.

Number

- 30+ series — International Octal base.
- 40+ series — B8A skirted base.
- 50+ & 60+ series — Miscellaneous bases and wired in.
- 80+ series — B9A miniature base.
- 90+ series — B7G miniature base.

CIRCUITS

A glance at Fig. 5 will emphasise the differences between valve and transistor circuits of similar function. Compare the values of resistors, capacitors and voltages between the two. Valves are high impedance devices and are voltage, not current controlled.

Valve circuit design is also simplified by the fact that characteristics vary very little between specimens of a given type. Also, valves do not need stabilising against temperature changes as do transistors, and they are fairly difficult to damage by accidental abuse.

Valves are being re-introduced into military equipment as they are immune to damage from electromagnetic pulse (EMP). Bear in mind that in the event of a nuclear war breaking out an airburst 100 miles high over the North Sea could destroy ALL semiconductor equipment in Britain and Western Europe! Valves are also making a comeback in hi-fi circles as valve power amplifiers "sound nicer", to put is crudely.

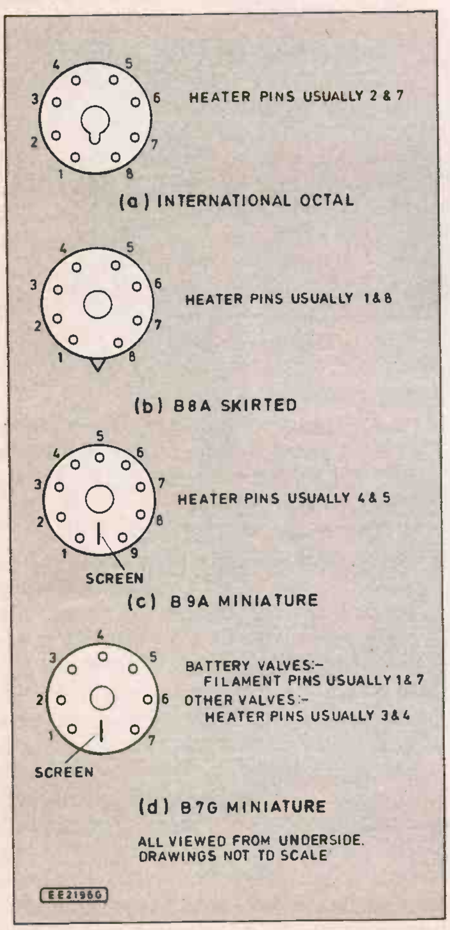


Fig. 4. Common valve bases.

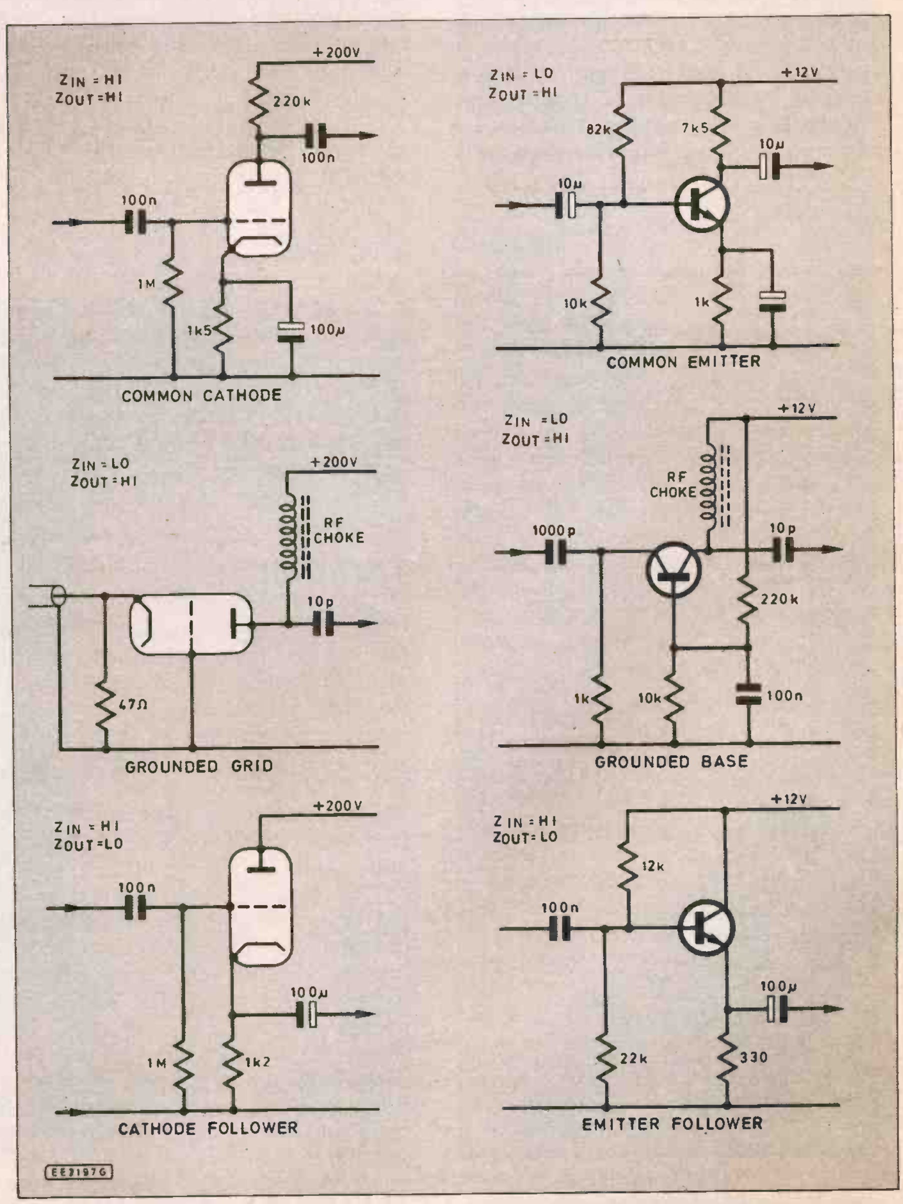


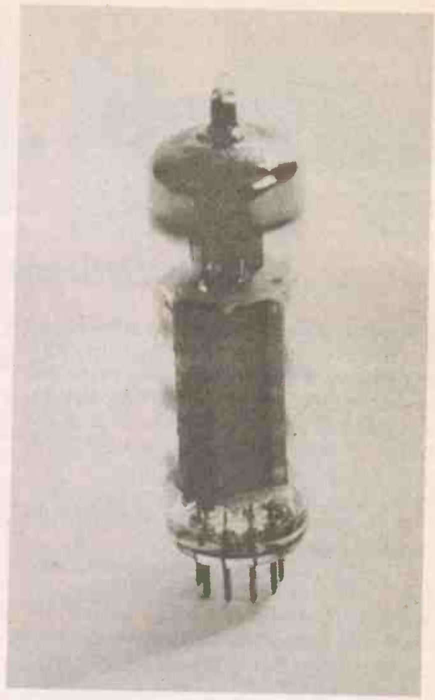
Fig. 5. Basic circuit comparison.

There are some really odd valves used at v.h.f. and microwave frequencies, these include the cavity magnetron (used in radar as well as the domestic microwave oven), klystrons, used as power amplifiers in u.h.f. TV transmitters, and travelling wave tubes, found in satellite transponder output stages. These devices are beyond the scope of this short article as their design and use owes more to a mixture of plumbing and magic rather than conventional design techniques!

Finally, should anyone still believe that valve technology belongs in the Dark Ages, bear in mind that almost every signal you pick up on the latest digitally synthesised radio, together with teletext and satellite TV, has originated in some form of thermionic valve.

Acknowledgement to P. M. Components, Selectron House, Springhead Enterprise Park, Springhead Road, Gravesend, Kent, DA11 8HD (0474) 60521 who supplied most of the sample valves free of charge.

A 5Z4 type full wave rectifier.



The EL84 a well known output pentode.

b...Beeb...Beeb...Beeb...Beel

. . . Line Drivers . . . MIDI Interfacing . . . Line Drivers . . .

CARRYING on from last month's article about serial interfacing and the BBC computer's 1MHz bus, we will consider the subject of line drivers. An RS232C signal is nominally at unloaded levels of plus and minus 12 volts, and should not go below plus and minus 3 volts. In practice, provided long cables are not going to be used, it is possible to get away without using negative signal voltages.

A simple line driver of the type shown in Fig.1. will usually provide good results, and I have not encountered an RS232C input that cannot be driven from a simple circuit of this type. This is just a simple common emitter switch that gives an output at standard 0/5 volt logic levels. Current limiting at the output is provided by resistor R4.

Like a line receiver, a line driver must provide a phase inversion in order to produce a signal of the correct polarity. A simple common emitter stage of this type provides the required inversion.

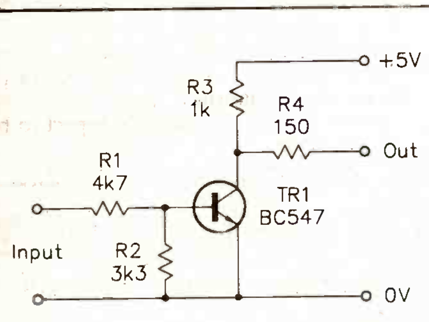


Fig. 1. A simple line driver circuit.

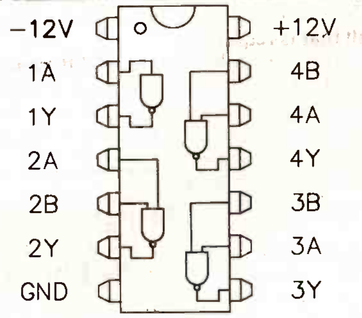


Fig. 2. Pinout details for the MC1488 line driver i.c.

Probably the best way to obtain full RS232C voltage levels is to use a special driver chip, such as the MC1488. This provides four line drivers, as will be apparent from the pinout details provided in Fig.2. It has no built-in voltage converter circuit, and it therefore requires dual balanced supplies of about plus and minus 12 volts (plus and minus 15 volts maximum).

There is no −12 volt supply output on the power port of the BBC computer, and so either a voltage converter or a mains power supply for the unit would be needed. The mains power supply is perhaps the better option, and would meet Acorn's recommendations for user port add-ons.

Three of the drivers in the MC1488, for reasons that are not entirely clear to me, have twin inputs and are effectively a form of NAND gate. Presumably the gate action will not normally be required, and either both inputs can be wired together, or one input can be connected to the earth rail and the other input can be driven from the 6850.

Max

For maximum convenience, a chip such as the aptly named MAX232C can be used to provide the line driver and receiver functions (see page 437 of the Maplin catalogue). This provides two line drivers and two receivers, plus integral voltage converters so that operation from a single 5 volt power supply is possible. I have no first hand experience of using this chip, but it certainly seems to be a very good one, if a trifle expensive at the present time.

In order to set the required baud rate a suitable clock signal must be supplied to the baud rate clock inputs of the 6850. The conventional way of achieving the standard baud rates is to use a crystal oscillator that operates at a frquency which, when repeatedly divided by two, gives frequencies that provide many of the standard baud rates.

You will find 2.4576MHz crystals in many component catalogues, and these are intended for use in baud rate generators. For example, using a seven stage binary divider with a 2.4576MHz input gives an output at 19,200Hz, eight stages give 9,600Hz, and so on.

System Clock

With a micro based system there is the alternative approach of using the system clock plus a divide by "n" counter. In the case of a circuit interfaced to the 1MHz Bus, the system clock would obviously be the 1MHz clock signal, and the divide by "n" action could be provided by the timer/counters of a 6522 VIA. You could even use one of the internal VIAs and tap off a suitable clock signal from the user port.

When using the divide by "n" method it is unlikely that dividing 1MHz by an integer will give exactly the required clock frequency. For example, the required clock frequency for 1200 baud operation with the 6850 in the divide by 16 mode is 19.2kHz (1200 × 16 = 19200Hz = 19.2kHz). Dividing 1,000,000 by 19,200 gives the required division rate of 52.083.

In practice a division rate of 52 should be perfectly satisfactory, giving an error which is only a small fraction of 1 per cent. In fact an error of as much as one or two percent is likely to be perfectly satisfactory in practice.

Midi

MIDI seems to become ever more popular, and MIDI using the BBC computer is certainly a popular pastime. Articles on anything connected with both MIDI and the BBC computer certainly produce a large reader response.

MIDI interfacing can be achieved in three basic ways, with the most simple of these being the largely software approach. I will not elaborate on this method here, since it was covered in an article in the MIDI feature in the March 1989 issue of *Everyday Electronics*. However, it is only fair to point out that using the microprocessor to do the encoding and decoding reduces the amount of processor time left for other purposes. Whether or not this is important depends on the complexity of the MIDI software you will wish to run.

The most complex method is to have a so-called "active" or "intelligent" interface. This is one which has hardware to provide the serial encoding/decoding, plus a built-in microprocessor to aid with the data processing. Often this type of interface has two or more independent MIDI outputs, permitting 32 or more channels to be handled. While this type of interface is highly desirable, it is inevitably quite complex and expensive, and is only worthwhile when used with very complicated software that really requires the power it provides.

The middle route, and the most common form of add-on MIDI interface, is the type which uses a UART (universal asynchronous receiver/transmitter) or other serial interface chip to provide the serial encoding/decoding, but does not give any further assistance. This is a good way of doing things in that it is quite cheap, but still enables quite complex MIDI processing to be undertaken provided the computer has a reasonably powerful microprocessor, since none of the processor's time is taken up on the serial encoding and decoding.

A 16 bit microprocessor is preferable for a high power application such as MIDI processing, but as MIDI programs do a lot of shuffling with byte-size chunks of data, an 8 bit processor is not at such a big disadvantage as you might think. Certainly some impressive MIDI programming is possible with the BBC computer.

A MIDI interface based on the 6850 was described in my article in the March 1986 issue of *Everyday Electronics*, but it is worth looking into this subject again here. Firstly due to the popularity of the original article, and secondly because a number of constructors seemed to run into difficulties with this project! The 6850 is well suited to this application as it can handle the relatively high baud rate of 31,250 baud, and the required word format of one start bit, eight data bits, one stop bit, and no parity checking is within its repertoire.

Input Stage

While MIDI is an asynchronous serial system, much like the RS232C system, it is very different in terms of the type of signal that is used to convey data from one unit to the other. The positive and negative voltages of the RS232C are replaced by a current loop system. This uses a current of five milliamps which is used to drive an opto-isolator at each MIDI input. The opto-isolation helps to avoid problems with "hum" loops, the coupling of digital noise from a micro-controller to the audio stages of an instrument, etc.

This opto-isolation provides a slight design difficulty, since a "bog standard" opto-isolator lacks the speed and efficiency to give good results in this application. A Darlington type will give the necessary efficiency, but will be so slow that when fed with a MIDI signal it is unlikely to couple any signal through to its output at all!

Probably the best type of opto-isolator for an application of this type is one which has a photodiode driving an emitter follower, which in turn drives a common emitter switching stage. The photodiode and emitter follower stage give a relatively high operating speed, while the amplification of the common emitter output stage provides good efficiency. Opto-isolators of this type can handle baud rates of up to about 300k baud, and the 31.25k of MIDI is well within their capabilities.

The circuit for a MIDI input stage based on the 6N139, which is available from a number of suppliers, is shown in Fig.3. This is a bit more expensive than the CNY17-3 used in my original design, but it should provide excellent reliability and repeatability. In fact the CNY17-3 used in the original design should also provide good reliability and repeatability, but only if the correct type with a "3" or "III" suffix is used.

I would not recommend the use of a device having any other suffix, or the use of a substitute. Come to that, I would not recommend the use of a substitute for the 6N139 either. There are similar devices available that would probably work properly in this circuit, but as the 6N139 is fairly easy to obtain there would seem to be little point in using a substitute device that might not be entirely satisfactory.

There is no difficulty in designing a MIDI output stage. All that is needed is a simple common emitter switching stage with current limiting resistors to set the required five milliamp output current. The circuit of Fig.4 will suffice, and it is possible to drive several of these from the 6850 if multiple MIDI outputs (for the "star" connection system) are needed.

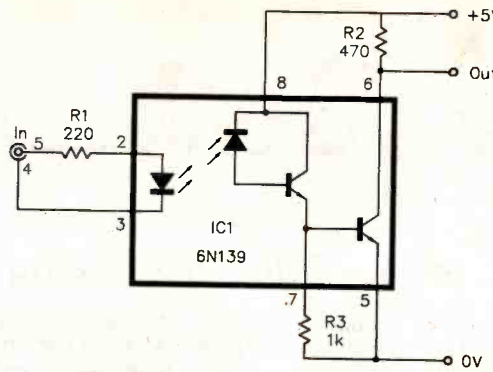


Fig. 3. A reliable MIDI input stage.

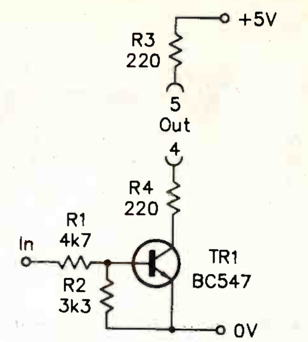


Fig. 4. A simple MIDI output stage.

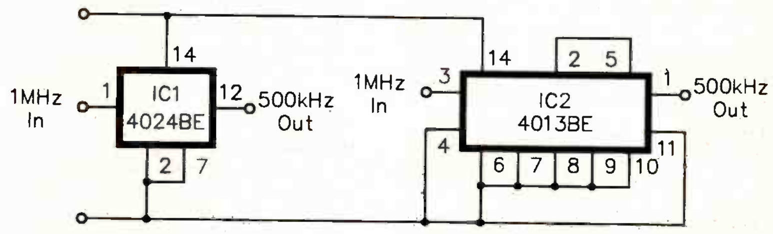


Fig. 5. Two divide-by-two circuits which will give a 500kHz clock signal from the 1MHz signal from the computer.

Baud Rate Clock

Although the MIDI baud rate of 31,250 baud might seem to be an odd choice, dividing one million by 32 gives you a figure of 31,250. In other words, using a 1MHz basic clock signal, a division rate of 32 will provide the correct baud rate. This enables the required baud rate to be obtained using standard frequency crystals and binary dividers. As the 1MHz Bus provides a 1MHz clock signal, and the 6850 can be set to provide a baud rate equal to one sixteenth of the baud rate clock frequency, a divide by two flip/flop between the 1MHz clock and the clock inputs of the 6850 are all that is required.

There must be dozens of different ways of obtaining the divide by two action, and two suggestions are provided in Fig.5. The first of these is a 4024BE seven stage binary ripple counter. In this case only the first stage is utilized while the other six are ignored. The second circuit uses one section of a 4013BE dual D type flip/flop to provide the divide by two action.

MIDI interfacing is very simple in that no handshaking is used. At least, no hardware handshaking is utlized. Some system exclusive messages make use of software handshaking using messages sent via the normal data links, but no other form of data flow control is used.

One problem with a home made MIDI interface is that it is not likely to be compatible with commercial MIDI software. Therefore, it is only worthwhile taking the d.i.y. approach if you will be able to write MIDI software to suit your needs. If you "try to have your cake and eat it" by using a home made interface with commercial software you can reasonably expect to be disappointed.

PROBE POCKET TREASURE FINDER

ANDY FLIND

An invaluable tool for the serious metal detecting enthusiast. Pinpoints the "find" in seconds.

THIS is a most useful accessory for keen metal detecting enthusiasts. As any "detectorist" will confirm, objects located with metal detectors are often hard to see, even though their presence has been clearly indicated. Small pieces of iron, if the detector is not discriminating against these, will usually have rusted to a soil colour and much time can be wasted spotting them in the hope that the signal might be something of greater interest. "Half-p" coins are also a considerable nuisance on many sites; although no longer in circulation there are still vast numbers of them in the ground, usually corroded to a deep earth-brown.

Some detectors do not "pinpoint" very well either and, taken with the above factors, this often leads to time-consuming excavation of unnecessarily large holes. Such activity doesn't improve the find rate on expeditions, and may aggravate the opposition to metal detecting found in some quarters.

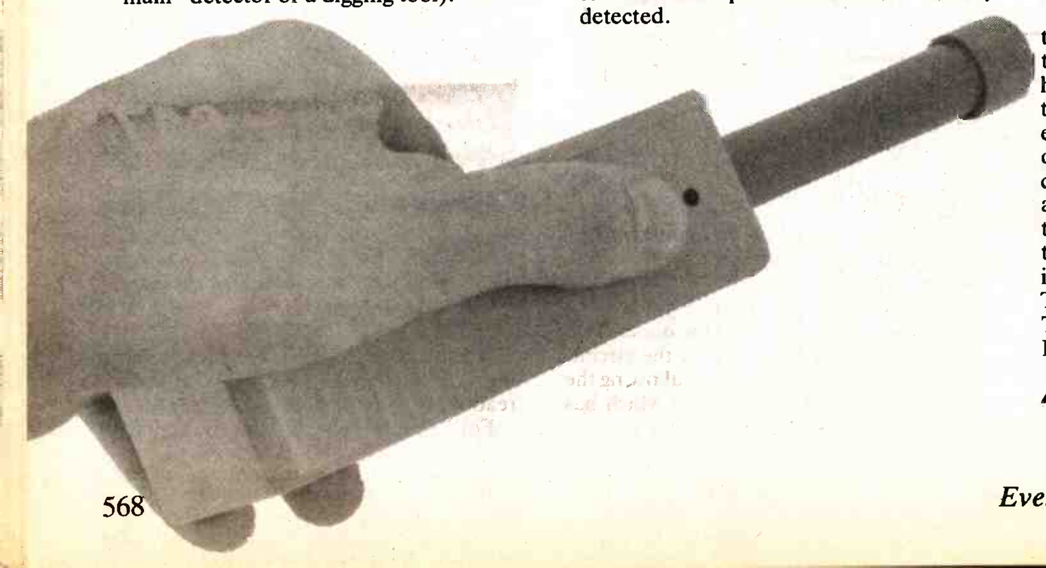
The "Probe" is the answer to these problems. Pocket-sized, with a compact detecting coil designed to find small objects at close range, it will pinpoint hard-to-see finds immediately, saving much time and effort. Operation is simple and as far as possible automatic for fast, one-handed use. (The other hand will be holding the "main" detector or a digging tool).

The "Probe" has just one control, a pushbutton. This turns it on and automatically adjusts it to threshold sensitivity. Should a false signal appear, due to "ground effect", another touch of the button will instantly reset the threshold. After use, the unit is simply replaced in the pocket where it will switch itself off after about thirty seconds.

CIRCUIT

The circuit uses a slightly unusual principle for detecting the presence of metal. It generates an alternating magnetic field with a coil in the usual manner, but makes use of the fact that a metal object entering this field absorbs a minute amount of power from it. This causes a fall in the coil voltage, and it is this voltage drop that is sensed. The principal is simple, works equally well for both ferrous and non-ferrous objects and requires only a simple coil with no fiddly alignment procedures.

In the full circuit, Fig. 1. the oscillator is built from two of the four gates in IC1, a CMOS 4011B quad "NAND" gate chip. The frequency, about 80kHz, is determined by the resonant frequency of coil L1 and tuning capacitor C3, the coil being actually driven through resistor R2. The high value of this resistor limits the drive power to the coil, so that voltage drops due to absorbed power are more readily detected.



Detection of the coil voltage is performed by the transistor stage, TR1, TR2 and TR3. If the voltage on the base of TR1 exceeds that on the base of TR2, TR1 will conduct and it's collector current will turn on TR3, collector current from which will raise the voltage at TR2 base to match that of TR1. This voltage will be stored on C4, decaying relatively slowly through R5, so the voltage across this capacitor corresponds accurately to the peak positive value of the a.c. signal applied to the base of TR1.

The "differential pair" arrangement of TR1 and TR2 compensates for their temperature-dependant base-emitter voltages. Ideally these should be matched transistors in the same case. Although such transistors are available they are difficult to find among hobby suppliers, and tend to be expensive. In practice, two standard BC184L's stuck together have proved an effective substitute.

AMPLIFICATION

The signal has now been converted to a d.c. voltage which falls slightly when the coil approaches a metal object. The effect is very small though, and requires amplification. This is provided by IC2, a straightforward inverting amplifier with one exception; it is "charge coupled", the usual gain-determining resistors being replaced with capacitors C5 and C6, giving a voltage gain of C5/C6 or about 300.

The advantage of using capacitors is that standing d.c. input voltages are easily cancelled by closing a d.c. feedback loop and allowing a charge to form across the input capacitor, after which the d.c. loop is opened and only subsequent input changes are amplified. The circuit works well, provided an amplifier with a very high input impedance, such as the 3130, is used.

Op-amps in feedback circuits normally try to balance their input voltages. The voltage at the non-inverting input of IC2 is held at 2.5 volts by divider R7, R8, so it tries to match this at the other input. If the electronic switch IC4a is closed, the output of IC2 will swing sufficiently negative to counter the current from VR1 and R9 and achieve 2.5 volts at the inverting input. If the switch is then opened, small drops in the input voltage will appear amplified and inverted (positive-going) at IC2's output. This output voltage is then converted by TR4 and R12 to a current drive for l.e.d. D1.

AUDIO

Audio output is a useful addition to the

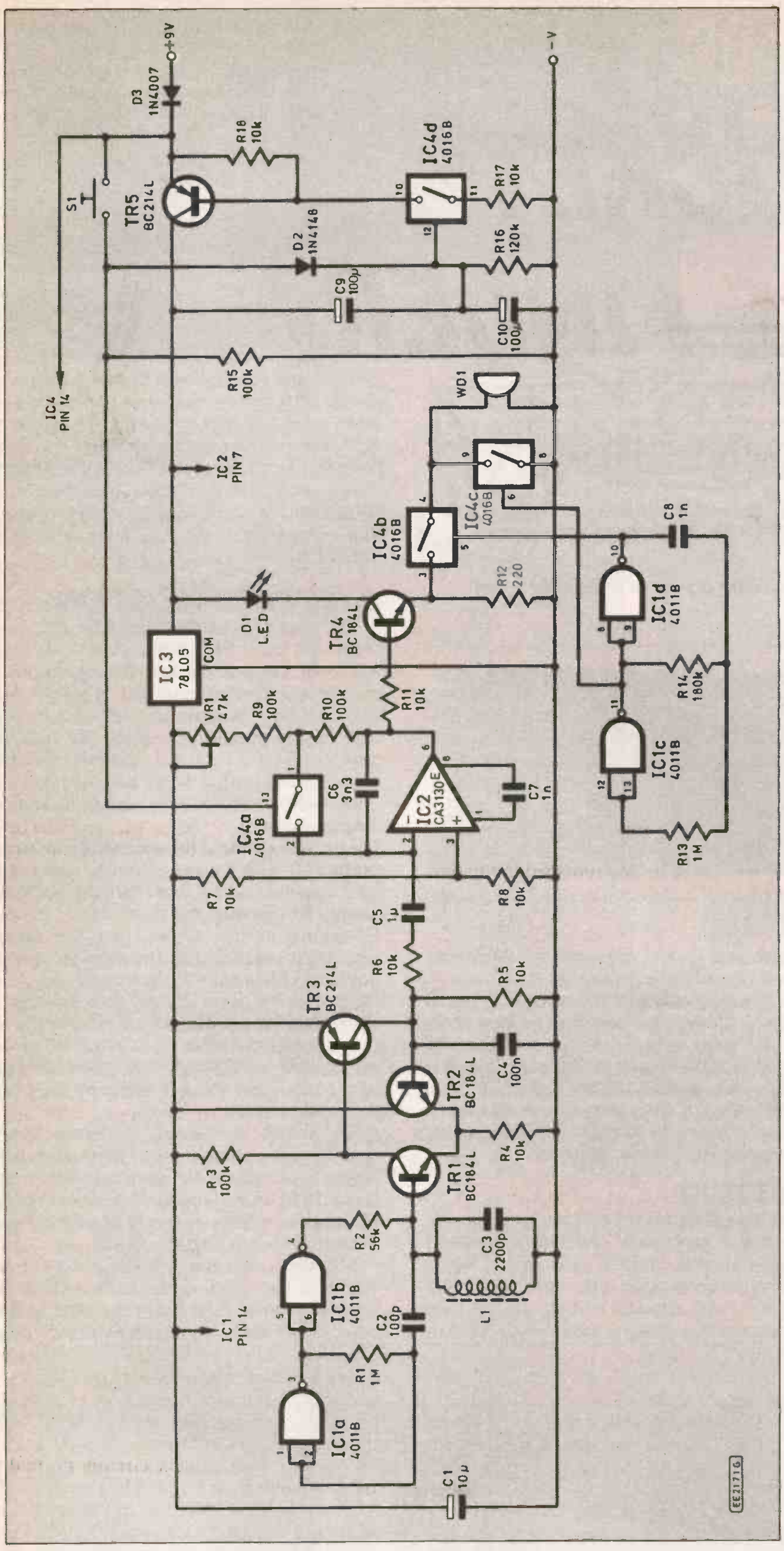


Fig. 1. Complete circuit diagram of the Probe Pocket Treasure Finder.

COMPONENTS

Resistors

R1, R13	1M (2 off)
R2	56k
R3, R9, R10, R15	100k (4 off)
R4 to R8, R11, R17, R18	10k (8 off)
R12	220
R14	180k
R16	120k

All 0.6 watt 1% metal film type.

Shop Talk
See page 578

Potentiometer

VR1	47k vertical sub-min preset.

Capacitors

C1	10µ axial elect. 25V
C2	100p ceramic
C3	2200p polystyrene
C4	100n miniature polyester layer
C5	1µ miniature polyester layer
C6	3n3 miniature polyester layer
C7	1n ceramic
C8	1n polystyrene
C9, C10	100µ axial elect. 10V

Semiconductors

D1	miniature 3mm, red l.e.d.
D2	1N4148 silicon diode
D3	1N4007 silicon diode
TR1, TR2, TR4	BC184L *npn* silicon transistor (3 off)
TR3, TR5	BC214L *pnp* silicon transistor (2 off)
IC1	4011B CMOS quad NAND gate
IC2	CA3130E MOSFET input op-amp.
IC3	µA78L05 positive regulator, 5 volt 100mA
IC4	4016B CMOS quad electronic switch

Miscellaneous

WD1	ceramic piezo buzzer element.
S1	switch, momentary press-to-make.

P.C.B. available from the EE PCB Service, order code EE653; 8-pin d.i.l. socket; 2×14-pin d.i.l. sockets; PP3 battery clip; 50mm by 9mm diameter ferrite rod for coil — see text; 0.25mm (32 s.w.g.) enamelled copper wire for coil; case, ABS plastic box 120×65×40mm; ABS pipe, etc for coil probe (see text).

Approx. cost guidance only **£17**

l.e.d. indication. It is obtained by chopping the voltage developed across R12 at audio frequency with two switches from IC4, driven by an oscillator built from the two remaining gates of IC1.

The resulting audio signal voltage, proportional to the output from IC2, is fed to a piezo transducer. These are not very loud, but the noise made is very penetrating and has been found quite sufficient in practice.

POWER

Power for the circuit, from a 9 volt PP3 battery, is controlled by TR5. When the button (S1) is pressed. C10 charges through D2 and the remaining switch in IC4, IC4d, is turned on. This biases TR5 which then powers the rest of the circuit. The button also turns on IC4a, allowing the circuit to adjust to a threshold which has been preset by VR1.

When the button is released, IC4a opens. R16 then slowly discharges C10 until IC4d starts to turn off. As soon as the supply from TR5 starts to drop, the voltage across C10 is pulled down through C9, ensuring a clean, rapid switch-off. If the button is pressed again at any time this timing action is restarted and the threshold readjusted.

For stability, critical parts of the circuit

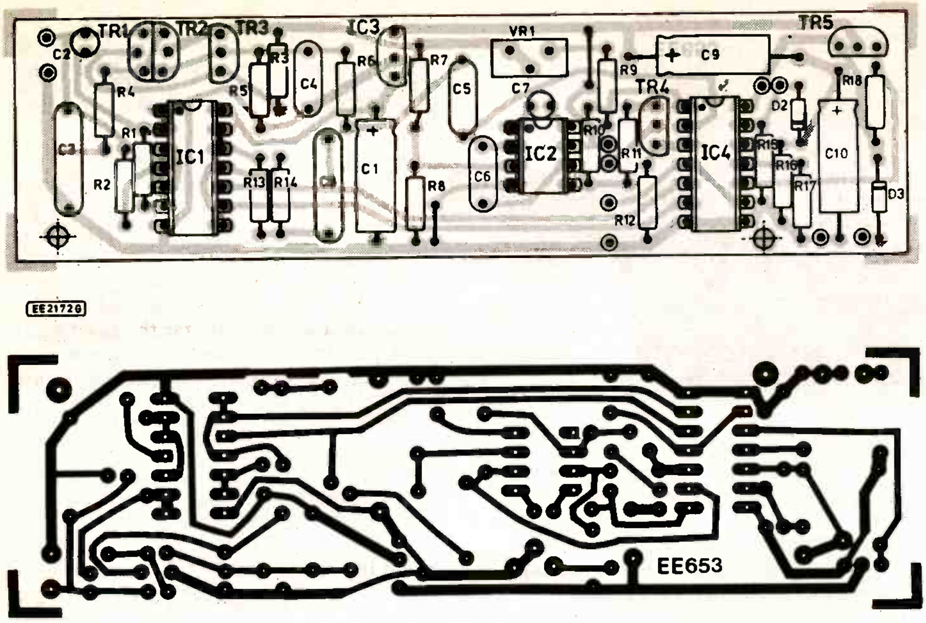


Fig. 2. P.C.B. layout and wiring for the Probe. This board is available from the EE PCB Service.

are supplied by the five volt regulator IC3. Diode D3 lowers the battery voltage very slightly, the reason for this being that, with a really fresh battery, the "high" outputs from IC1c and IC1d may not exceed half the battery voltage, so IC4b and IC4c will not switch, causing loss of sound output. The inclusion of D3 reduces the battery voltage just enough to prevent this possibility. Also, it's a usefull precaution against reversed supply polarity, as the unit cannot be switched off during battery replacement.

HIGH IMPEDANCE

It should be noted that parts of this circuit, especially around IC2, operate at very high impedance and any leakage across the p.c.b. may cause drift during operation. For this reason the p.c.b. should be handled with care to avoid contamination with skin oils, etc. A wipe with a good solvent before commencing construction and again on final assembly, is advisable.

ASSEMBLY

Assembly of the p.c.b. is straight forward, though care is required because of its compactness. The component layout is shown in Fig. 2. The two transistors TR1, TR2 have their "flats" glued together with a spot of "Araldite" resin, the "Rapid" version of this being more convenient. They should be pressed together with a clothes peg or similar until the adhesive has cured.

Two holes at the bottom of the board are enlarged to about 3mm diameter so that l.e.d. switch and battery leads can pass through them. D.I.L. sockets are recommended for IC1, IC2, and IC4. Leads for connection to the l.e.d. switch and sounder should be added at this stage.

The coil consists of 180 turns of 0.25mm (about 32s.w.g.) enamelled copper wire, wound in two layers over about 20mm of a 50mm length of 9mm diameter ferrite rod. This gives an inductance of about 1.6mH and, with 2n2 capacitor C3, resonates at about 80kHz. None of these dimensions are especially critical, however.

TESTING

When the coil has been wound, the p.c.b. can be tested. The author has built quite a number of these units, testing being limited to simply powering up the complete p.c.b.'s and dealing with faults as they arose. Solder "bridges" around the pins of IC1 occasionally gave trouble, so it's worth inspecting this area with a magnifying glass.

Component failures consisted almost exclusively of faulty 3130 op-amps, the fault sometimes appearing to be the drawing of input current. CMOS handling precautions should be observed whilst fitting this chip and it should be the prime suspect in a probe that refuses to tune or drifts badly.

If the board does not work, the supply current should be checked. It should not exceed about 5mA quiescent and 30mA with sound and l.e.d. full on. The battery voltage, less about 0.6 volt, should appear at the positive end of C9 after the button is pressed and the five volt regulated supply should then be present across C1. Pins 3 and 4 of IC1 should be somewhere around 2.5 volts average, indicating that the coil oscillator is running, as should pins 10 and 11 for the audio oscillator. TR3 collector should have a potential of about two volts, this being most easily measured from the top of C4.

CASE CONSTRUCTION

The case is made from an ABS box and some 3/8 inch ABS pipe, glued together with ABS cement obtained from plumbers' merchants. Finding a source of supply for the pipe may be a small problem, as 3/8 inch is narrower than usual. Swimming pool installers often use it, and may even be able to assist with a short length, possibly an unwanted off-cut. A piece about 220mm long is required.

The end of the tube should be sealed, preferably with a proper end cap if one can be obtained, and a hole drilled halfway along its length for coil lead entry. Glassfibre resin, as sold for car body repairs, is poured into the tube to give a depth of 15mm or so at the bottom, the coil pushed down into it, and just sufficient resin added to ensure the coil is completely potted at the bottom of the tube. The wires are hooked out through the hole in the side of the tube, and the assembly set aside for the resin to cure.

The ferrite should not come into direct contact with the ground as this causes strong false signals, so if the end of the tube is not fitted with a cap, arrangement should be made to ensure a couple of millimetres of resin between ferrite and soil.

The tube is cemented into the case as shown in Fig. 3, using the ABS cement. A "collar" of ABS material at the entry to the case tidied and strengthened the pro-

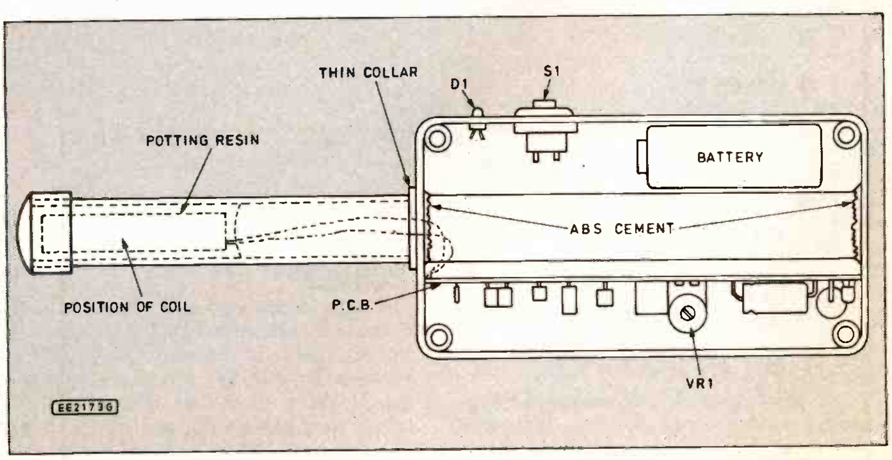
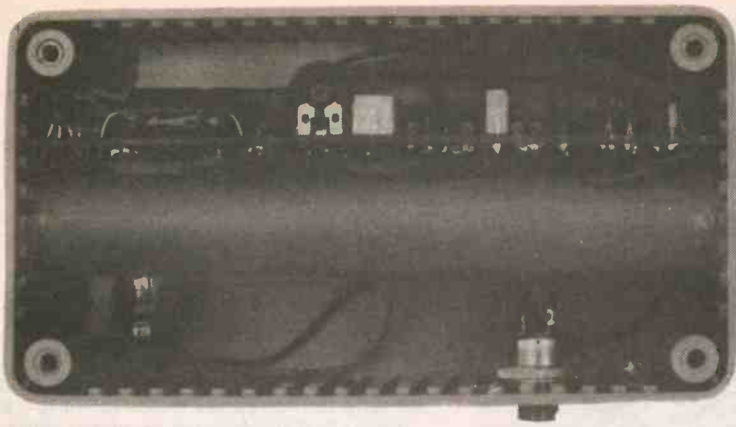


Fig. 3. Construction and layout of the Probe case.



totypes; this could be made with a ring cut from a connector, or even the end cap.

CONNECTING UP

Connections to the p.c.b. are shown in Fig.4. The piezo sounder is soldered directly to the leads and glued to the side of the box with "Evostik". The l.e.d. is secured with a drop of ABS cement. A small piece of foam plastic will prevent the p.c.b. rattling, and another piece will hold the battery firmly in place.

Adjustment of VR1 consists of keeping the button pressed and carefully trimming until the audio and visual signals are just apparent. The unit will then return to this setting each time the button is pressed.

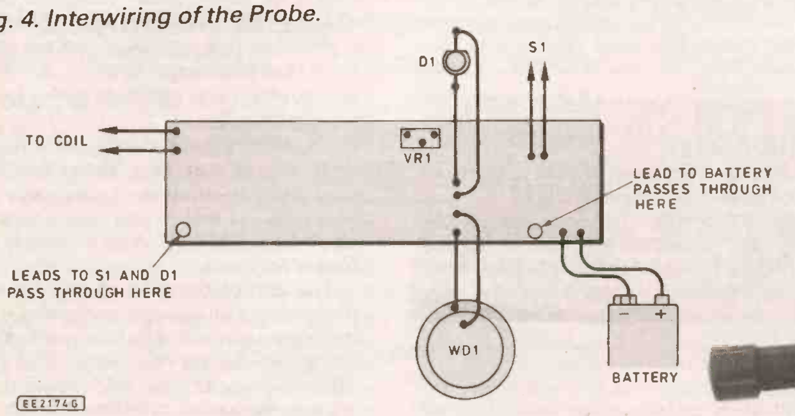
IN USE

The unit is reasonably weatherproof, though not totally so. If it is to be used in pouring rain or very muddy conditions (metal detecting enthusiasts are a hardy lot) it would be a good idea to operate it inside a plastic bag. Alternatively S1 could be replaced with a waterproof type, if one can be found, and the joint around the case sealed in some way. By far the most common problem experienced has been mud entering the pushbutton, against which precautions should be taken.

The Probe will be found extremely useful in the field, saving a lot of tedious digging and sifting. An unexpected bonus is that it keeps the user's hands much cleaner, since the usual method of locating an invisible object is by feeling for it! This is useful when the aforesaid hands have to operate the controls of the "main" detector, often a complex and expensive piece of equipment.

False signals during probing, such as ground effect, can be eliminated with another touch on the button with the tip in the vicinity of the ground, which will automatically compensate for it by retuning. Similarly, the sensitivity can be reduced with another touch in the presence of a signal, which is sometimes useful for larger objects. □

Fig. 4. Interwiring of the Probe.



FOR YOUR ENTERTAINMENT

BY BARRY FOX

Carbon Copy

If you are travelling in Europe, have a look in the lighting department of large stores. Many are now selling a new kind of light bulb which uses technology abandoned a hundred years ago.

These lamps cost ten times as much as a conventional bulb, are difficult to make and have very poor efficiency when converting electrical energy into light. They use carbon instead of tungsten metal for their filament. But they look so good and give such a restful light that manufacturer Philips is having to transfer production to a new factory to keep up with demand.

To make the bulbs, Philips has had to re-invent old production techniques because no-one who worked on the original production line is still alive.

When Thomas Edison and Joseph Swan started making electric lamps in 1880, they both made the filaments from carbon. Edison used madake bamboo, from Japan. Swan preferred cotton thread. When Gerard Philips started making lamps in Holland in 1891 he squirted a colloidal cellulose paste through a die to form flexible threads which, when heated, turned into carbon fibre.

By 1913 the lamp industry had switched to using tungsten wire, because it was easier to make and lasted longer. Since then virtually all incandescent lamps have had tungsten filaments. The metal is efficient at converting electricity into light, rather than heat, but gives a harsh glare which many people do not like.

As an experiment Philips recently started to make lamps with carbon filaments again. These give a more restful and attractive glow than tungsten. To Philips' surprise, the public are now buying them, even at £5 each.

Strategic Information

The price is high because workers at the Philips factory in Weert, Holland must make each glass stem, which holds the filament, by hand on fifty year old jigs. They are very secretive over their manufacturing method.

This may be because the company is genuinely worried about the competition. More likely it is just the usual knee-jerk reaction by the Philips in-house PR people when asked any on-the-record question other than the time of day.

A few months ago I asked about the manufacture of video head drums at Philips's factory in Vienna. Philips corporate PR people in the UK wouldn't even tell me the name of the machinery which the factory buys in to do the job. *"It's strategic information..."* I was told. But I'll bet the next time I visit the factory we'll be proudly shown the head-making process!

All Philips will say about the carbon production process, is that the filament is made by the same colloidal extrusion process as before. Modern automation only begins when the stems are loaded into a modern carousel machine which automatically inserts each stem in a glass bowl, evacuates the air and seals the glass.

The new/old lamps are currently on sale only in West Germany, Austria and Holland. They have proved so popular that Philips is transferring production to a larger factory at Gmunden in Austria in September. They may then go on sale in the UK.

Unofficial imports from the Continent have the wrong fitting, a screw instead of a bayonet, and are designed for use on the 220 volts. So when used on Britain's 240 volts they may burn out more quickly.

At £5 a time, the lamps may seem expensive, but when electric lamps were first sold, a hundred years ago, they cost over £1 each, only later reducing to five shillings (25p).

Tone Deaf!

Poor British Telecom. It tries to be modern, but never quite gets it right.

When several London telephone exchanges converted to digital switching recently, BT warned subscribers still renting old telephones from them that they would need to exchange them for new push button units if they wanted to take advantage of the new digital system, to get faster connections and use "Star Services" such as automatic re-routing of calls. The key point is that old phones and exchanges work with electrical pulses, whereas new digital exchanges only perform the new tricks with phones which use tone dialling.

Doing exactly as BT advised, I took my old antique phone to BT's Dial House sales centre in Central London and chose a new model. When I got home and plugged in, something odd happened. The phone dialled just as slowly as the old one. Sure enough, it turned out to be dialling with pulses, not tones.

Underneath there was a tiny recessed switch, with three positions cryptically marked LD, MFE and MFT. The instruction book makes only confused mention of LD and MFT, and suggests that users contact their "local BT sales office". But it was BT's Sales Office which had pre-set the switch to LD.

Moving the switch to the other positions I got tone dialling. But only because I knew enough to know that something was wrong in the first place.

If BT's Dial House goes on exchanging old pulse phones for new phones wrongly set to pulse dialling, many subscribers will unwittingly continue dialling with pulses and never know that they are missing the benefits of BT's expensive new digital exchange technology.

For things to go right in a company, the people at the top have to know the job well enough to know when things at grass roots level are going wrong. I often wonder whether the people at the top of BT have a clue what is going on.

Crisis Talk

The cellular phone business is in crisis, a victim of its own success. So many people are now signing onto the *Cellnet* and *Vodafone* services that in just four and a half years both have a third of a million subscribers and are gaining nearly 4000 more each week. However, no amount of reassuring statistics can conceal the fact that cellphone users are sick and tired of paying a high price for the privilege of being unable to make or take calls at peak times, or in a traffic jam.

As users reach the end of their tether, British Telecom who control Cellnet, has chosen just this moment to shunt John Carrington the respected boss of BT's Mobile Communications division to the USA, and replace Cellnet's equally respected boss Colin Davis with a new man, Stafford Taylor. BT confirms that Taylor has spent his life working for IBM or dealers selling IBM computers, and has no experience whatsoever of the cellular radio business.

So a lot of eyes, especially inside BT and Cellnet, are on Stafford Taylor. People who work for IBM call themselves IBMers. Working for IBM is a bit like working for the Church, British Rail or the Civil Service. There's no competition. But things are very, very different in cellular radio.

WRONG LETTER!

Telephone dials used to have both letters and numbers. British Telecom dropped the letters in 1967, when all-number subscriber trunk dialling came in. This upset a few snobs who were proud of post codes, like HAMpstead instead of SWIss Cottage. There were also legitimate objections from people who found it easier to remember a mix of letters and numbers than a string of digits.

The changeover was slow. Until quite recently a public toilet in Paddington gave the number for the nearest VD clinic as a letter-number mix. One New York hotel still clings to the telephone number PEN 65000, in memory of the pre-war days when Glenn Miller played there regularly.

Now, nostalgics with £500 or £600 to spare, can re-live the old days. The new Roamer cellular telephone has both letters and numbers on the key pad. But we are sorry to tell the Japanese designers, that they have got the letters in the wrong place.

The letters on BT's old dials began with "2". That is why London Transport's enquiry service, now 222 1234, was originally ABBey 1234.

The Roamer starts with ABC on key 1, DEF on key 2, GHI on key 3, and so on. So anyone using it to dial PEN 65000 in New York or ABBey 1234 in London, will get a wrong number.

FREE ENTRY COMPETITION

TOTAL PRIZE VALUE OVER £500

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A MAPLIN ROAD WINNER Radio Control 1/10 scale, 4-Wheel Drive Model Car (measuring 405 × 234 × 178mm), complete with controller, racing battery pack and mains charger. Total Value Over £100.

To enter the competition simply put the following eight points in the order you feel would be most important to a teenager contemplating buying the Maplin Road Winner. If you feel that "Operators manual supplied" is the most important put letter "B" in square one, etc. Then complete the tie-breaker sentence.

Each entry must be on a coupon **cut from** *Everyday Electronics.* Members of staff (and their families) of Maplin Electronics and Wimborne Publishing are excluded from entry. Results will be published in the December 1989 issue of *Everyday Electronics.*

Closing date for entries to be received is Monday, 15th September, 1989.

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- **A.** Monocoque chassis with strong front bumper.
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- **F.** Powerful electric motor.
- **G.** All-round independent suspension.
- **H.** Excellent value for money.

After the closing date for entries, judges—drawn from the Directors of Maplin Electronics and Wimborne Publishing—will place the points in their considered order of merit and prize winners will be those that match or are nearest to the judges' order. In the event of a tie the tie-breaker sentences will be judged to decide the winner and runners up.

The decision of the judges is final. No correspondence will be entered into. Illegible entries will be excluded. No responsibility will be accepted for non-receipt of entries.

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EVERYDAY ELECTRONICS/MAPLIN ROAD WINNER

COMPETITION

1		5	
2		6	
3		7	
4		8	

TIE BREAKER I think the Maplin Road Winner is great because ....

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NAME ....

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CLOSING DATE FOR *RECEIPT* OF ENTRIES— MONDAY 15TH SEPTEMBER, 1989

Send your entry to:- Everyday Electronics, 6 Church Street, Wimborne, Dorset BH21 1JH

ACTUALLY DOING IT!

by Robert Penfold

WHEN first making a start at electronics construction it is advisable to choose a simple project that is complete with detailed instructions, including easy to follow drawings of the circuit board and wiring (one of our *Pocket Money Projects* would be ideal—Ed). However, before too long most electronics hobbyists wish to try their hand at building a project from a source that only provides a circuit diagram.

There are many popular books full of project circuits, as well as features in magazines such as *Everyday Electronics* which only provide a circuit plus a few quick notes. You might also be faced with similar problems when trying to construct a project where the instructions provided are something less than explicit.

Starting from scratch faces the budding constructor with two problems, one of which is designing the layout of the circuit board. This is something that has been covered in a previous *Actually Doing It* article, and is something that we will not consider on this occasion (although it is a topic that we will almost certainly return to at a later date). The second problem, and the one to which our attention will be given on this occasion, is working out which lead on the circuit diagram represents each component leadout wire, and how interconnections are shown on circuit diagrams.

DOTS AND LOOPS

There are actually two different ways of representing connections between components on a circuit diagram. Both systems are the same in that a variety of symbols represent the different components, with lines emanating from the symbols representing the connecting wires. They differ in the way that connections between two wires and cross-overs (i.e. two wires crossing without any interconnection) are represented. The method used by *Everyday Electronics*, and virtually all electronics publications these days, is to have cross-overs shown as two lines simply crossing straight over one another, as in Fig. 1(a).

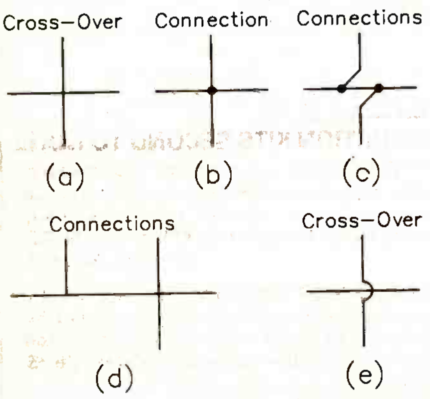

Fig. 1. Various methods of showing joints and crossovers on circuit diagrams.

Joints are represented by a dot at the point where two lines meet. Four wires meeting and joining are sometimes represented in the manner shown in Fig. 1(b), but the method of Fig. 1(c) is probably better and is more common these days. This may seem to be a rather fussy way of doing things, but if one or two connection dots should happen to go "absent without leave", which is not exactly an unknown occurrence, this second method will still make it reasonably clear that the wires should all be joined together. With the system of Fig. 1(b) a missing dot will indicate a cross-over rather than a four way connection.

The less common method is for any points where lines simply cross-over or meet to count as connection points, as in Fig. 1(d)—you may find this system on old circuit diagrams. If wires must cross over without any connection between them, one line must be looped over the other, as in Fig. 1(e). This method is sometimes used with dots to indicate connections. This may all seem a little confusing, but provided you understand the basic conventions a quick glance at any circuit diagram should be enough to make it clear which are cross-overs and which are connection points.

SYMBOLISM

The common circuit symbols are shown in Fig. 2, which also identifies the components they represent. When dealing with circuit diagrams you have to keep in mind that there is no rigid standardisation of circuit symbols. The British standard for resistors is the "box" type symbol, but the zig-zag style resistor symbol is the one you will probably encounter more often. There was a system introduced some years ago which had all the components as boxes, and you had to look at the component number (R1, C3, L4, etc.) in order to determine whether a component was a resistor, capacitor, inductor, etc.

Such a system makes it easy to draw circuit diagrams, but the resultant diagrams are not easy to read. You may find circuit diagrams of this type in equipment manuals but, fortunately perhaps, this system has never become widely established and is almost never seen in publications for the home constructor.

In American publications you may find rather unusual capacitor symbols. The convention seems to be to have electrolytic capacitors with the positive terminal as a straight line and the negative one as an arc. Apart from major differences in circuit symbols, you also have to make allowances for differences in style.

With the application of a little common sense it is usually not too difficult to sort things out. Remember that if you come across an unfamiliar circuit symbol, the identification number for the component plus reference to the components list should enable you to identify it.

LEADOUT SORT OUT

In many cases there is no difficulty in working out which lead on an actual

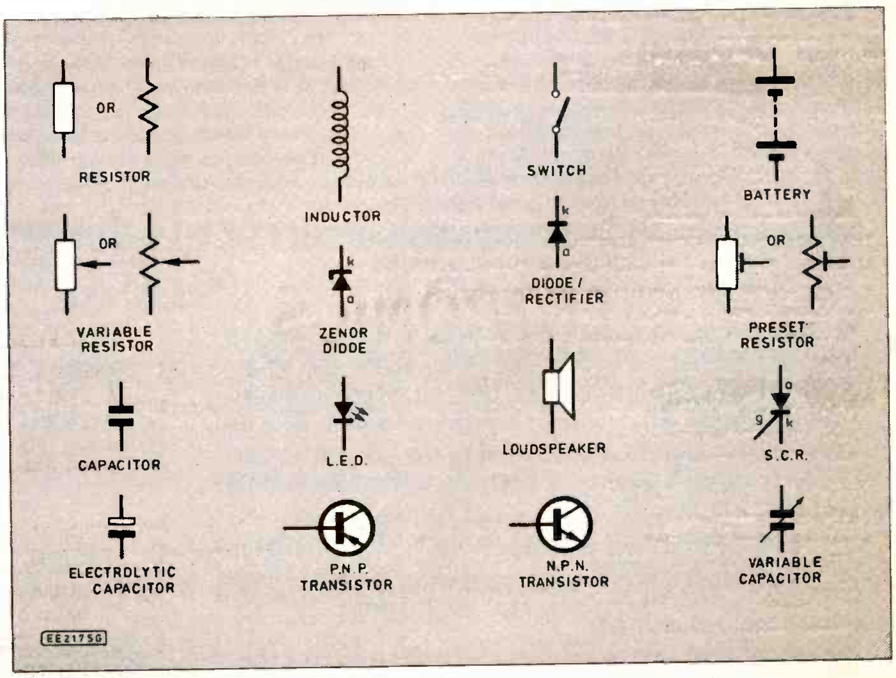

Fig. 2. A selection of common circuit symbols.

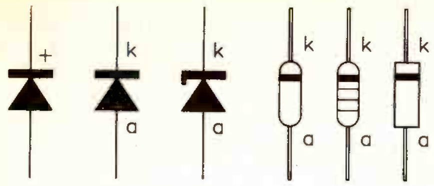

Fig. 3. Always take care to get any type of diode connected the right way round.

component is represented by each line on the diagram. Resistors, inductors, and non-polarised capacitors have only two leadout wires, and they can be connected either way round. This leaves no room for error. You need to be a little more careful with polarised capacitors though, which mainly means electrolytic or tantalum types.

The axial type usually have the positive and negative leads marked with "+" and "−" signs at the appropriate ends of the component. Also, there is an indentation around the body of the component at the positive end, which makes it immediately obvious which leadout is which.

Radial electrolytic capacitors are usually less clearly marked. Often only the positive or negative leadout is marked with the appropriate sign, and in some cases neither are marked in this way. There is then a bar which runs the full height of the component, and this indicates the negative leadout wire. This bar is sometimes present even if "+" and (or) "−" signs are present.

DIODES

Diodes, rectifiers, and Zener diodes are also twin leadout components that must be connected the right way round. Fig. 3 should make the relationship between circuit symbols and actual components perfectly clear. This is all pretty straightforward apart from some recent diodes (usually the 1N4148 type) which have multiple bands. Apparently these bands are a system of colour coding which is used to mark the type number, very much like the system of value marking used for most resistors.

You will probably not need to worry too much about this method of coding, except that you will obviously need to know how it indicates the polarity of the component. There should be a band at one end of the component that is much wider than the others, and this indicates the cathode (+) leadout. Unfortunately, in practice diodes of this type are not always marked quite as clearly as they might be, and you may need to look quite closely in order to determine which band is the thick one.

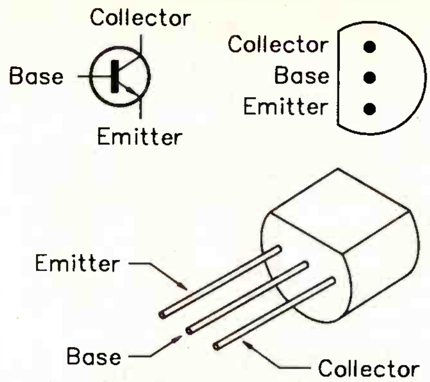

Fig. 4. Transistor leadout diagrams are always base views.

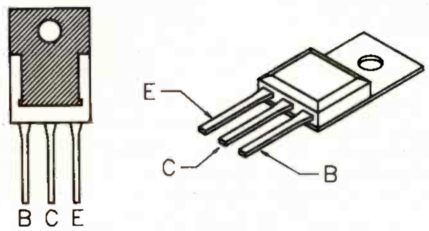

Fig. 5. Power transistor diagrams are also base views.

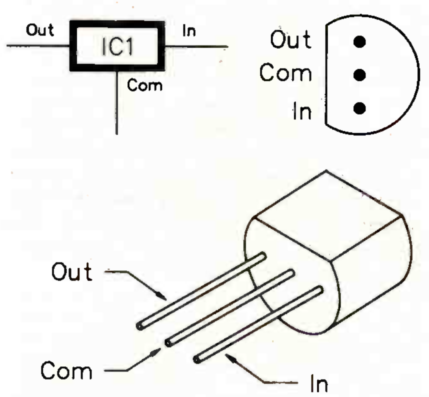

Fig. 6. Integrated circuit leadout diagrams are usually top views.

TRANSISTORS

In order to correctly equate a transistor with its circuit symbol you need a leadout diagram. There are several possible sources for information of this kind. One possibility is to check through constructional projects such as those in *Everyday Electronics* to see if you can find some information on the devices you are using. A data book represents a more convenient source for this type of information, since with one of these you should be able to rapidly find a leadout diagram for any common transistor.

With the larger transistor data books you can quickly locate the correct leadout diagram for practically any transistor under the sun. The only problem with some of these books is that they are quite expensive, being aimed more at commercial organisations rather than the electronics hobbyist. There are some good low cost transistor and general data books available though.

Perhaps the best low cost sources of data are the larger mail order component catalogues. These often contain a lot of information on semiconductors, including transistor leadout diagrams. They are something every electronics constructor should have anyway.

Note that the convention is for transistor leadout diagrams to be base views. In other words, the view represents the one you see when looking onto the leadout wires. Fig. 4 makes the relationship between a leadout diagram and an actual transistor perfectly clear. For both plastic and metal power devices, the leadout diagrams still show the components as underside views (Fig. 5).

The pin numbering of d.i.l. integrated circuits is something that was covered in a recent *Actually Doing It* article, and we will not go over the same ground again here. There are numerous small integrated circuits which are contained in transistor type encapsulations, and you need to be careful when dealing with these. Often these are not used with any form of pin numbering, but have the leadout wires identified by names ("In", "Out", etc.). The main point to note is that the convention is for integrated circuits to be shown in pinout/leadout diagrams as top views. This differs from the convention for transistors, which as mentioned previously, are always shown as base views. Fig. 6 should help to clarify matters.

On circuit diagrams, apart from a few exceptions such as operational amplifiers and logic gates, integrated circuits are simply shown as boxes. Numbers or names identify the various lines which emanate from each box. The same pin numbers or legends should be present on the leadout diagram, which shows the device as seen looking onto the top of the device (the opposite face to the one from which the leads emanate). This is generally more convenient than the transistor base view method, as it shows the device as you see it when it is fitted onto a circuit board.

a regular feature for the Spectrum Owner...

by Mike Tooley BA

TO CONFOUND the pundits who insist that software development for the Spectrum is a thing of the past, this month's instalment of *On Spec* contains information concerning two recently updated compilers which are available from **Mira Software**. For those who may be contemplating moving on to another programming language, we shall be making a few comparisons between ZX-BASIC and Mira's implementation (to BS 6192) of Pascal.

We begin by setting the scene with a brief discussion of the merits of compiled programs when compared with their interpreted counterparts.

Compile or Interpret?

The resident Sinclair/Amstrad ZX-BASIC (immediately available whenever you power up your Spectrum) is an *interpreted* language. The code responsible for ZX-BASIC (including its crude but effective line editor) is contained within the Spectrum's 16K ROM. Since the software is *non-volatile* (i.e. not placed in RAM where it would be vulnerable to power failure) it is appropriately referred to as *firmware*.

At execution time, your ZX-BASIC program code is converted into machine code instructions and executed by the Z80. This conversion process is undertaken one line (or, more strictly, one *statement*) at a time. The advantage of this method of program execution is that it allows changes to be very easily made to the program; the offending line is identified, modified and execution resumed using BASIC's **RUN** command.

Anyone who has developed even the most straightforward of programs will be only too well aware of the need to make very frequent changes to improve code and correct for errors. The ability to test the odd line of code, enter a direct command, or rapidly debug a program line by line, is only available with interpreted languages. Such an environment is, of course, ideal for the beginner.

Despite this, interpreters do have several notable disadvantages. The interpreter program must itself be present in memory (occupying valuable memory space) whenever a program is to be executed. Furthermore, interpreted languages execute somewhat slowly as each statement needs to be converted to machine code whenever it is executed.

Also, statements contained within the body of a loop will be converted into machine code *every* time the loop is executed. This is clearly rather wasteful since identical machine code will be generated on *every* pass!

For those of you who may not have experienced the use of a compiler, this useful software tool will generate executable (usually *stand-alone*) machine code (known as object code) from a source code program written in a high-level language such as BASIC, Pascal, or C. The compiler is only resident in memory whilst the object code is being generated. Once compiled, the program will no longer require the services of the compiler and the machine-code program can be executed directly (or linked with other object code modules to form a larger executable program).

Mira Pascal

Some time ago I mentioned the Pascal compiler which is available from Mira Software. This compiler has recently been updated and is now available in versions which cater for tape, Sinclair Microdrive, MGT Disciple and Plus-D, Beta, Opus Discovery and Rotronics Wafadrive. With the exception of the Wafadrive version, the compiler is available in versions for both the 18K and 128K versions of the Spectrum.

The Mira Pascal compiler is a full implementation of the BS 6192 standard and offers further extensions specifically for the Spectrum. The compiler generates Spectrum machine code from Pascal source code which is entered using a simple editor which is provided as part of the package.

A brief but adequate manual is supplied with Mira's compiler. This handbook explains how the compiler is installed and used and also provides details of the language extensions which have been provided specifically for the Spectrum.

It is important to note that Mira's manual is not a tutorial guide for the Pascal language. They do, however, recommend a suitable introductory text, alternatively Donald Monro's ***"A Crash Course in Pascal"*** (published by Edward Arnold, ISBN 0-7131-3553-0) can be highly recommended. Armed with one or other of these books and Mira's compiler, the would-be Pascal programmer should be producing working Pascal code within a few hours.

Altogether, Mira Pascal can be very highly recommended. It is simple to use and sensibly priced and indicates that the development of serious software products for the Spectrum is far from dead. — ***Well done Mira!***

Mira Pascal versus ZX-BASIC

In order to put Mira's Pascal compiler through its paces, I hastily put together a simple program (see Listing.1) to change the base of a number and display the result on the Spectrum's screen. It then occured to me that readers may be interested to compare this Pascal program with its nearest equivalent in BASIC (Listing.2). In fact, the BASIC program turns out to be more compact than its Pascal counterpart but is greatly lacking in structure. In fairness, the BASIC program could have been much improved if it had been written in Beta BASIC (where improved control structures are available).

For the benefit of newcomers, it is well worth pointing out some of the more important features of the Pascal program. The first line of the program declares the program name (demo) and informs the compiler that it will take its input from the keyboard and output to the display. The second line is simply a comment (equivalent to a BASIC **REM** statement). The third line declares the variables used in the program and informs the compiler that they are to be treated as integers.

The main body of the program is contained between **begin** and **end** and comprises a series of statements, each terminated by a semi-colon. It should be fairly obvious that **writeln** is equivalent to BASIC's **PRINT** whilst **readln** provides the equivalent of **INPUT**. A loop is implemented between **repeat** and **until** and this is clearly a much more elegant structure than the conditional **GOTO** used in the BASIC program!

Mira FORTRAN

If, like me you were first introduced to computing at college through the medium of FORTRAN (rather than BASIC or Pascal) then Mira have produced a second compiler which will accept FORTRAN source code. The compiler operates in much the same manner as its Pascal counterpart but may be preferred by those of

Listing 1

```
program demo(input, output);
{Decimal to any base converter}
var number,base,count : integer;
begin
  writeln('E.E. Base Converter');
  writeln('Enter a number: ');
  readln(number);
  writeln('Enter the base: ');
  readln(base);
  count:=0;
  repeat
    writeln('Digit: ',count,number mod base);
    number:=number div base;
    count:=count+1;
  until number=0;
  writeln('Finished!')
end.
```

Listing 1 Pascal demonstration program

Listing 2

```
10 REM Decimal to any base converter
20 PRINT "E.E. Base Converter"
30 PRINT "Enter a number: "
40 INPUT n
50 PRINT "Enter the base: "
60 INPUT b
70 LET c=0
80 LET m=b*((n/b)-INT(n/b))
90 PRINT "Digit: ";c,m
100 LET n=INT(n/b)
110 LET c=c+1
120 IF n<>0 THEN GOTO 80
130 PRINT "Finished!"
```

Listing 2 ZX-BASIC equivalent of Listing 1 you who may be more concerned with scientific applications and who may wish to make use of existing software written in FORTRAN.

The Mira FORTRAN package is of the same high quality as its BS 6192 Pascal but I would not recommend this package to a newcomer wishing to develop a familiarity with a second language. Pascal would be a far better choice for most applications which will be instrumental in helping the user to develop a structured approach to his or her programming.

Mira Software can be contacted at 24 Home Close, Kibworth, Leicestershire, LE8 0JT.

Next Month: We shall be taking a detailed look at the hardware of the SAM COUPE and will provide details for those wishing to get to grips with interfacing MGT's exciting new machine to the outside world. In the meantime, if you would like a set of our *On Spec Update* sheets, please drop me a line enclosing a large (250mm×300mm) and adequately stamped (currently 42p for UK postage) and addressed envelope.

Please note that I can no longer provide individual replies to queries but instead will do my best to provide answers through *On Spec* or through the *Update*. Mike Tooley, Faculty of Technology, Brooklands College, Heath Road, Weybridge, Surrey.

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WANTED Everyday Electronics April 1988 Volume 17 No. 4 in good condition. Ian Davis, 11 Phillip Street, Pukekohe 1800, New Zealand.

WANTED Anything about Truvox Tape Deck Mark III and Type "C" tape recorder amp. Details and price please. Edward Pinheiro, El Socorro Road, San Juan, Trinidad & Tobago, West Indies.

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SELABS EM102 oscilloscope with manuals probes and hood. Dual beam £45. Tel. 0708 24102 Evenings (Romford).

SWAP QL Computer for a dual beam oscilloscope at least 15mHz with Probes. A. Scott, 84 Studley Tower, Canford Close, Highgate, Birmingham B12 0YZ.

WANTED ZX81 with 16K Ram pack also ZX printer wanted. Would pay around £25. Mr. M. Cullis, 4 Sandgord Rise, Tettenhall, Wolverhampton WV6 9JQ. Tel.0902 759034.

EVERYDAY ELECTRONICS most issues June 1979 to March 1989. Offers plus p & p. Allan Dunnett, 11 Silverknowes View, Edinburgh EH4 5PY. Tel. 031 336 4904 (Evenings).

WANTED any info. on ICL PERQ computer. Nigel, Crawley (0293) 513354.

FOR SALE TRS80 computer upgraded Level II plus expansion unit and monitor and manuals. Good condition. £85 o.n.o. Tel. 01-582 7839.

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WANTED Maplins Combo Amplifier p.c.b. (GA41U) and TCA3502 bucket brigade i.c. to finish project. Contact Brian on 0926 497056.

WANTED 500MHz frequency counter also wanted scanner with frequency read out. Tel. 0742 326126 (Sheffield).

WANTED Manuals for Realistic DX-200 and TI59 programmable calculator. P. Rex, 61 London Road, Luton LU1 3UE.

WANTED to buy or borrow circuit diagram National digital counter and marker type RD-9600. Sean Miuar, Greygrove, Kilmihil, Co. Clare, Eire.

WANTED SN76477 sound effects generator i.c.—two needed. Richard C. Doughty, 10 Northdown Way, Margate, Kent CT9 3QX.

SPECTRUM 128K programmable joystick interface, joystick, books, many extras, leads, etc. £150 o.n.o. Tel. 04446 47179.

WANTED circuit and construction details for Osram Music Magnet Four. D. T. Walker, 97 Raemoir Road, Banchory AB3 3XQ. Tel. 03302 2476.

WANTED service manual or copy for record changer BSR Model UA55. G. Stuart, 35 North Gyle Grove, Edinburgh EH12 8LA. Tel. 031 339 7306.

WANTED 1/2 track 15 i.p.s. mastering tape recorder working or not. Tel. 01-346 9851. Phone after 9 p.m.

WANTED full circuit diagram World Band Amatuer Radio or information where I will get it. Also pen friend. Haneef Unniyal, P.B. No. 1956, Doha, Qatar, A.G.F.

WANTED circuit diagram for Dragon 32 computer or number of chip IC9. Roy Prescott, 22 Calremont Range, Gorton, Manchester M18 7LT.

OSCILLOSCOPE Thandar SC110A Battery/Mains portable d.c. - 10MHz with probes. v.g.c. £150 o.n.o. Tele. 0722 23086.

WANTED valve tester plus valve data manual. Phone 09823 357.

DIGITAL Decpack RG05J for disposal also Atari Quadrascan tube power unit etc. Anyone interested? Mr. Harry Speight, 106 Farrar Lane, Adel, Leeds L16 7JW. W. Yorks. Tel. 670666.

WANTED Sinclair flat screen pocket TV need not be in good condition. Will consider faulty set. Dave Carter, 12 Martins Lane, Bracknell. Tel. 0344 420265.

WANTED Manual, system disk, etc. for Burroughs B21-2T, 384K also manual for Racal CT488 counter timer. D. Armstrong, 85 Lower Bagthorpe, Bagthorpe, Notts NG16 5HF. Tel. 0773 810358.

WANTED Circuit Diagram for Sinclair (Thandar) DM450 Multimeter—please. G. O'Brien, 105 Roxborough Road, Harrow HA1 1NT.

MARCONI Valve Radio, old, small, good working order. Offers over £25. J. De-Almeida, 18 Langton Place, Wroughton, Swindon. 0793 812566.

WANTED information where I can obtain any professional (Siemens, etc.) Analogue Semiconductor Catalogue. Mr. Jan Kurcharski, 10 Dalton House, Ebury Bridge Estate, London SW1.

ANTIQUE SETS of Practical Wireless—complete issues 1951 to 1958—some partly bound—offers. Mr. P. P. Dusek, 11 Hoylake Gardens, Eastcote, Ruislip, Middx. HA4 9SJ. 01-868 9845.

ROGERS A75 Ser.2: Also Ravensbourne amplifiers; Tandberg TCD310 c/recorder; JVC JT V10 Tuner; Connoisseur deck; best offers. (Monmouth) 0600 860705.

WANTED 934MHz rig with Cybernet board also 934 service manual or circuit diagram. State price. Contact B. J. Rowlands, 8 Camrian Avenue, Gilfach Goch, S. Wales, Glamorgan CF39 8TB. Tel. No. 0443-672280.

TRANSMITTER (Micro) 70-150MHz £5. N. Porter. Tel. 0366 383380.

ULTRAVIOLET exposure unit, timer, brand new, two 8W tubes, £50. Oscilloscope Hameg, 8MHz £55. Tel. 0274 575484 evenings.

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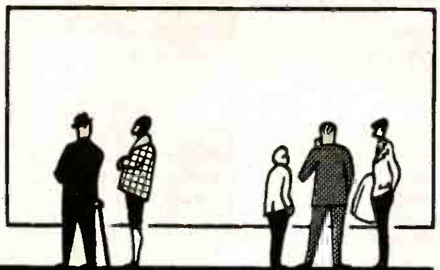


BY DAVID BARRINGTON

Xenon Beacon

Due to the very high voltages present in the *Xenon Beacon*, some of the components used must, of course, be special items. First, a word of warning. With such high voltages "floating" around the circuit, we advise that extreme care be exercised by ***any*** person, novice or professional, constructing this project.

The xenon tube and trigger transformer may prove difficult to locate locally but the prototype model used items purchased mail order from **Maplin**. The trigger transformer used is the 6kV type, code JE15R (6kV trigger trans.) and the tube is the "beacon" type designated FS79L (Xenon Tube Beacon).

The waterproof case was bought from the same company and is the medium version (code YM93B), with transparent lid. You can, of course, use any suitable size case but you will have to devise some form of waterproofing. You could use one of the "bathroom/kitchen" silicone sealing compounds to make holes and joints water tight.

Another approach would be to use one of the large "lantern" type torches sold to motorists and build the beacon in the space provided for batteries and bulb. Again you would have to make it water tight for portable use.

The high voltage capacitor can be any polyester or polypropylene type provided it has a similar *minimum* or *higher* rated working voltage; it must *NOT* be less than specified. The one used in the authors model is a metallised polypropylene type.

The mains transformer secondary is rated at 6V-0V-6V 250mA and most component suppliers stock a fairly large range of transformers and should be in a position to suggest a suitable item. The only point to keep in mind is the mounting dimensions for the p.c.b. The one used in the model is from the miniature 250mA range listed by Maplin, code YN140Q.

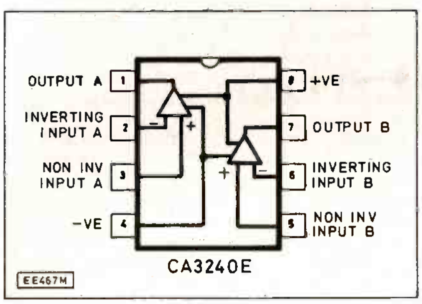
The 12V 1.2Ah sealed lead-acid battery may well be another case where finding a local stockist could prove to be troublesome. The one used in our model is the UK made Yuasa NP1.2-12V, 1.2Ah from Maplin code, YJ69A. This is not a cheap battery (£13.50), but you want long life and relability.

The printed circuit board for the Xenon Beacon is available through the *EE PCB Service*, code EE650 (see page 612).

Fuse Tester

Checking out component availability for the *Fuse Tester*, one of this month's pocket money projects, we find that most of our component advertisers are more likely to offer only the 8-pin version of the CA3240 MOSFET op. amp. However, a 14-pin d.i.l. CA3240E-1 is currently listed by **Cricklewood Electronics**. The 14-pin device seems to be a RCA manufactured chip and carries the suffix -1.

Although the circuit function is completely identical, using the 8-pin version will, of course, entail changing the circuit board layout to accomodate the differing pin configuration and may even end up with a completely new component layout. To help constructors using the 8-pin package we give the pinout details below.



Stabilized Power Supplies

A couple of items required for the two power supply units, contained in the *Stabilized Power Supplies* series, need special mention.

Of the components required for the *"Fixed Voltage Unit"*, the mains transformer was specially selected by the designer and wound by Trent Coil Winding Co. For the fixed voltage version quote order code 00490 (£10.25 plus £2.55 post and packing).

Many of our advertisers now supply special transformer kits for making up your own mains transformers. With these kits you just select the secondary requirements and, referring to a table, wind on the necessary number of turns. Alternatively, specialist transformer suppliers such as **Jaytee Electronic Services** should be able to come up with a suitable unit.

The Fixed Voltage Unit printed circuit board, covering both the 5V and 15V supplies, is available from the *EE PCB Service*, code EE654. Using a junior hacksaw and exercising *extreme* care, you can, if you wish, separate the board into two small independent boards.

Turning to the *"Variable Stabilized Power Supply"*, the 2A thermal circuit breaker and the 0-15V moving-iron meter are both RS components. These components can be ordered through any *bona-fide* RS stockist or by mail order from **Electromail (☎ *0536 204555*)**, quote order codes 335-996 (contact breaker) and 259-577 (meter). Moving-iron meters are stocked by some of our advertisers and it might be worthwhile checking around for the best price.

Once again, and for the forthcoming units, the author has selected from the specially wound mains transformers from the Trent Coil Winding Co. The one used in the model is order code 00491 (£10.25 plus £2.55 post and packing) and can be obtained from **Trent Winding Co. Dept EE, 26 Derby Road, Long Eaton, Notts.**

There are many suitable metal instrument cases on the market and final choice is left to the constructor. However, the case must have a separate metal chassis plate to take the transformer and heatsink.

The printed circuit board for the Variable Stabilized Power Supply is obtainable through the *EE PCB Service*, code EE655 (see page 612).

Probe Pocket Treasure Finder

Readers should not experience any difficulties when purchasing components for the *Probe Pocket Treasure Finder*. All parts appear to be standard "off-the-shelf" items.

To meet the requirements of the printed circuit board, when ordering components for the probe keep in mind the physical size of the board. This applies particularly to the polyester capacitors, these should be the metallised layer or "Siemens" types.

The ferrite rod for the "detection" coil may prove a little difficult to locate but it is currently listed by **Maplin**, **Cirkit**, **Omni** and **TK Electronics**. One small problem likely to be encountered, not mentioned in the article, concerns the length of the ferrite rod.

All of the ferrite rods listed are 100mm or more long and will have to be cut down to the required 50mm length. This is where the problems start, the ferrite is very brittle and likely to "shatter" if care is not exercised when cutting it down to size.

The best approach to cutting the rod is to score a deep groove around the circumference of the rod with a hacksaw blade, at the required length. Holding one end of the rod and "gently" tapping it on a firm surface should result in it breaking cleanly around the scored area.

Another point to watch out for is the purchase of the BC184L transistor. When buying this transistor it is most important to specify the ***L*** suffix as pin connections for this device vary.

The printed circuit board for the Probe Pocket Treasure Finder is available from the *EE PCB Service*, code EE000 (see page 612).

Four-Way Chaser

We do not expect any component sourcing problems for readers undertaking the *Four-Way Chaser,* this month's pocket money project.

There are two popular CMOS versions of the standard NE555 timer i.c. and both of these will work quite happily in this circuit. These devices are designated ICM7555 and TLC555C and are stocked by most of our advertisers.

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KRAZY KEYBOARD KLEARANCE

Z8852 Keyboard: Superb brand new keyboard 392 x 181 with LCD displaying 1 line of 10 characters and a further line with various symbols. 100 keys, inc separate numeric keypad. Chips on board are 2x77HO5, 80C48. LCD + driver chips are easily removable from board. Looks like it was used with a comms package. Has anyone any more info?
£15.00
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Z8857 High quality Alphameric keyboard on aluminium frame 314 x 150mm. Contactless keys good for 20 million operations. Originally sold at over £100 each, they were used in a 'Printcom' portable terminal. Fully ASCII encoded output. Power supply + 5v and -12v @ 35mA supplied with comprehensive data.
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Z8848 Keyboard Alpha numeric separate numeric keypad. 104 keys. Also chips on board: LS373x2. LS374, LM3086x2. LS138x3, 555, LS08, 6805. Size 442x175mm. £12.00
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Z8863 Keyboard. High quality unit made by Micro Switch 69 pale grey and blue keys. 6 red 5mm LED's, 15 various LS chips and socketed D8048 by Intel. Output via 7 way plug and there's a 4 way edge connector too. Keyboard frame is 317 x 128mm. PCB on which it's mounted is 285 x 170mm. **Excellent value at £12.00**
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Z4116 24 way (8 x 3) membrane keypad. Large (200 x 90mm) area – these were originally used as a teaching aid. Overlay template and pinout supplied. Now only £2.00
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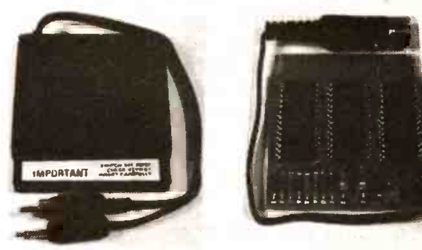
CURRAH µSPEECH & SPEECH 64



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Z914 Audio amp panel 95x65mm with TBA820 chip. Gives 1W output with 9V supply. Switch and vol. control. Just connect batt. and speaker. Full details supplied. Only £1.50; 10 for £12.00; 25 for £25.00; 100 for £75.00
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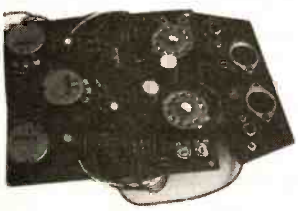

Z974 Mixer Amp Panel – 115x115mm and gives 1W O/P from a TBA820M chip. There are two inputs, one via a pre-amp, from phono sockets and separate volume controls. A third pot is used to fade from one input to the other. There are also 2 4p 3w rotary switches. Attached to the PCB by flying leads is a panel on which are mounted the 2 input skts, 2x5 pin DIN skts and 2 pin DIN speaker skt. A data sheet is supplied All this for just £2.50
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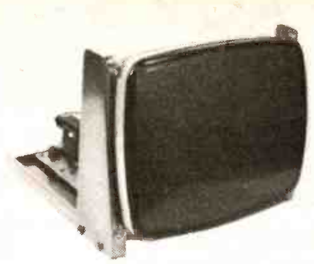

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Z620 68000 PANEL PCB 190 x 45mm believed to be from ICL's 'one per desk' computer containing MC68008P8 (8MHz 16/8 bit microprocessor) + 4 ROMs all in sockets. TMP52220CNL, 74HCT245, HCT138, LS38 & LS08, also 2 x 20w SIL sockets & 2 x 14w SIL sockets. £5.00
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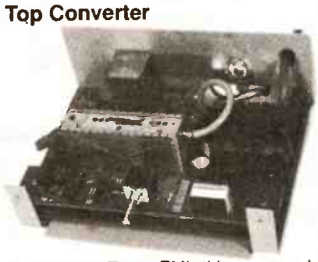

Z8828 Made by Thorn EMI, this was used to receive cable television. 2 part aluminium case 211x158x82mm (no front panel) contains 2 PCB's: (a) control board with multiway switch, dual 7 seg plug in display, couple of chips. (b) main board with mains transformer, tuner, RF section etc. Rear panel has input and output sockets. 2m mains lead with moulded on 13A plug. £9.00
SALE PRICE **£4.50**

Z803 Auto Dialler. Sloping front case 240 x 145 x 90/50mm contains 2 PCBs: one has 4 keypads (total 54 switches) + 14 digit LED display. 2xULN 2004, ULN2033 and 4067; the other has 12 chips +4 power devices etc. Case contains speaker. For use with PABXs, could probably be modified for exchange line. Needs 12V ac supply £9.00
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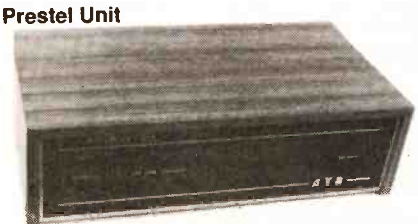
Prestel Unit



Z819 Brand new and boxed, complete with co-ax T connector, aerial lead and instruction book. Only one snag – the remote control hand-set is missing. Size of smart wooden case is 347x187x100mm. Mains operated. Old style BT plug. Made by Ayr Electronics, Model P £22.00
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Z8862 Video game unit with 10 games, utilizing, the AY-3-8610 chip. Consists of 2 handheld units 145 x 60 x 45mm made of light and dark grey high impact plastic. Unit 1 has a control panel with 0-9, serve and reset buttons, 3 switches for bat size, ball speed and sound on or off, and built in joystick. Unit 2 has a serve button and joystick. the two units have 2m of 5 core cable between them, and the 3m lead from unit 1 has 3 x 3.5mm plugs; 1) 7-5V input; 2) audio out; 3) composite video out. Worth what we're asking just for the cases! £9.95
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Dual Sheet Feeder

Z8837EXXON DUAL SHEET FEEDER Z200. Overall 395x210x285mm. Brand new and containing some very high class electronics. although of little practical use as it stands, it makes a great break down unit. It contains:
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1 PCB containing 4xTIP115, 4xTIP110, 2x7407, LM3302 comparator + T's. R's, C's, plugs, sockets etc.
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1xOPB703A opto coupler
1xOPB7111 opto coupler

Obviously, a very expensive piece of machinery to produce – but once again our contacts in the trade have enabled GREENWELD to procure a few hundred for a fairly modest sum, allowing us to offer them at the bargain price of £24.95
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Touch Pad

Z811 Cumana Touch Pad for the BBC 'B' computer. This remarkable add-on enables you to draw on the screen using a stylus with the touch sensitive pad. Supplied with 2 stylii, power/data connecting lead and demo tape with 4 progs. Contains state-of-the-art electronics. Originally being sold at £79.95 — but we can offer a limited quantity of these brand new and boxed for just £19.95
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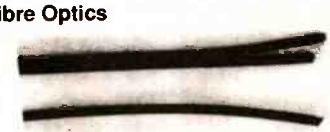

Scoop purchase of single and twin cable. For use with visible light or infra-red. Core 1mm dia, overall 2.25mm dia.
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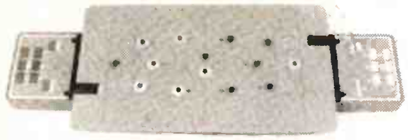
'JIMMY'

the electronic football game of skill



Z817 Exciting electronic football game – Waddingtons' 'JIMMY'. Brand new models in full working order, but without plastic peripherals, stickers etc. Red plastic case 420mm long x 93mm wide contains keypad and seven segment LED's to keep score either end. The centre section 'players' are represented by red 5mm LED's, 14 altogether. The main chip is the TMS1000, programmed to make odd noises whilst playing and a tune when a goal is scored. Also inside are 13 plastic transistors, 57mm 8R speaker, power supply socket, R's, C's etc. Powered by 2xPP3 batts. Solo or dual play. Supplied with instruction sheet, playing field complete with coloured 'players'. Good fun to play as a game and good value for the electronics within. Originally retailed at £19.95.

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Partially enclosed panel with fixing holes in steel case on 120 x 125mm centres.

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Special Series

STABILIZED POWER SUPPLIES

STEVE KNIGHT

Part Three

Apart from delving into the basic theory of p.s.u. design and potential problems, this short five part series will introduce three practical projects which are fairly simple to build and have reasonably good specifications.

The three stabilized units are: Variable 0V to 12V 1.5A; Variable 0V to 25V 1A; Variable 1.5V to 25V, with switched current limits of 0.5A, 1A, 1.5A and 2A.

THIS month we look at a couple of practical designs which are comparatively easy to make and not very heavy on the pocket. These are:

1. *A fixed voltage stabilized power supply, presettable between 5V and 15V at a current output of 1A;*
2. *A variable-output stabilized power supply, fully adjustable from 0V to 12V (15 V with a slight modification) at a current output of 1.5A.*

Before we get down to details, however, a few words on transformers and their ratings will not be out of place.

TRANSFORMERS

Transformers are essentially the only "awkward" components in most of the circuits to be discussed. True, there are plenty of transformers to be had, both conventional and toroidal, from all the usual component advertisers, but it is often very difficult or downright impossible to get one wound exactly to the secondary output requirements needed.

For some of the later projects to be covered in this series, specially wound transformers are essential and these can be obtained from the source mentioned in the *Shoptalk* page. In some cases off-the-shelf types can be used and suitable types and their suppliers will be mentioned as we go along.

Alternatively, there are transformer kits available with *primaries* already wound and a free secondary bobbin on which (with a suitable coil of wire) you can easily wind your own coil to give you the output or outputs you require. Full instructions are supplied with the kits and as only a comparatively few turns of stout gauge wire is needed, the work is no problem.

There is a point of some importance which should be appreciated when using an off-the-shelf transformer for *any* project. This is the stated current rating of the secondary (or secondaries). It is not necessarily correct to choose a transformer with a current rating which is the same as the d.c. output current you are likely to draw; it all depends upon the method of rectification you employ and the system of smoothing.

The current rating of a secondary winding is usually stated in terms of the r.m.s. continuous current. When this feeds into a bridge rectifier with capacitive smoothing (see Fig. 3.1a), the d.c. current available is roughly two-thirds of the stated r.m.s. rating; hence for a 1A d.c. output, the r.m.s. rating should be at least 1.5A.

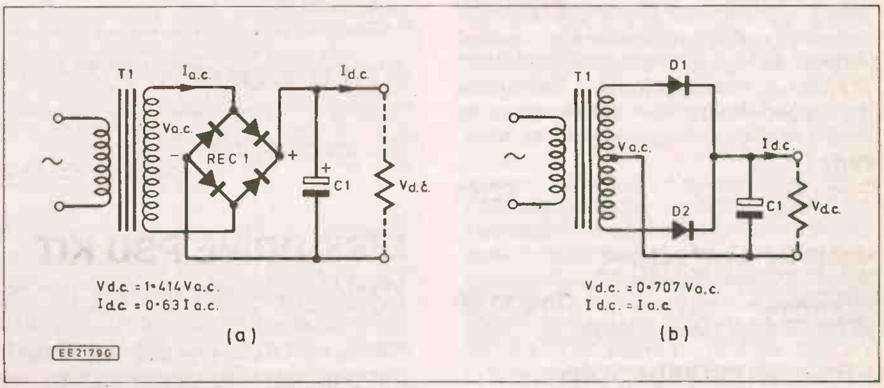


Fig. 3.1(a). Bridge rectifier with capacitive smoothing and (b) bi-phase rectification and smoothing.

The situation is different if a bi-phase rectifier is used with a centre-tapped transformer (see Fig. 3.1b); here the d.c. output can be identical with the r.m.s. rating. The $V_{a.c.}$ here is measured across the *total secondary*. This is one of those things which, in the writer's experience, is often overlooked — inadvertently in most cases.

Generally no harm comes about from using a transformer with, say, a 1A rated secondary winding feeding into a bridge rectifier with capacitance, and drawing out a d.c. of 1A. The transformer will run slightly warmer and its regulation will deteriorate a bit, but in most cases things will not end in disaster.

This statement is *not* made as a licence for bad practice! It is best in such cases as this to restrict the current output to two-thirds the stated r.m.s. rating (if you can). There is no problem with the bi-phase rectifier, but it is a feature of good design practice to keep these points in mind.

Constructional Project

FIXED VOLTAGE STABILIZED POWER SUPPLY

IT IS often useful to have a power unit which provides a choice of either single or balanced outputs for TTL work (5V outputs) or for CMOS experiments (15V outputs). As there are no panel controls on such a unit – apart from the mains on-off switch – details of a suitable board layout only are needed, and the selection of a suitable case to house the transformer and board (or boards) is simply a matter of personal taste – and finance.

The circuit diagram for the Fixed Voltage Stabilized Power Supply is practically identical with that given in Fig. 2.6 last month and is shown in Fig. 3.2. For this project we need a transformer with two secondary windings, each of 18V to 20V rated at 1.5A r.m.s. or anything above this. You can use a 1A type if you wish, but you should restrict your d.c. output to some 700mA.

The construction is made easy because everything except the mains transformer, on/off switch and output terminals are mounted on a single printed circuit board, including the "programming" potentiometers and the regulators. The board holds two identical circuits, and after assembly the outputs can be set to any voltage between 5V and 15V by adjustment of the potentiometers.

Further, by connecting the outputs in series (terminal B connected to terminal C) voltages between 10V and 30V are available, and by using the B-C connection as a common point, balanced supplies up to 15-0-15V are obtained. ***The outputs must not be paralleled.***

With the components specified, the regulation of the circuit is better than 0.05 per cent per °C and the ripple is less than 10mV peak-to-peak at 500mA.

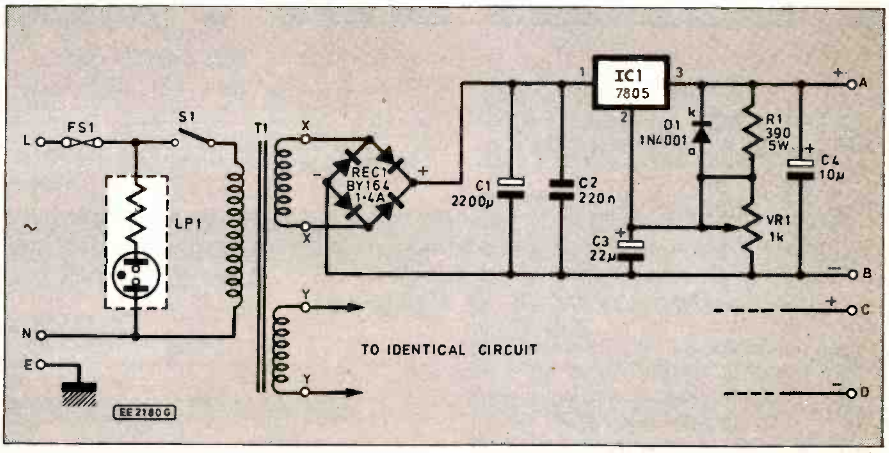


Fig. 3.2. Complete circuit diagram for the Fixed Voltage Stabilized Power Supply. This circuit can be preset for any output between 5V and 15V.

CONSTRUCTION

Most of the components for 5V and 15V outputs are mounted on a single printed circuit board and the component layout and full size copper foil master pattern is shown in Fig. 3.3. Letters refer to points common to board and circuit diagram. This board is available from the *EE PCB Service*, code 654.

Fitting the components to the board is no problem, but make sure that the bridge rectifiers, diodes and electrolytic capacitors are in the right way round. Also make quite sure that the rectifier you obtain has its output leads in the order + ~ ~ –. There are bridge assemblies in which the order is ~ + ~ –, and these *won't do* for this board. A fixing hole must be drilled to take a 6BA spacing screw.

The 7805 regulators (IC1) *must* be mounted on the *copper side* of the board, opposite to all the other components. This is because we have to bolt them to a sheet of aluminium which acts as a heatsink as well as the board support.

You will need a piece of 16 gauge aluminium bent to the dimensions shown in Fig. 3.4 and this should preferably be given a coat of matt black paint. Some garages and car parts shops sell a heat resistant black spray and if you can get this, so much the better. But *don't* spray the bracket until you have drilled all the necessary holes, see later.

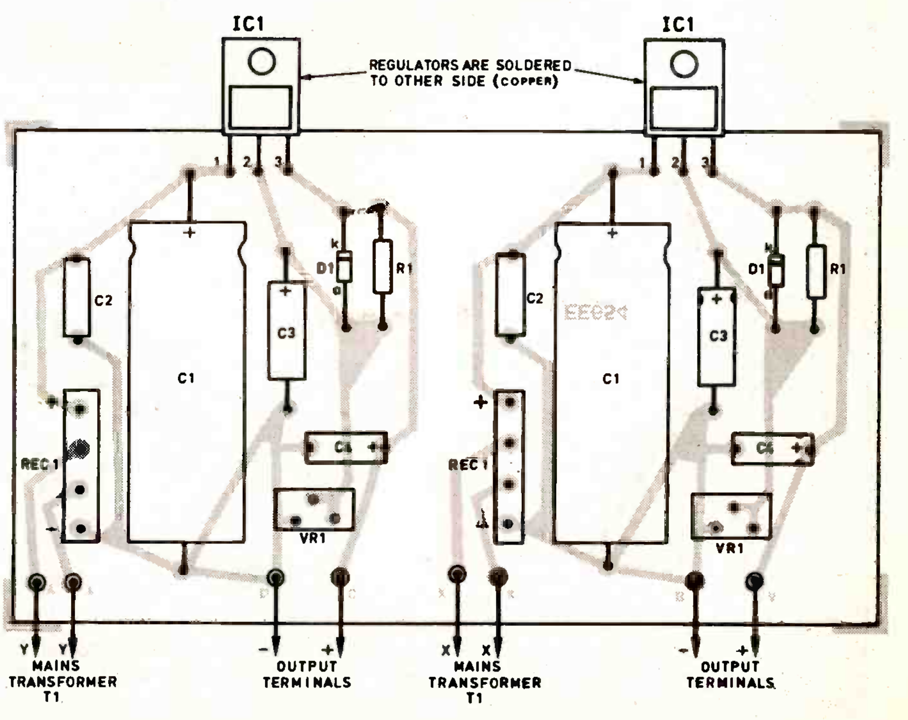
The pins of the 7805 regulators should be neatly bent at right angles at the point where there is change in the width of the pins, as Fig. 3.5 shows. The pins are then pushed carefully into the board (from the copper side!) so that the tips just protrude through onto the other side.

Using a small iron with a fine chisel bit, solder the pins into place. Some care is needed here to avoid bridging across tracks with solder but things are not so difficult as they might sound. How the regulators should look when soldered in position is shown in Fig. 3.5.

HEATSINK

Now position the board on the heatsink so that the board is level with the top edge of the aluminium, and after making sure that the regulators are straight (you can adjust them slightly on the natural spring of their pins) mark through their fixing holes and also a suitable board spacer hole on to the aluminium. Put a 6BA screw through the board spacer hole and tighten with a nut. Add a further nut to act as an adjustment later on.

Drill out the three marked holes in the aluminium; the hole sizes for the regulators will depend upon the insulating bushes you have, but the assembly is shown in Fig. 3.6. It is vital that the holes for the regulators are completely free of burrs, particularly so if you are using silicone-rubber insulating



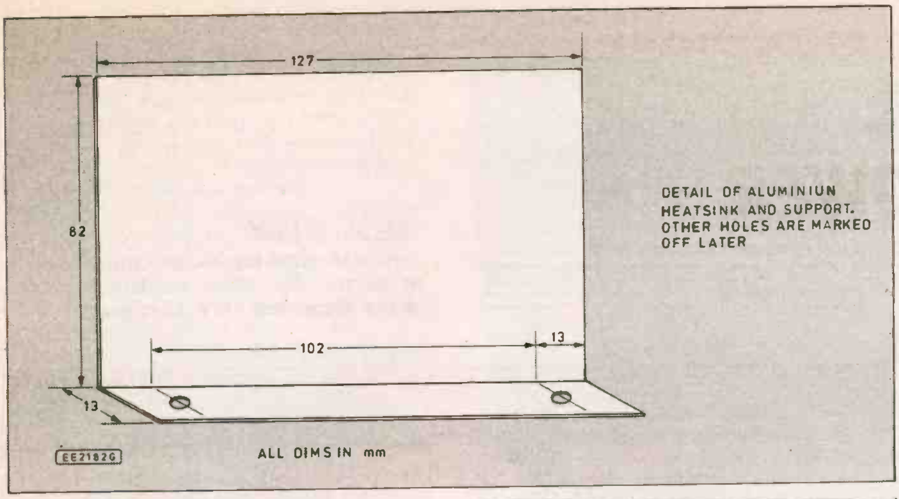
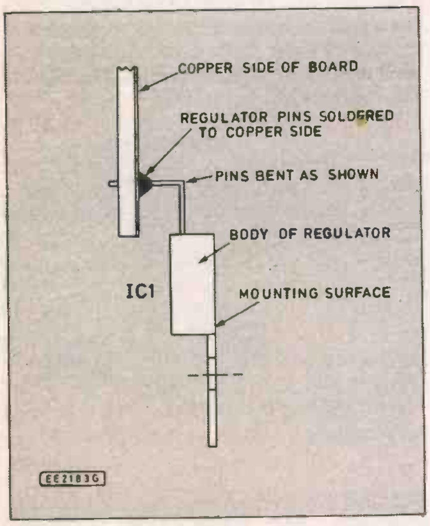


Fig. 3.4 (above). Drilling details and dimensions of the heatsink. The mounting holes are drilled later.

Fig. 3.6 (right). The completed assembly of the regulator and p.c.b. on the heatsink.

Fig. 3.5 (below). Method of mounting and soldering the regulator i.c. on the p.c.b.



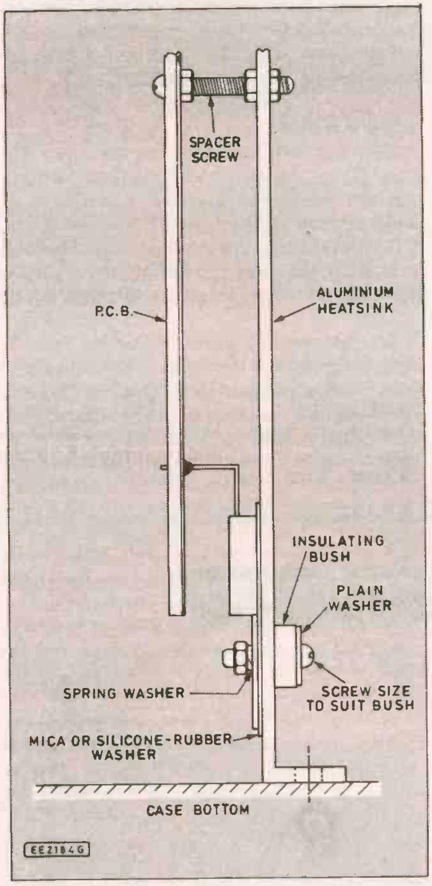


Fig. 3.3. Printed circuit board component layout (left) and full size copper foil master pattern (above). Note the regulators are soldered on the track side of the board.

washers. A rub down with a very fine piece of emery paper followed by fine wire-wool will save frustration later on.

You will have to use the bushes supplied to determine the right size of hole. Looking at Fig. 3.6 again as your guide, the bush should fit firmly into the hole and a 4BA (or maybe a 6BA) screw is then inserted from the rear through the bush and a mica or silicone-rubber insulating washer placed against the aluminium on the other side. Mica washers require a smear of heat transfer compound; this is not necessary with the silicone type but a tiny dab can be used to keep the washer in place while you manipulate things.

The board is positioned so that the spacer screw passes through its appropriate hole about the centre of the heatsink and the regulators drop over the screws at the base of the heatsink. The board and heatsink are now bolted together by adding spring washers and nuts to the regulator fixing screws and tightening them firmly but not excessively. Make sure that the washers stay in position as you tighten up.

The board spacer nut can now be adjusted to make the board and aluminium parallel to each other when viewed from the side, and finally tightened and locked with a further nut from behind. Your completed assembly should now look as shown in Fig. 3.6.

One check must be made at this point: by some appropriate means, such as a multimeter set to ohms, ensure that the fixing screws of both regulators are insulated from the aluminium. This is where any carelessness in de-burring the fixing holes earlier on will find you out!

COMPONENTS

FIXED VOLTAGE UNIT
(Each circuit requires)

Shop Talk See page 578

Resistor
R1 390 0.5W 5% carbon

Potentiometer
VR1 1k skeleton preset, vert.

Capacitors

C1	2200μ axial elec. 25V
C2	220n polyester
C3	22μ axial elec. 16V
C4	10μ axial elec. 16V

Semiconductors

D1	1N4001
REC 1	BY164 1.4A bridge rectifier
IC1	7805 Voltage Regulator

Miscellaneous

S1	d.p.s.t. mains toggle switch
LP1	220-250V neon indicator
T1	Mains transformer type 00490

Printed circuit board, available from *EE PCB Service*, code EE654; case, Maplin type Blue 226; terminals, 4mm socket type, 2 red, 2 black; aluminium heatsink, see text; connecting wire; solder etc.

Approx. cost Guidance only £29

It is a good plan, now that you've got the hang of putting this assembly together, to make up a second board which will give you a direct 5V plus 5V output. The same board print can be used and all you have to do is short-circuit the position of capacitor C3 and omit preset potentiometer VR1, simply connecting the junction of resistor R1 and diode D1 down to the negative line. A suitable transformer giving four secondary outputs, two of 8V and two of 17V to supply both boards is available from Trent Coil Winding (see *Shoptalk*).

Incidentally, it is not necessary to solder the transformer input wires or the d.c. output wires to the board before mounting the board on the heatsink. All these connections come out to copper pads at the top edge of the board and the wires can be pushed through the holes and soldered in situ. Use stranded wire in preference to solid; 7/02 gauge is suitable.

BOXING UP

The metal box mentioned in the components list does the job of holding both boards and transformer without difficulty, but there is no reason for not using an alternative (*providing it isn't plastic!*) if it will accept the parts. If you use the specified box, take out the internal chassis and bolt the transformer and the board assemblies directly down to the base.

The front panel can then be laid out as suggested in Fig. 3.7 using 4mm sockets for the output points. By linking the sockets at the indicated points and using this as a common (zero) connection, balanced supplies of +5V, 0V, −5V and +15V, 0V, −15V (or whatever you want) are available. The mains on-off switch and neon indicator are also fitted to the front panel, the mains lead being taken in at the rear, via a sleeved grommet and a suitable retaining clip.

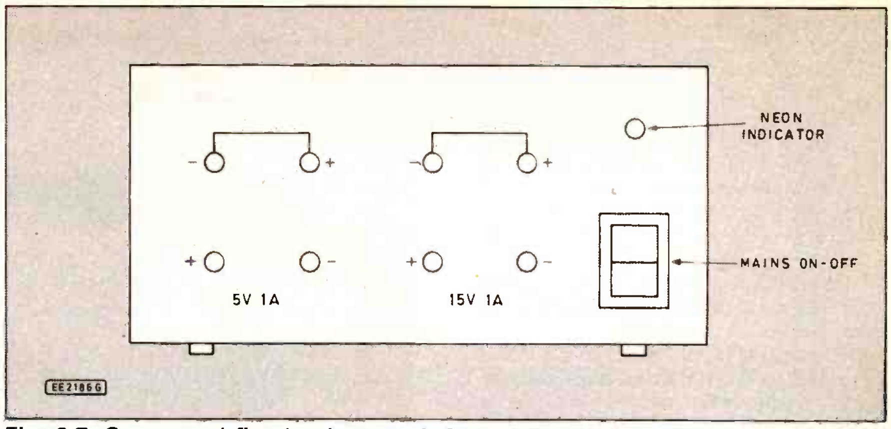


Fig. 3.7. Suggested fixed voltage unit front panel layout, providing single or balanced outputs.

TESTING

There is little testing to be done on this unit. All you need is a voltmeter and a high wattage resistance that you can use as a load. Set the programming potentiometers VR1 on the adjustable output board to mid position and, after switching on, simply measure the outputs at the appropriate terminals.

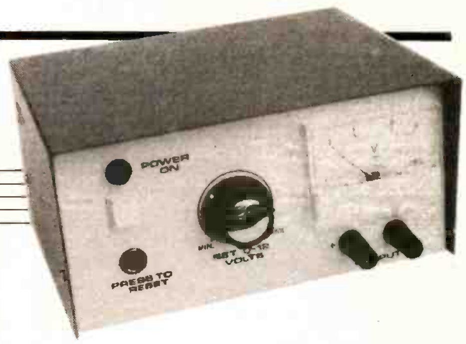
The 5V outputs should be within ±0.2V of that figure; for the other outputs, adjust each of the programming potentiometers to obtain the outputs you need. These will normally be either 12V or 15V for general CMOS op.-amp work, but you are the boss here and you can set the outputs to what you need. If you are going to use balanced supplies, both outputs should, of course be the same.

A simple check that the regulators are working properly consists of putting on a load to each output and noting that the output voltage change is negligible. Select the load value (a high wattage resistor is suitable) so that the current drawn is about 1A for each output.

The change in the output voltage *will* be noticeable when the load is switched in but it should not exceed about 0.1V on the 5V range or 0.2V on the programmable range. This, of course, is a rough and ready check but it will show that the unit is working as it should. Those who are knowledgeable about such things will know how to make a more sophisticated test.

Constructional Project

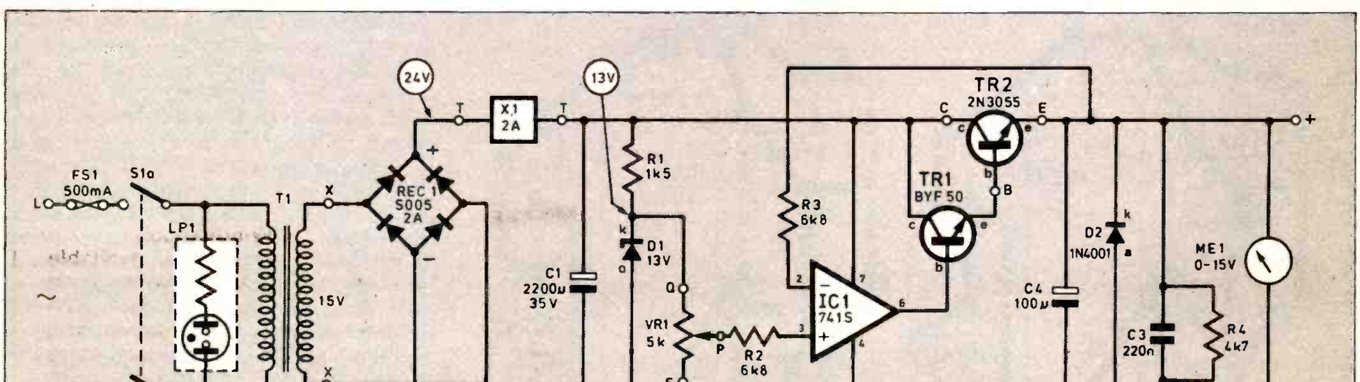
VARIABLE STABILIZED POWER SUPPLY



THE CIRCUIT diagram of the second project, a Variable Stabilized Power Supply, is shown in Fig. 3.8. Here a transformer is required giving an output of 15V to 18V at 2A, plus a winding giving 5V to 6V at a current of 10mA. ***The windings must be separate!*** A specially wound unit is available from Trent, see *Shoptalk*.

The main secondary output from the transformer T1 is rectified by the bridge REC1 in the usual way and smoothed by capacitor C1. The peak voltage across C1 can be up to 25V if you use an 18V transformer and a minimum working voltage of 35V should be selected. The capacitor specified has such a working level and a rip-

Fig. 3.8 (below). The complete circuit diagram for the 0-12V Variable Stabilized Power Supply.



ple rating of 3A; this last figure is as important as the former.

This unregulated supply is connected to the regulator system consisting of integrated circuit IC1 and the series pass transistor TR2, with its base bias controlled by TR1. IC1 is a high gain amplifier functioning as a differential comparator.

The non-inverting input (pin 3) of IC1 is fed from potentiometer VR1 which is connected across the Zener diode D1. The Zener maintains a stable 13V across its ends; the slider of VR1 can therefore be varied between 0V and 13V.

The inverting input (pin 2) to the IC1 is connected to the stabilized output of the supply. Whatever the potential at the slider of VR1 happens to be, this is compared with the output potential and any difference is detected and amplified by IC1.

The output of IC1 then adjusts the base voltage of TR1 in such a way that the difference is reduced (theoretically) to zero. Hence the output voltage is held at whatever voltage setting has been selected by VR1.

A 13V reference Zener is used as the output is always slightly less than this reference because of the drop across TR2. An output of up to 12V can therefore be obtained. If the output tends to change for any reason, that change will be immediately corrected, hence the output will be *stabilized*.

THERMAL TRIP

As this simple circuit does not incorporate a current limiting feature (as later designs will) a thermal trip X1 is included in the positive feed line following the rectifier. This will trip at a current of 2A so the unit will be protected against inadvertant short-circuits or serious overload.

You can, if you wish, replace this trip with a panel mounted 2A fuse. This saves a few bob but is not so convenient as the trip and after a few blow-outs might lead to the insertion of a larger rated fuse because of the frustration. And hence to more expensive disasters!

Diode D2 across the output terminals is also protective in that it prevents reverse high voltage spikes from being fed back into the unit from inductive loads such as motors.

NEGATIVE SUPPLY

So that the unit can be adjusted down to zero volts, a negative supply line is provided (see Fig. 3.8). This is obtained from the additional secondary winding of the transformer T1.

After rectification by the single diode D3, smoothing is carried out by capacitor C2 and Zener diode D4 maintains a steady 4.3V feeding the negative supply pin (4) of IC1. The value of resistor R5 is given for the specified transformer; if you use an alternative transformer where the secondary may be greater than 6V, you may have to modify this value to ensure that the Zener does not exceed its power rating (500mW) under no-load conditions.

The actual current drawn from this negative rail is very small (about 3mA) and there is no problem with the ripple rating of capacitor C2.

CONSTRUCTION

The construction of the Variable Stabilized Power Supply is reasonably straight-forward with most of the components mounted on a single printed circuit board (p.c.b.). The full size copper foil master pattern for this board is shown in Fig. 3.9, together with the component positioning on the topside.

The completed unit showing front panel layout and lettering.

COMPONENTS

VARIABLE VOLTAGE UNIT

Resistors
- R1 1k5
- R2, R3 6k8 (2 off)
- R4 4k7
- R5 1k8

All 0.5W 5% carbon

Shop Talk
See page 578

Potentiometer
- VR1 5k rotary carbon, lin

Capacitors
- C1 2200μ axial elec. 35V
- C2 470μ axial elec. 16V
- C3 220n polyester
- C4 100μ axial elec. 25V

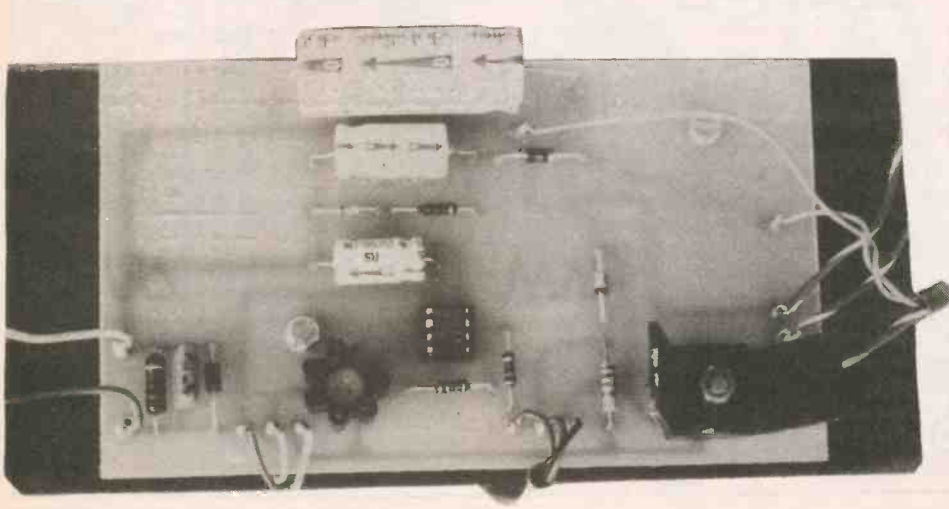
Semiconductors
- D1 13V 1.3W Zener
- D2, D3 1N4001 (2 off)
- D4 4.3V 500mW Zener
- TR1 BFY50 *npn* silicon
- TR2 2N3055 (or 2N3771) *npn* silicon power
- IC1 741S op.amp
- REC1 S005 2A bridge rectifier

Miscellaneous
- S1 d.p.s.t. mains toggle switch
- LP1 220-250V neon indicator
- ME1 0-15V moving-iron meter, RS type 259-577
- T1 Transformer type 00491 (Trent Coil Winding Co.)

Printed circuit board, available from *EE PCB Service*, code EE655; X1 circuit breaker, 2A thermal type; case, Maplin type Blue Case 237; Terminals, 4mm type 1 red, 1 black; aluminium heatsink (2 off), see text; corrugated T039 heatsink; connecting wire; solder etc.

Approx. cost Guidance only **£48**

The complete printed circuit board for the variable supply unit. Note the two heatsinks on TR1 and the bridge rectifier REC1.



There is no close packing of the parts, and unless you prefer to obtain your board ready made, it is a simple matter to make one for yourself using either etch-resistant transfers or a careful hand drawing using a Dalo pen. A ready-drilled printed circuit board is available from the *EE PCB Service,* code EE655.

When assembling the board, great care must be taken to ensure that the rectifier REC1 is correctly orientated. It can go in any one of four ways and only one is the right way! The same applies to the Zener diodes D1 and D4, the diodes D2 and D3, and the electrolytic capacitors. Notice that C2 has its *positive* end to the "earth" or "chassis" line.

Fit Vero pins at positions XX, YY, TT, PQS and CBE for later wiring to the transformer T1, the trip X1, the control potentiometer VR1 and the pass transistor TR2 respectively. Fit a corrugated TO39 type heatsink to transistor TR1. Also fit pins to the plus and minus output points. Drill two 4BA clearance holes at points K.

A small heatsink for the rectifier REC1 itself is recommended if you are thinking of drawing currents up to 1.5A for any extended period. This is a simple piece of 16 gauge aluminium 3in. (76mm) long by 1in. (25mm) wide, bent as shown in Fig. 3.10 and secured to the rectifier by way of its central hole and a countersunk 4BA screw and nut. Do this *before* soldering the rectifier to the board!

Once everything is on the board, it has to be fitted to the main aluminium heatsink which carries the power transistor TR2.

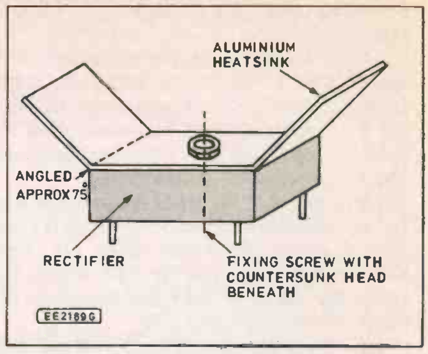


Fig. 3.10. Mounting the small (76mm×25mm) 16 gauge aluminium heatsink on the bridge rectifier.

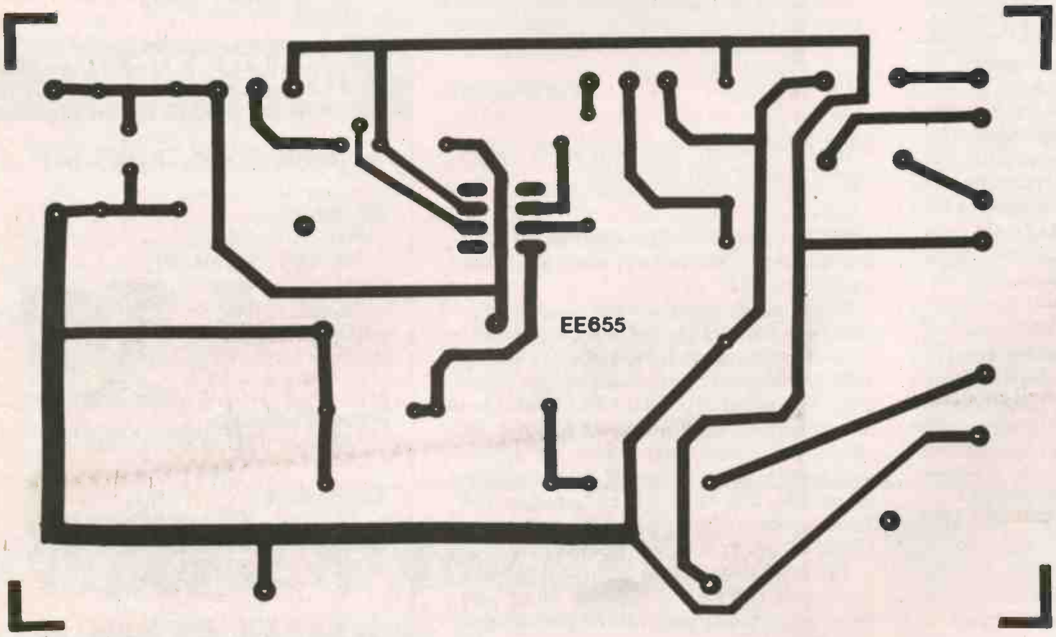
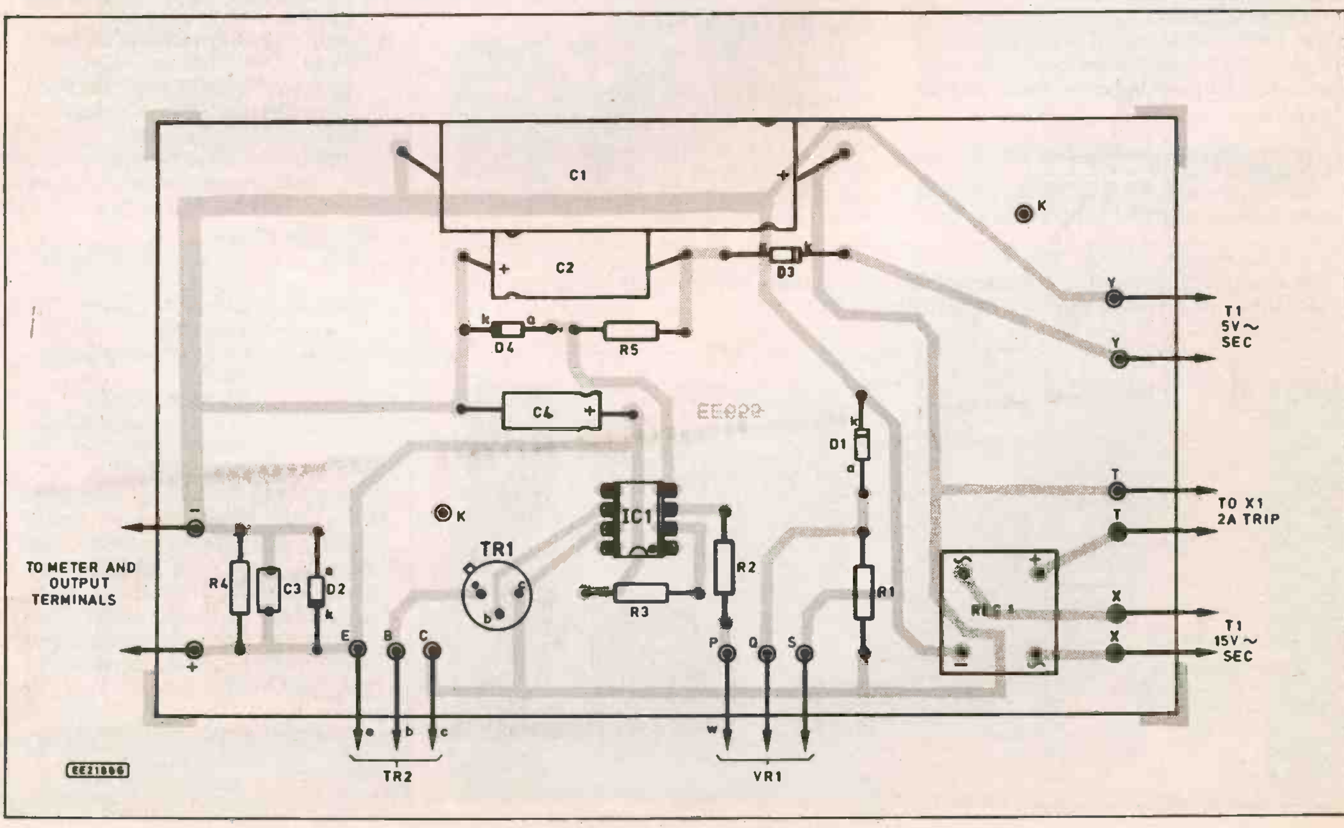


Fig. 3.9. Full size printed circuit copper foil master pattern and topside component layout for the variable power supply. A small T039 "corrugated" heatsink should be placed over TR1 – see photos. This board is available through the EE PCB Service, code EE655.



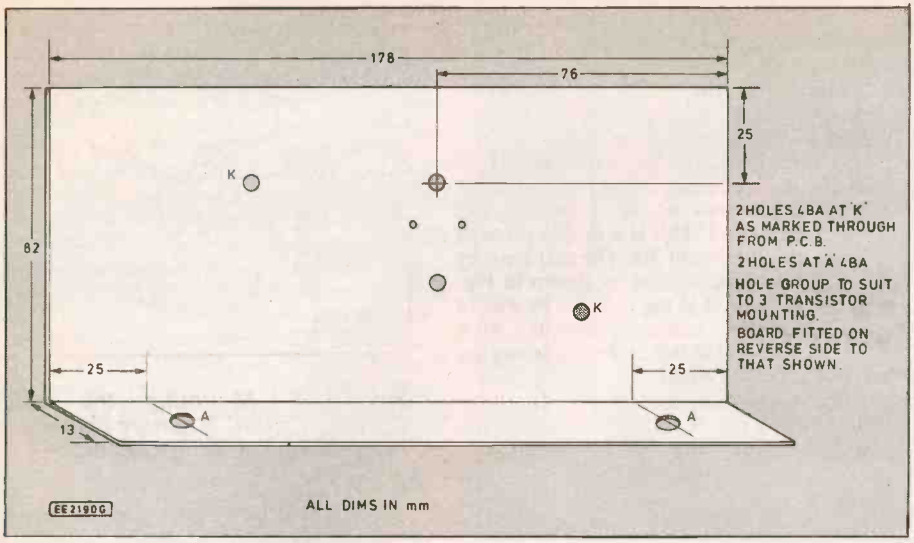


Fig. 3.11. Drilling details and dimensions of the main aluminium heatsink.

The aluminium is cut, bent and drilled to the dimensions given in Fig. 3.11 and then sprayed matt black as for the earlier project. You can use your mica or silicone-rubber insulating washer as a template for the transistor mounting holes, making sure there is adequate clearance round the base and emitter pins.

The board is now placed against the heatsink and the two 4BA fixing hole positions marked through; keep the top edge of the board in line with the top edge of the heatsink. None of this is particularly critical and can be judged by eye well enough.

The 2N3055 transistor should now be mounted on the aluminium, using the usual insulating bushes and washer. A soldering tag is fitted under the upper nut so that connection can be made to the collector (the case) of transistor TR2.

Check that the transistor is not shorting to the aluminium, and then solder flexible leads to the collector tag and the base and emitter pins for later connection to the board. Use three colours for this so as to avoid any future confusion.

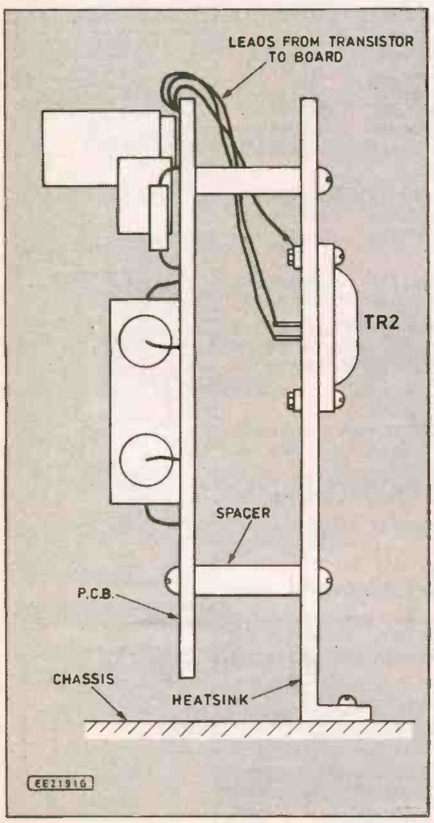
The board can now be screwed to the heatsink using half-inch spacers and the three leads from TR2 brought over the top edge of the board and soldered to the appropriate Vero pins at the points C (collector). B (base) and E (emitter). Fig. 3.12 shows the general appearance of the completed mounting.

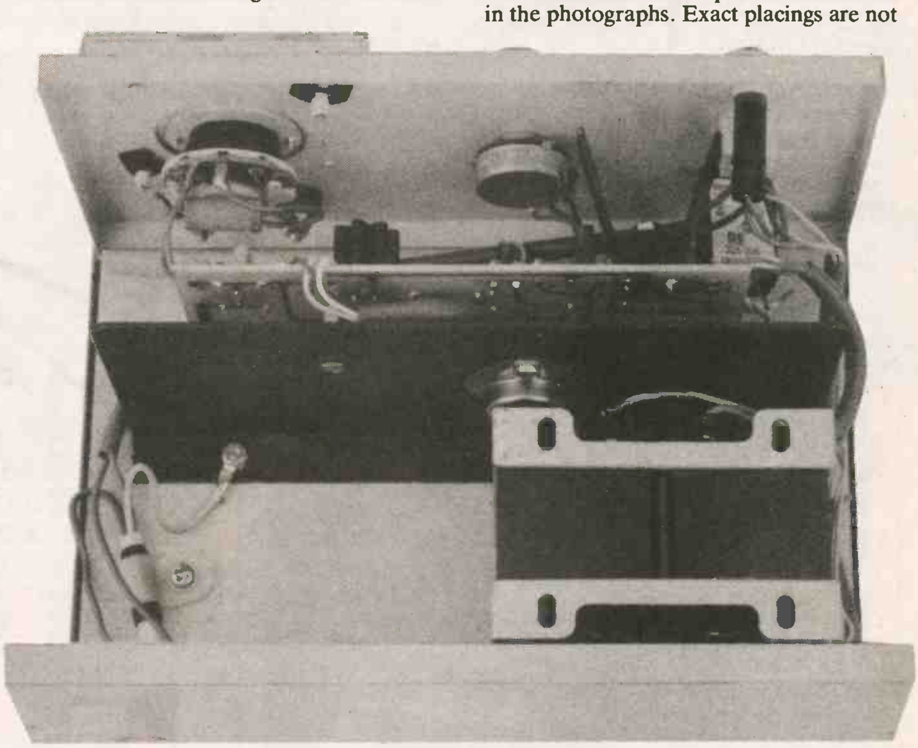
BOXING UP

The case mentioned in the components list makes an attractive housing for this power supply, but any alternative may be used provided it measures at least 8in. (203mm) by 4in. (102mm) by 6in. (152mm) back to front. The front panel carries the meter (which is optional — you may prefer to calibrate directly onto a panel scale), the thermal trip X1, the voltage control VR1, the mains on/off switch and indicator neon and the d.c. output terminals.

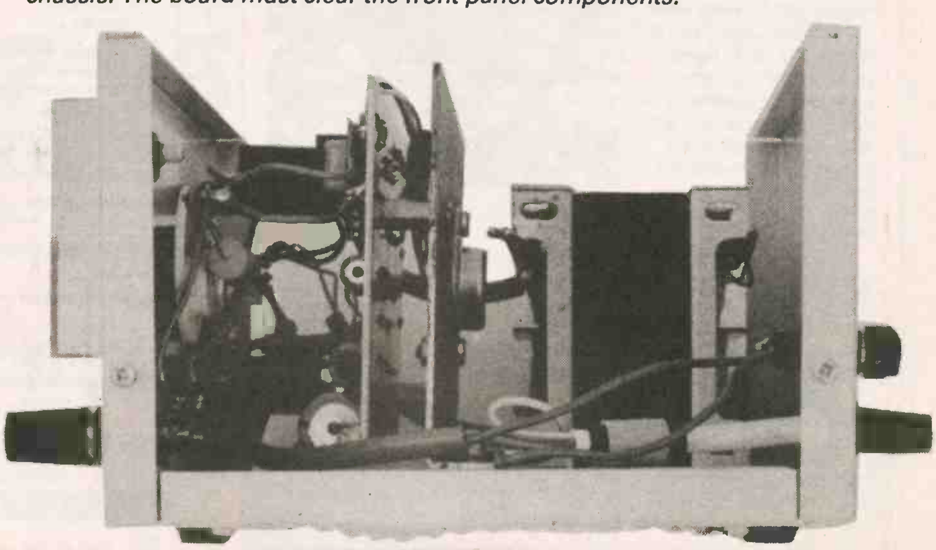
If you use the specified case, the transformer and the printed board should be mounted on the internal chassis provided with these cases in the positions indicated in the photographs. Exact placings are not

Fig. 3.12. Mounting the circuit board on the main heatsink.





Positioning of the mains transformer, p.c.b. and heatsink on the internal chassis. The board must clear the front panel components.



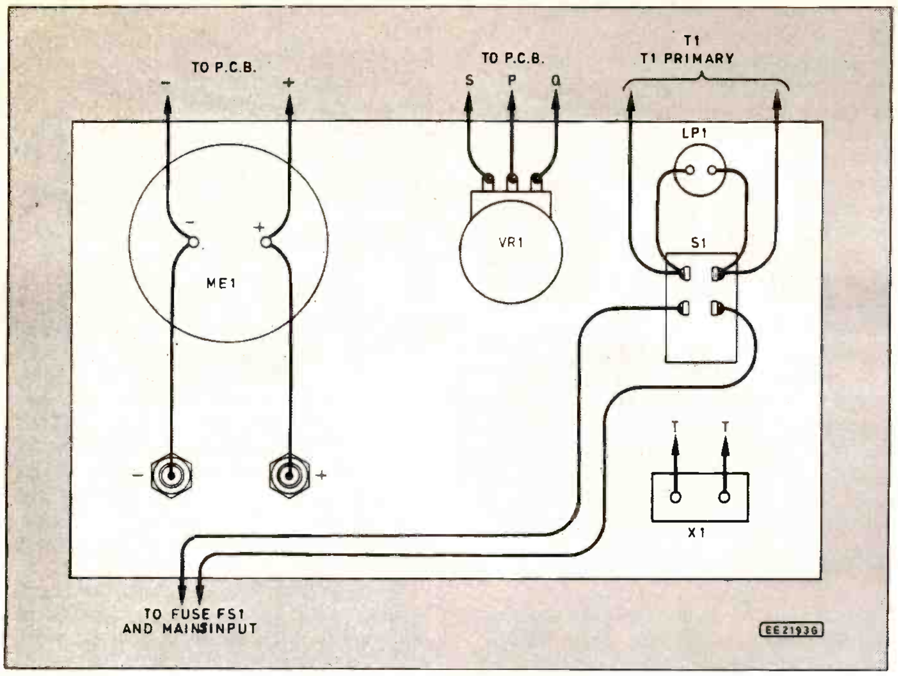


Fig. 3.13. Interwiring to front panel mounted components. Letters relate to points on the p.c.b.

critical but should be as far to the rear of the chassis as possible so that room is left for the inwardly projecting components mounted on the rear of the front panel.

INTERWIRING

A suggested front panel layout is shown in the photographs; lettering can be carried out using Letraset or other systems before mounting any of the components. With the internal chassis now screwed into the case, interwiring between the p.c.b., the transformer secondaries and the panel can be quickly made; the panel interwiring is shown in Fig. 3.13.

A word at this point about the meter: the one used in the prototype is a moving-iron meter, scaled 0-15V. These meters are quite cheap as analogue instruments go these days and the fact that the scale is non-linear and the movement does not have the "smoothness" found in more expensive moving-coil units is no great hardship in the present usage. Over the bulk of the scale length there is a good approximation to linearity, anyway, and it does tell you what is coming out of the terminals!

If you wish to use a moving-coil meter, you will have to hunt around to find one scaled 0-15V (or thereabouts); alternately, you can rescale one of the many units available from advertisers. Choose a 1mA basic meter, then add a series resistor to convert it to a voltmeter to suit the new scaling. A small preset is useful here.

You can if you wish, of course, omit the meter entirely and draw yourself a panel scale calibrated 0-12V (or 0-15V). It is not a difficult job to mark a scale off against an external voltmeter as monitor.

TESTING

There is little to go wrong with this simple power unit and it should work correctly right away. If you want to get up to 15V output, replace D1 with a 16V type, and you may have to replace D4 also with a 4.7V type. Nothing else needs any modification.

Typical voltage levels are shown in the circuit diagram of Fig. 3.8. These can be used as a guide if the unit does not work properly and will probably enable any gross fault to be quickly located.

The most likely causes of difficulty are the old favourites of reversed diodes or electrolytics, so watch out for these particularly. The output current is nominally 1.5A as maximum, but 2A can be drawn for periods not exceeding ten minutes or so.

NEXT MONTH: We will describe power supply units, with current limiting, which will give us outputs up to 30V.

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DOWN TO EARTH

BY GEORGE HYLTON

TUNING DIODES

RECENTLY, in the course of developing a simple short wave receiver, I tried to substitute a variable-capacitance diode (Varicap) for the conventional tuning capacitor. At first it seemed to work, but on closer acquaintance defects appeared. Tuning was erratic. The audio signal was distorted. Mains hum was audible. These imperfections became apparent when the receiver's regeneration (reaction) was adjusted to give as much gain and selectivity as possible.

Evidently my tacit assumption that a Varicap is just a straightforward alternative to an ordinary variable capacitor was incorrect. It was time to review what knowledge I had of Varicaps and try to figure out what was going wrong.

DEPLETION LAYER

Any *pn* junction diode has capacitance. When unbiased, current carriers move to either side of the junction area, leaving a layer of semiconductor material which is more or less free of holes or electrons and can act as a dielectric.

If the junction is reverse-biased by an external voltage, the depletion layer widens. This is like pulling apart the plates of a capacitor, so the capacitance falls.

The effect of reverse bias on capacitance for a silicon junction diode made by the technique known as epitaxy is shown in Fig. 1. The "diode" is actually the base-emitter junction of a BC168 transistor.

The amount of capacitance change which can be obtained is rather small. Other manufacturing techniques yield better voltage sensitivity and sometimes more conveniently shaped curves.

The Varicap I was using (KV1235) is really intended for long and medium wave receivers. When placed in circuit (Fig. 2) with one particular inductor it gave a frequency range shown. This indicates that a three-to-one frequency ratio is obtainable for a voltage change of less than 9V: a convenient performance for battery radios.

This type of Varicap is sold in groups of three, matched so that the same voltage applied to each one gives the same capacitance within a small percentage. In a superheterodyne receiver, at least two Varicaps are needed, one for signal circuit tuning and one for local oscillator tuning. My short wave receiver has only one tuned circuit so a single diode would suffice – if it worked.

Varicaps have the advantage over mechanical tuning elements that the actual tuning control (usually a potentiometer) can be remote from the tuned circuit. This gives the designer a free hand in laying out his circuitry.

SIGNAL VOLTAGE

A Varicap will respond to any voltage which reaches it, d.c. or a.c. The intended voltage is the d.c. tuning voltage V_T, but also present is the signal

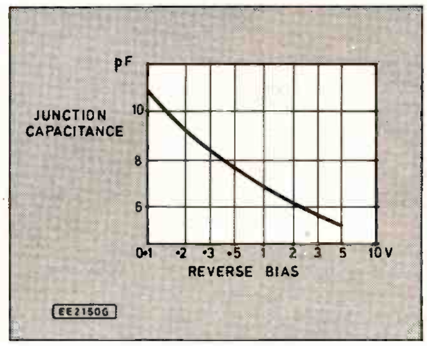


Fig. 1. How the capacitors of a pn *junction changes with reverse bias.*

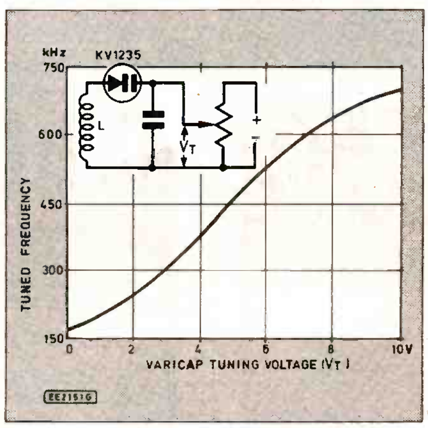


Fig. 2. Tuning curve for a KV1235 Varicap.

voltage. This puts an a.c. wobble on the d.c., pushing the tuning high on one half cycle and low on the next.

If the signal voltage is very small compared with the tuning voltage the effect is negligible. It must, however, be significant if the signal becomes large. A large signal superimposed on the tuning voltage is shown in Fig. 3.

Because of the way the C/V curve bends, negative half-cycles have a greater effect that positive ones. The result is that as the signal voltage is increased the tuning is pulled lower in frequency.

To see what this means in practice the simple test circuit shown in Fig. 4 was used. Here, a signal generator with a comparatively high output voltage is loosely coupled to the tuned circuit formed by *L* and the capacitance of the Varicap D_T1.

The voltage across the tuned circuit is rectified by an ordinary diode D2 and

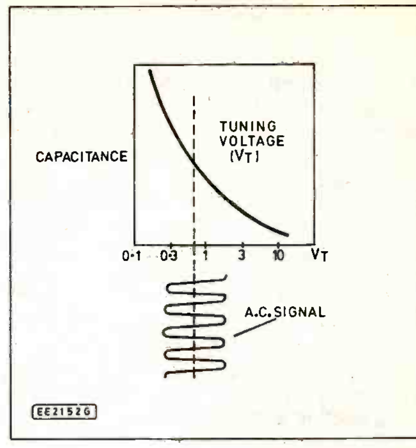


Fig. 3. A.C. signal superimposed on d.c. tuning voltage.

monitored with a high-resistance d.c. voltmeter. With small signals the rectified voltage changes with frequency to give the usual sort of resonance curve (A).

When the signal voltage across *L* is raised so that it is an appreciable fraction (e.g. one third) of the tuning voltage, the resonance curve changes to (B). Here, on the low-frequency side of the true resonant frequency, there is a steep jump as the signal pulls the tuning towards itself.

EFFECTS

This behaviour can have serious effects in a radio receiver. It makes the tuning point vary with signal strength. If the signal is amplitude-modulated, the tuning must change over each modulation cycle, going lower in frequency at the envelope peaks and staying put at the troughs.

This makes for distortion of the audio component of the rectified signal. Worse, if there happens to be a strong unwanted signal on the low-frequency side of the wanted signal, the unwanted signal will pull the tuning.

If strong enough it may capture the tuning and force the signal circuit of the receiver to become tuned to itself. If too weak to capture the tuning but still strong enough to have some effect the modulation of the unwanted signal may wobble the tuning to and fro, with the result that the wanted signal becomes

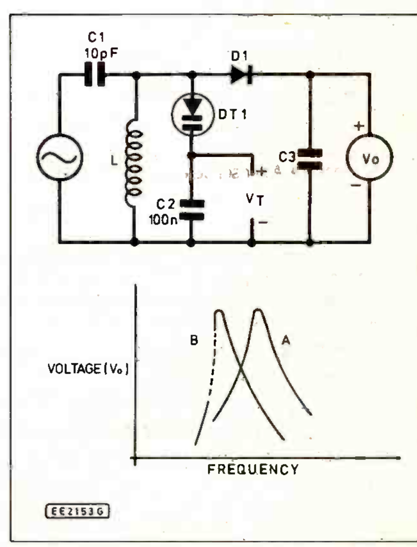


Fig. 4. Test circuit and curves showing effects of large a.c. signals.

amplitude-modulated by the unwanted one.

If any stray mains voltage is mixed up with the tuning voltage there will be frequency-modulation of the tuning. This shows up as hum on the signal, after rectification. In the same way, if any audio signals from later stages in the receiver find their way into the tuning voltage source they cause distortion.

In a regenerative receiver, where positive feedback of the radio-frequency signal is used to improve gain and selectivity, all these effects tend to be exaggerated. One result can be a form of instability in which a gently-oscillating receiver amplitude-modulates itself at a low frequency.

REMEDIES

The obvious remedy is to ensure that signal levels don't become large enough to upset the Varicap. In a normal receiver where the aerial circuit is the only one tuned to the signal and there is no regeneration, signal levels will be low enough to be harmless (unless you happen to live near a transmitter). Varicaps are also used to control the frequency of the local oscillator, where the r.f. voltage must be relatively high to make the receiver work.

One possible remedy might be to design the local oscillator on the lines of Fig. 5a. Here, the amplifier part of the oscillator circuit is followed by a voltage limiter which ensures that the voltages fed back to the Varicaps in the tuning part are safely low.

Another ploy (Fig.5b) is to use two Varicaps connected back-to-back across the tuning inductor *L*. When the oscillation voltage drives the capacitance of D_T1 high, the effect of D_T2 is the reverse. So the unwanted changes in capacitance tend to cancel one another. Also, since the r.f. voltage is shared by the diodes there is less of it across either than in the single-Varicap circuit.

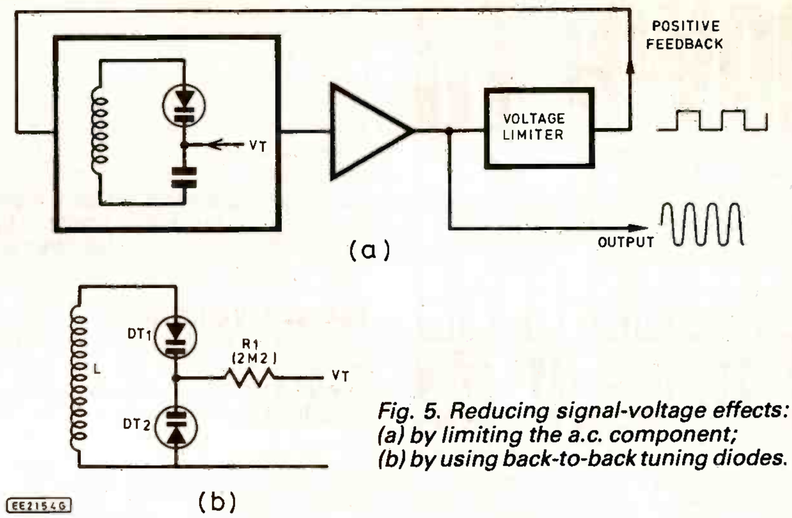


Fig. 5. Reducing signal-voltage effects: (a) by limiting the a.c. component; (b) by using back-to-back tuning diodes.

Having tried this back-to-back method in my test circuit, the pulling effect was reduced but not eliminated. (This is to be expected. The two Varicaps cannot give perfect cancellation of unwanted capacitance changes.) So, although back-to-back may be good enough for many applications it's not a cure-all.

A third remedy is to use high-voltage Varicaps so that the signal can never become comparable with the tuning voltage. Virtually every TV receiver these days has high-voltage (say 30V) Varicaps in its front end, and so do some v.h.f./f.m. receivers. There are also a.m. receivers whose local oscillator frequency is created by frequency synthesis. These systems often have a voltage-controlled oscillator (VCO) and this may use a Varicap. They work.

That's fine, but it doesn't help me. Even with both a voltage limiter and back-to-back diodes my short wave receiver tells me very clearly that Varicaps are not for it. So it's back to the clumsy old tuning capacitor for me. Ah, well, it was fun finding out.

City and Guilds C+G

Certificate Course

Introducing DIGITAL ELECTRONICS

Part 12 Sequential Logic

By Michael J. Cockcroft
Training Manager, Peterborough ITeC

This concluding article in the series expands on previous treatment of electronic logic to round off our introduction to digital electronics. The following are the remaining City and Guilds objectives (the section 8 objective are not dealt with in this part but have all been covered at one time or another throughout the series):

6.2 Flip-Flops

6.2.1 State the need for a flip-flop.

6.2.2 Describe, in very simple terms, the action of a 'D' type flip-flop.

6.2.3 Draw the block symbol for a simple 'D' type flip-flop and label the inputs and outputs.

6.2.4 Verify the operation of a simple 'D' type flip-flop in conjunction with a breadboard or logic tutor.

6.2.5 Describe a typical application of a 'D' type flip-flop.

7. Logic Systems

7.1 Combinational and Sequential

7.1.1 Distinguish between combinational and sequential systems.

7.1.2 Derive truth tables for a variety of combinational systems assembled on a breadboard or logic tutor including:-
Tandem arrangements of inverters (NOT gates)
Combinations of two-input AND, OR, NAND or NOR gates
Combinations of two-input AND, OR, NOR or NOT gates

7.1.3 Construct, on a breadboard or logic tutor, a binary half-adder using a combination of the basic logic gates and verify its operation.

7.1.4 Construct, on a breadboard or logic tutor, a four-stage asynchronous binary up-counter using data type flip-flops and verify its operation.

Last month we looked at digital electronics as a general concept and, in particular, at how digital circuits are formulated using combinational logic devices such as AND, OR and NOT gates. We used the binary number system as a systematic method of providing, in the form of a truth table, a precise statement of a logical argument; for example, the decisions involved in the two-way light switch system that turned a light on if either (but not both) of the switches were closed. This month we investigate sequential logic.

Combinational and Sequential Logic

Combinational logic circuits are made up of basic (or networks of) gates from SSI devices and are restricted to the simple conversion of binary input patterns to specified binary outputs. This means that, for combinational logic, an output (acccording to the truth table) depends on, and changes at any time according to, its binary input pattern.

As an example, consider the combinational circuit of Fig. 12.1; here, the variation of inputs and outputs with time are shown by a graph. Twice the switch is momentarily depressed for different durations causing input A to follow suit going low twice and making the output of the NOR gate high for the same time periods.

In contrast to this is the sequential logic circuit of Fig. 12.2 whose output does different things depending on what went on previously with respect to the applied input; if the last input

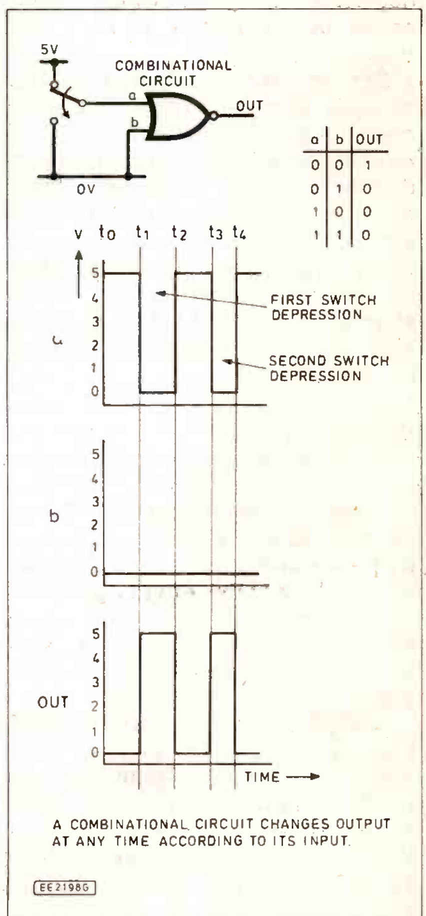


Fig. 12.1. Combinational circuit operation

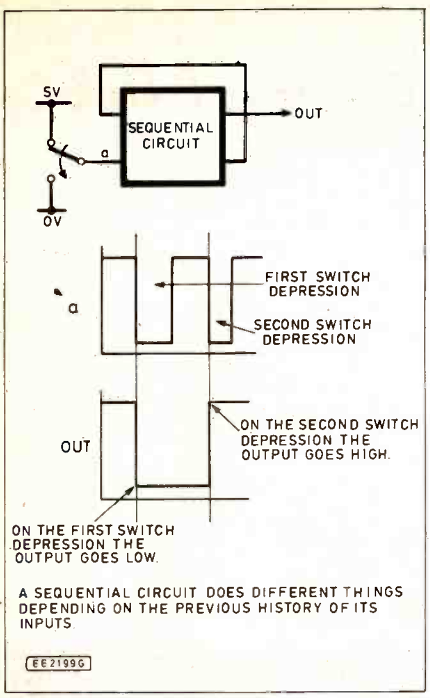


Fig. 12.2. Sequential circuit operation

caused the output to go high then the next input will cause the output to go low, if the last input caused the output to go low then the next input will cause the output to go high. In other words, the output always does the opposite to its previous action. Sequential circuits, by definition, are circuits whose present outputs depend on the present inputs *influenced by the history of their past inputs.*

Of the two types of logic, combinational is the more primitive because it does not have the ability to *remember* previous inputs. Many digital networks, particularly those dedicated to counting or timing operations, require sequential devices to allow the action of progressing sequentially through a number of states. What sequential devices possess that combinational devices do not is *memory*.

Memory

What is memory? Anything that has the ability to record an event can be said to possess memory. Events can be recorded in a number of ways; by pencil and paper, magnetic tape, even a photograph. Anything that can remember (store) the effect of an input *after* the input has been removed can be regarded as memory.

In digital electronics we use **feedback** to store events. Feedback is not entirely new to you (although you may not know it) because we used it in the experimental relay circuit of Part 6 (reproduced here as Fig. 12.3) to latch the relay contacts closed after the release of the push button switch. This circuit can be regarded as a basic memory device; the output (the closed relay contacts) is fed back to

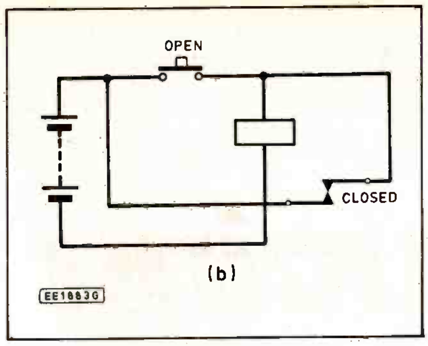


Fig. 12.3. Relay latch circuit

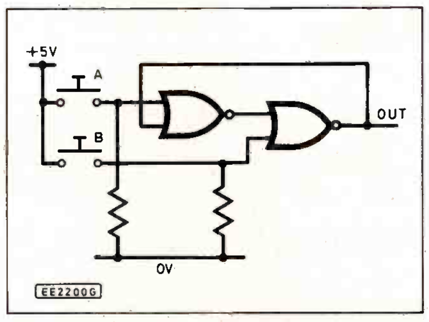


Fig. 12.4. Feedback provides memory

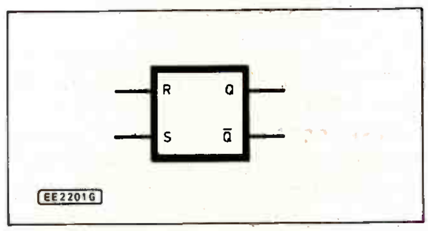


Fig. 12.5. The RS flip-flop

the input (the switch) to maintain the flow of current forever, or at least until the power is removed.

Similar feedback can be applied to combinational networks, as shown in Fig. 12.4, to provide them with memory and therefore a sequential action. The output is fed back to one of the gate inputs to allow the input action to be stored – in the diagram, switch A sets (and latches) the output high, and switch B latches the output low. Using combinational logic devices to produce sequential actions, however, is not always practical since, for many purposes, sequential devices offer a cheaper and simpler solution.

Bistables

Sequential devices always incorporate memory, and the most simple memory device is the **bistable** or, as they are usually called, the **flip-flop** or **latch**. A bistable latch is essentially a binary storage device and, as such, is required to accept and hold a binary state for an unlimited period until directed to do otherwise.

The simplest bistable is the R-S flip-flop which has two inputs and two outputs, as shown by its symbol in Fig. 12.5. The R and the S labels at the inputs stand for Reset and Set respectively: a flip-flop is reset if its Q output is at logic 0 and it is set if Q is at logic 1. The $\overline{Q}$ output is at all times in the opposite logic state to the Q output. A pulse to the R input latches the flip-flop in the reset condition and a pulse to the S input latches the flip-flop in the set condition.

There are two types of R-S flip-flop, as shown in Fig. 12.6. A logic 1 to the R input of Fig. 12.6a resets Q to 0, and a high to S sets Q to 1. Because the Reset and Set inputs are activated by a logic 1 they are said to be *active high* inputs.

An *active low* R-S flip-flop configuration is shown in Fig. 12.6b. The NAND configuration requires a logic 0 at the Reset input to reset the flip-flop, and a logic 0 at the Set input to set the flip-flop.

R-S flip-flops are limited in their usefulness because, as shown by their truth tables, the R and S inputs are never allowed to assume the active state at the same time. If a system uses R-S latches the circuit must be designed such that it is impossible to activate both inputs simultane-

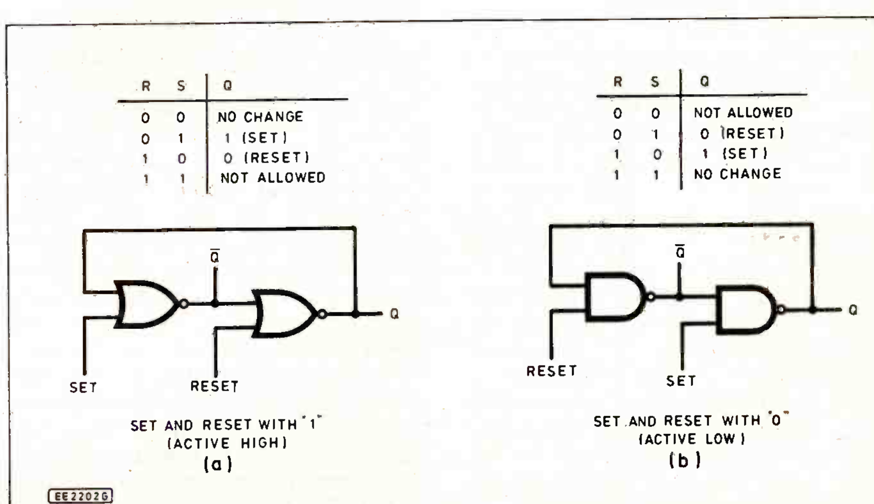


Fig. 12.6. Two types of RS flip-flop

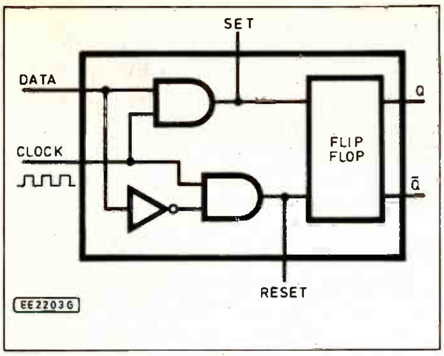


Fig. 12.7. The D type flip-flop

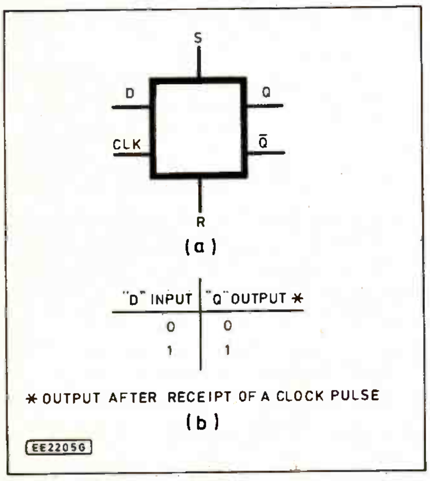


Fig. 12.8. D type flip-flop symbol

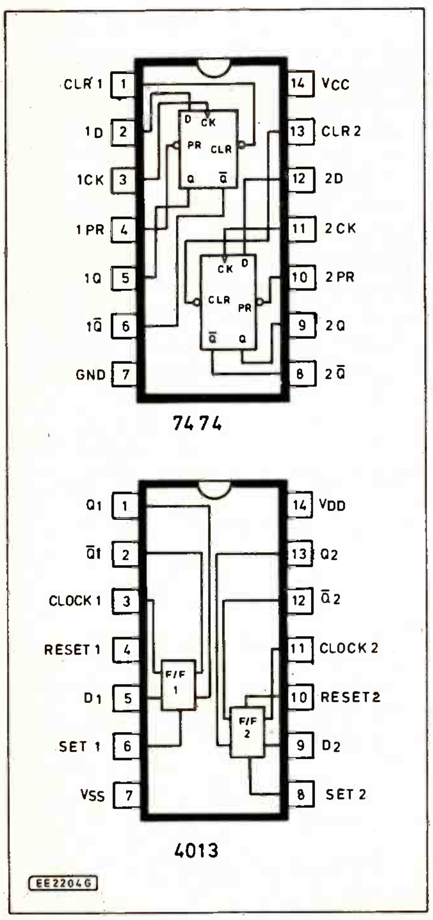


Fig. 12.9. Pin outs of the 7474 and 4013

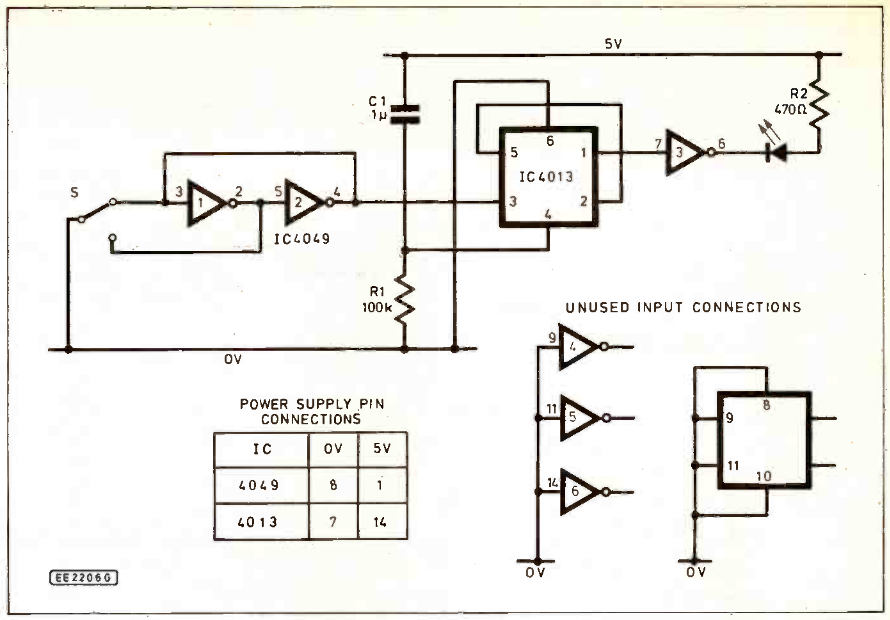


Fig. 12.10. Circuit to demonstrate the D type flip-flop

ously, otherwise it would give rise to ambiguity as to the systems correct operation. For this reason, R-S flip-flops as i.c. devices are less common than other flip-flop types.

D-Type

They do however, form part of all other available MSI flip-flop circuits; as in the *D-type flip-flop*, for example, as shown in Fig. 12.7. The D-type flip-flop, as indicated by its symbol in Fig. 12.8a, has a *data* input (D), a *clock* input (CLK), a *set direct* input (S), a *reset direct* input (R), and two outputs (Q and $\overline{Q}$). Operation of this device is very simple: the logic level at the D input is transferred to the Q output after receipt of a pulse at the CLK input. The Q output can be set directly (set to Q=1) by applying a pulse to S or reset directly (reset to Q=0) by applying a pulse to R. The $\overline{Q}$ output is always in the opposite state to (the logic compliment of) Q.

Two example D-type flip-flop i.c.s are the TTL 7474 and the CMOS 4013 devices, the pin-outs of which are shown in Fig. 12.9 (notice that there are two flip-flops per i.c. device). The operation of D-types can be better understood by constructing the circuit of Fig. 12.10 on breadboard and observing its action. Precautions must be taken, as outlined under Static Sensitive Devices below, when assembling this circuit because it uses CMOS i.c.s which are **sensitive** to static discharge.

Demo Circuit

The circuit uses half (just one of the two flip-flops) of a CMOS 4013 device to demonstrate the "flipping to the high state and flopping to the low state" action of the flip-flop. The push-button switch S when first activated turns the l.e.d. on, the next depression turns it off, the next turns it on again – and so on. The l.e.d. is wired to illuminate when the Q output is high.

When power is first applied to the circuit, C1 charges through R1 to provide what is called a *power-up-reset* pulse to the flip-flop's *reset direct* pin. This technique is very often used in digital circuits to force sequential devices to a known state when power is switched on.

The power-up-reset pulse can be seen by connecting the probe of an oscilloscope or logic probe to pin 4 of the i.c. before applying power to the circuit. The *set direct* input of the 4013 is not used in this application so it is connected to 0V (we say the input is tied low: all the unused inputs of CMOS devices must be tied high or low, otherwise they can cause undefined output levels).

Now, since Q has been reset (Q=0), $\overline{Q}$ must be high ($\overline{Q}$=1). $\overline{Q}$ is wired to the D input pin, so, on the next pulse to the clock input at pin 3 (by depressing S), the high at D will be transferred to Q turning the l.e.d. on. When Q=1, $\overline{Q}$=0 so the D input is always in the opposite state to the l.e.d., waiting for the next depression of S to turn it off if it is on and on if it is off.

Debounce

The purpose of the two inverters in this circuit (Fig. 12.10) is to suppress the effects of the switch contacts vibrating (bouncing) when they first come into contact with each other. Without this "switch debounce" part of the circuit an undefined number of pulses, rather than the single one intended, will be applied to the CLK input and the circuits action will be unpredictable. You can remove the feedback link between pins 3 and 4 of the 4049 to show how the circuit reacts without the debounce.

The graphs in the diagram of Fig. 12.11 show what the signal looks like

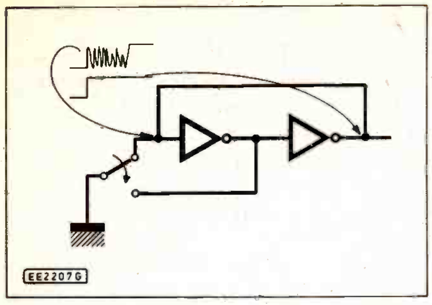


Fig. 12.11. Debounce circuit

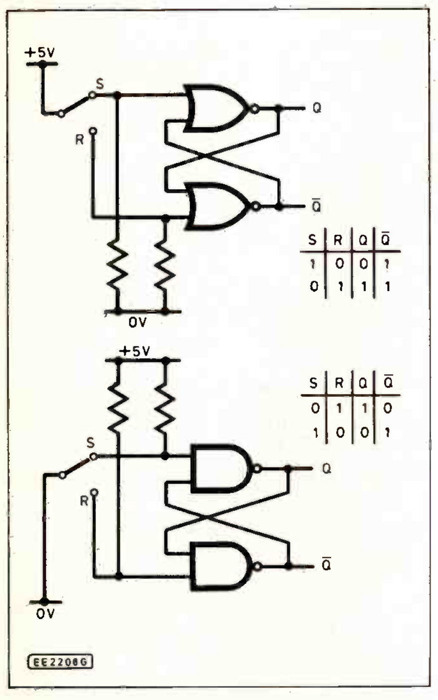


Fig. 12.12. Debouncing with flip-flops

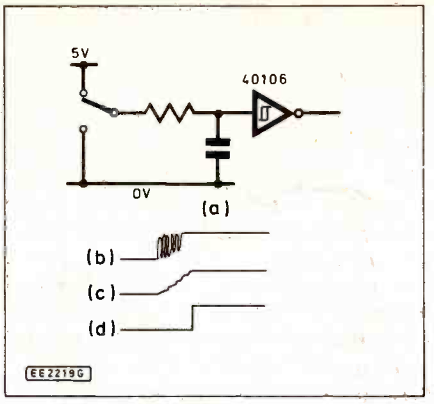


Fig. 12.13. CR filtering

at either side of the debounce circuit. As soon as the input switch changes state the output of the second inverter (2) feeds back to lock it in the state according to that switch position (the feedback acts like the relay circuit of Fig. 12.3), thus ignoring the spurious signals from the switch contacts.

R-S flip-flops can also be used for switch debouncing, as shown in Fig. 12.12. Connection of the "common" switch contact is either to 5V or 0V depending on whether the cross coupled gates are NAND or NOR.

There is another way of debouncing switches using a capacitor and a resistor. This method is shown in the circuit of Fig. 12.13a, the graphs in the figure show what the signal looks like before (b) and after (c) CR filtering. The superfluous pulses are smoothed out by the CR network and the CLK input of the flip-flop only sees the one pulse as shown in Fig. 12.13d.

Registers

A number of flip-flops can be grouped together to form a single storage unit, as shown in Fig. 12.14. Such a group of flip-flops is called a **register**, the purpose of which is to store a binary number. There must be one flip-flop for each bit in the binary number, so the 4-bit register in the diagram is capable of holding any of

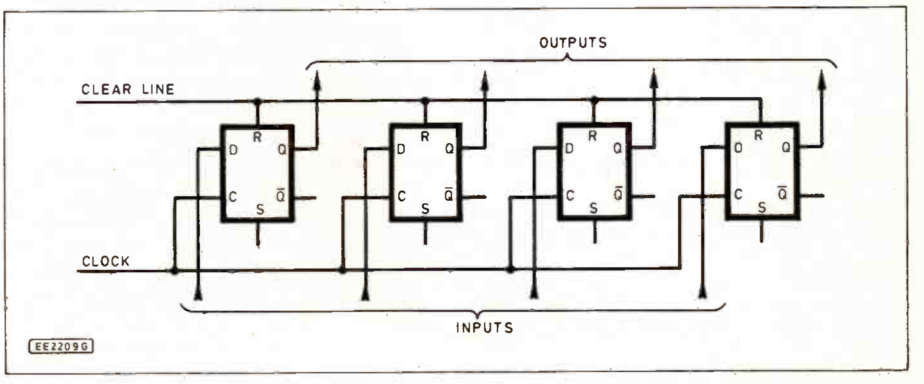
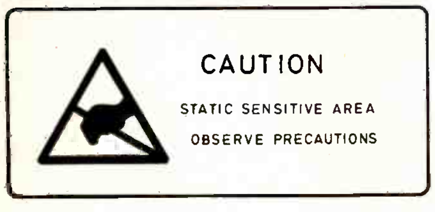


Fig. 12.14. Flip-flops wired to form a register



Static Sensitive Devices

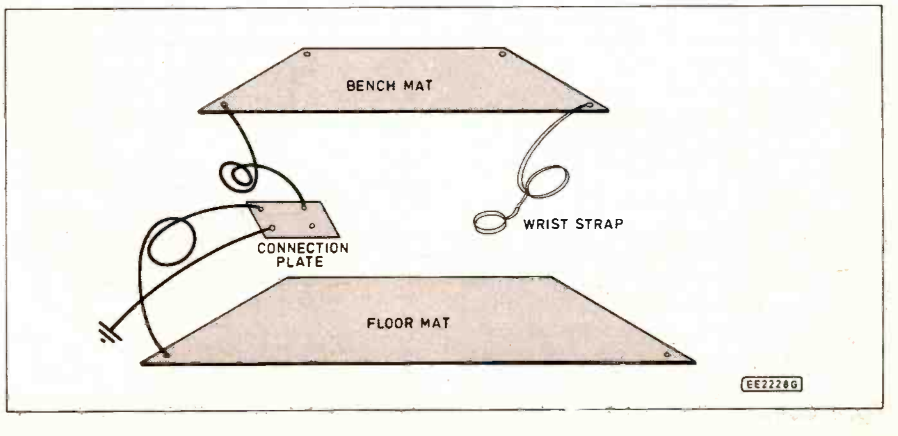
There are recommended handling precautions for CMOS integrated circuits (in fact all "metal-oxide semiconductor" [MOS] devices) because they are sensitive to static discharge. Anything greater than 100V can damage the oxide insulating layer inside these devices. If the handler is charged up with static electricity (by, say, synthetic carpets) with respect to the bench surface, voltages much greater than this can be generated and discharged through the i.c. chip.

The protection of static sensitive devices is taken very seriously in industry. Special areas are often set up where anyone handling MOS components are connected (by conductive wrist straps) to a ground point. Work-benches, tools and soldering iron tips in the SHA (Special Handling Area) are also connected to earth and devices are stored and transported in conductive material so that all their exposed leads are shorted together.

Typical SHAs contain work-areas equipped with the special mats and straps shown below. Precaution areas are usually indicated by the Static Sensitive Area standard symbol (also shown).

Of course, the student/hobbyist is not expected to take these kind of precautions; after all, the worst that can happen is a damaged i.c. It is important in industry because companies will not, understandably, compromise the performance or reliability of their products.

It is possible to handle i.c.s without ever touching the leads (only handle the plastic [or ceramic] package). If you remember to do this, and *not* to remove i.c.s while the power is applied, you will probably never damage a device.



sixteen (2^4) binary coded values: any number, including zero, up to the value of denary 15.

The four-bit binary number is applied to the four D inputs of the register and then a pulse is applied to the four CLK pins to store (latch) them. Each bit of the number can be applied to the D inputs at different times providing the intended bit pattern exists at the instant the CLK pulse arrives. *Please relate this to the PencilBox latch exercise (Exercise 4) of Part 6.*

There are two methods for entering binary numbers into registers. The first is the above method of presenting all of the binary digits of the binary number for latching at the same time, thus (in the above case) sending the information down four lines (conductors). The second method sends the information one bit at a time down a single line. The former method is said to transmit in *parallel* fashion and the latter in *serial*.

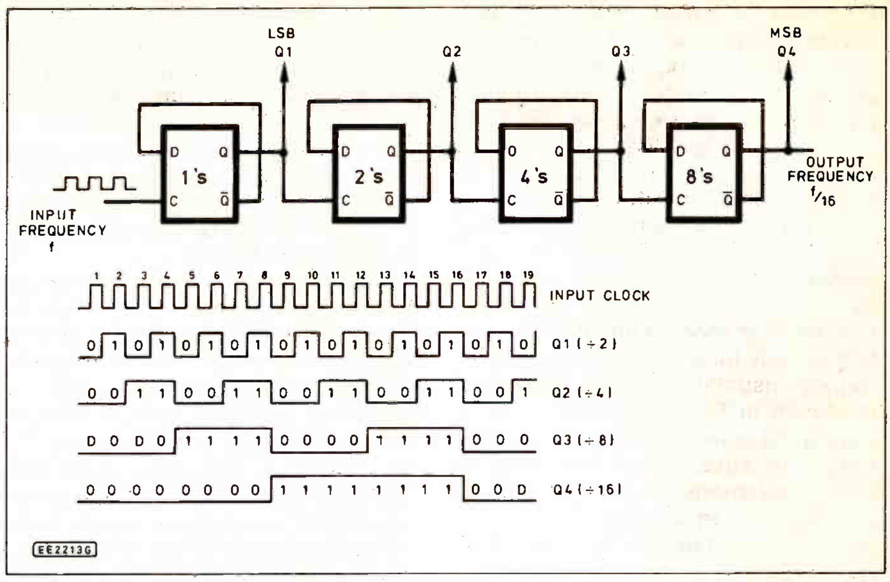


Fig. 12.18. A shift register

We will be looking at a serial configuration for the flip-flops in the above register shortly, but first we need to know something about the generation of digital waveforms.

Binary Signals

We have looked at various electronic signals in previous parts. Although we did look briefly at the difference between digital and analogue signals in Part 1, most treatment of the subject emerged in Parts 4 and 5 when we investigated the measurement of (mainly) analogue signals, such as sine and triangle waveforms.

Digital waveforms are very much simpler than analogue waveforms. Digital signals correspond to two voltage levels, so a typical digital waveform, as shown in Fig. 12.15, moves up and down between two voltages to represent a series of binary "0"s and "1"s. This particular waveforms might have been produced by the clock generator (oscillator) circuit in Fig. 12.16.

A clock generator is required in any digital circuit that needs to test, indicate, record, time or otherwise *do* something automatically. Computers, calculators, digital watches, and industrial controllers all have a master clock to control and determine when events must occur. There are many widely used oscillator designs depending on the specific requirements of the circuit that the clock is to drive; for example, the frequency and duty cycle specification.

An infinite number of digital waveforms can be derived from the

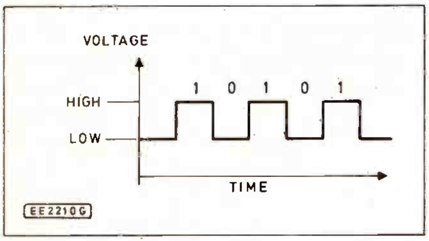


Fig. 12.15. A typical digital waveform

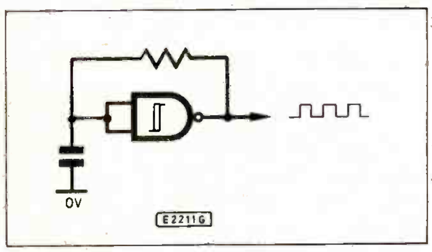


Fig. 12.16. A clock generator

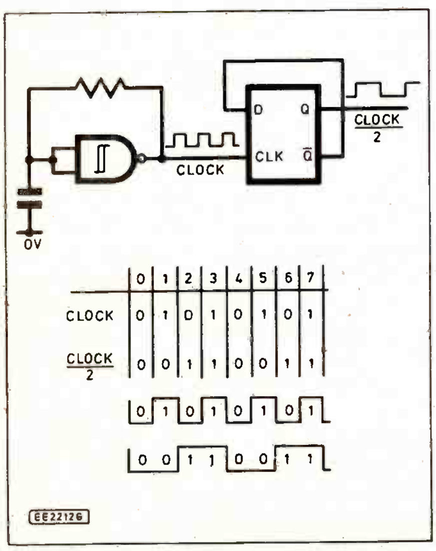


Fig. 12.17. Frequency division

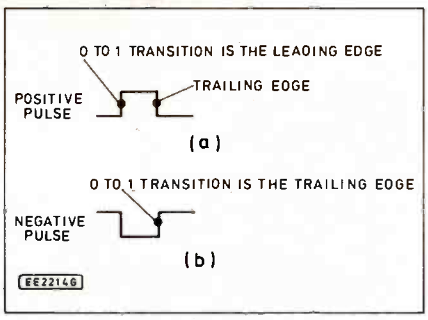


Fig. 12.19. Leading and trailing edges

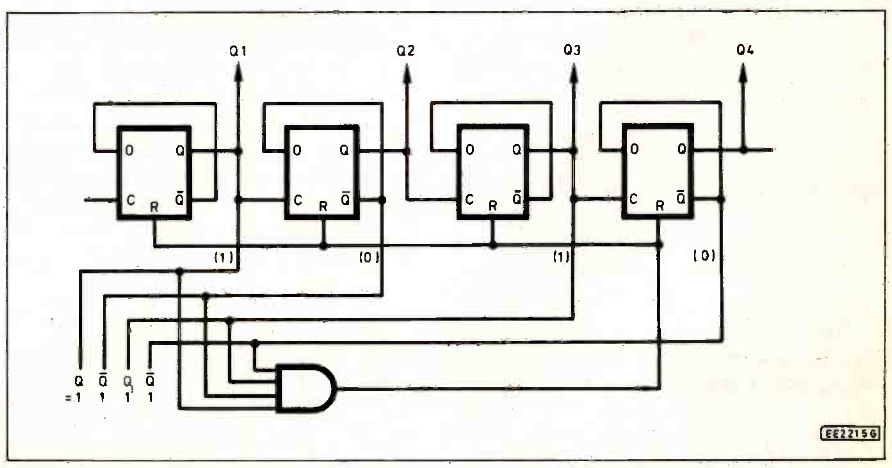


Fig. 12.20. Resetting the counter at 1010

master clock; for example, a simple flip-flop configuration (the same configuration as in experimental circuit above) can divide the number of clock pulses (the clock frequency) by two. As shown in Fig. 12.17, these sequences of states can be interpreted as serial binary information.

If, by the same means, we divide by two the signal that is already divided by two, and then divide that signal by two — and so on, we end up with a register that accepts binary information serially (one bit at a time). Such a register, usually called a shift-register is shown in Fig. 12.18 along with a timing diagram showing the binary output voltages. Please note that this diagram demonstrates a very important application of registers; that is, the conversion of data from serial to parallel form.

The shifting of data in and out of sequential devices is initiated by the change between logic levels (known as the *transition*) of the clock input. There are two transitions for each clock pulse: there is the 0 to 1 or "positive edge" transition and the 1 to 0 or "negative edge" transition. If the clock pulse is positive going, as in Fig. 12.19a, the so called *leading edge* is the 0 to 1 transition and the *trailing edge* is the 1 to 0 transition.

For a negative going pulse the opposite is true, the 1 to 0 transition will be the leading edge and the 0 to 1 transition will be the trailing edge, as shown in Fig. 12.19b. Before the exact operation of a sequential device can be determined, then, the i.c. manufacturers timing specification for the device must be consulted.

Shift registers are available as MSI devices classified into four distinct groups:

(a) *Parallel-in/Parallel-out*, where all the data bits are shifted into the flip-flops at the same time and, when output is required, shifted out all at the same time.

(b) *Parallel-in/Serial-out*, where all the data bits are shifted into the flip-flops simultaneously and, when output is required, shifted out one bit at a time under clock control.

(c) *Serial-in/Parallel-out*, where the register is loaded serially and, when output is required, the stored data is shifted out of the flip-flops simultaneously.

(d) *Serial-in/Serial-out*, where all the data bits are shifted in and out of the register one bit at a time.

Shift registers can be used for the temporary storage of data, for serial to parallel data conversion, for parallel to serial data conversion, and a variety of other functions including, as we are about to see, for counting applications.

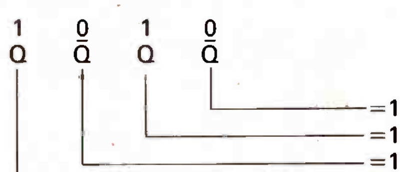
Counters

The shift register of Fig. 12.18, as it stands, is a simple four-bit binary *ripple counter*. This *4-bit binary ripple counter* generates a sequence of binary numbers: it accepts serial binary data at its input and propagates (ripples) through the sequence of parallel binary numbers, from LSB to MSB, at its output.

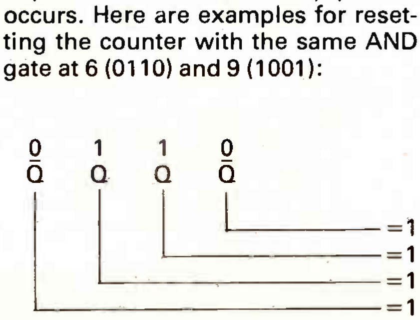
The binary waveforms produced by the ripple counter, as shown in the figure, are the input clock divided by 2, 4, 8 and 16 which, when taken in the context of the positional weight or *place value* of a digit within the binary number (last month), represent the columns 2^1, 2^2 2^3 and 2^4 respectively. We call this an *up-counter* because it counts from LSB to MSB, but it can easily be transformerd into a *down counter* by connecting all the $\overline{Q}$ outputs (instead of the Q outputs) to the succeeding clock inputs of each flip-flop.

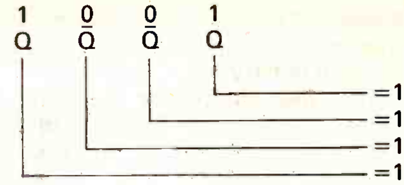
As shown by the binary waveforms in the figure, the up counter will continue to count from 0000 (assuming a power-up-reset) to 1111 in repeating cycles for as long as the input clock pulses are maintained. It is, however, a simple matter to modify the counter to reset to 0000 after any number by adding a logic gate to trigger the reset direct inputs at the desired binary number.

The AND gate in Fig. 12.20, for example, resets the counter at 1010 (denary 10). The R input is active high and requires a 1 to clear the Q output to 0 and the output of the AND gate is connected to all of the R lines. The AND gate requires all its inputs to be 1 to produce a 1 output and 1111 is achieved at 1010 by connecting the gate inputs to the $\overline{Q}$ outputs for the 0 bits in the number, thus:



What we have done here is to select a unique binary pattern – the binary pattern that corresponds to the number at which we want to reset the counter – and gated it such that it activates the reset lines of the flip-flops whenever that binary pattern occurs. Here are examples for resetting the counter with the same AND gate at 6 (0110) and 9 (1001):





This resetting after n counts gives rise to the name *divide by n counter*. The frequency of the clock at the output of the last flip-flop is the frequency of the input clock divided by n.

Decoders

The AND gate that performs the reset at n counts, above, is in fact operating as a **decoder**. It decodes the binary number at which the counter is reset. An extension of the same decoding operation, as shown in Fig. 12.21, converts the binary outputs to decimal.

This type of decoding is called BCD (Binary Coded Decimal) to Decimal Decoding and it is so common in digital circuits that special-purpose devices are manufactured to fulfil the function. One commonly used device is a *4-to-10 line decoder* which has four input lines and ten output lines, as shown in Fig. 12.22. If the inputs are A=0, B=0, C=0 and D=0 then the output marked 0 will be at logic 0, as shown in the truth table.

Another decoder in widespread use is the *BCD to 7 Segment Decoder*. Seven segment displays are those used in digital multimeters, calculators and many other systems which feature digital readouts. These displays are arranged into seven separate segments which can be individually illuminated to form decimal numbers. This idea is illustrated in Fig. 12.23 where combinations of the segments a-f are illuminated to form the digits; for example, 0 is formed by illuminating all the segments except g, 1 is formed by illuminating segments b and c, and so on as shown by the truth table.

The basic principle behind the formulation of a simple denary number generator using a counter, BCD to seven segment decoder/driver, and a seven segment display is shown in Fig. 12.24.

Of course, all of the sequential functions that we have described throughout this article are available in MSI integrated circuit form and many designs use these devices extensively. It is sometimes feasible to use SSI devices in place of an MSI equivalent; however, the increased number of external connections required to do so can increase the size and complexity of the circuit, and generallly reduce overall reliability.

In addition to the flip-flops, registers, counters and decoders discussed in this last part of the series, there are other MSI implementations such as encoders, multiplexers, demultip-

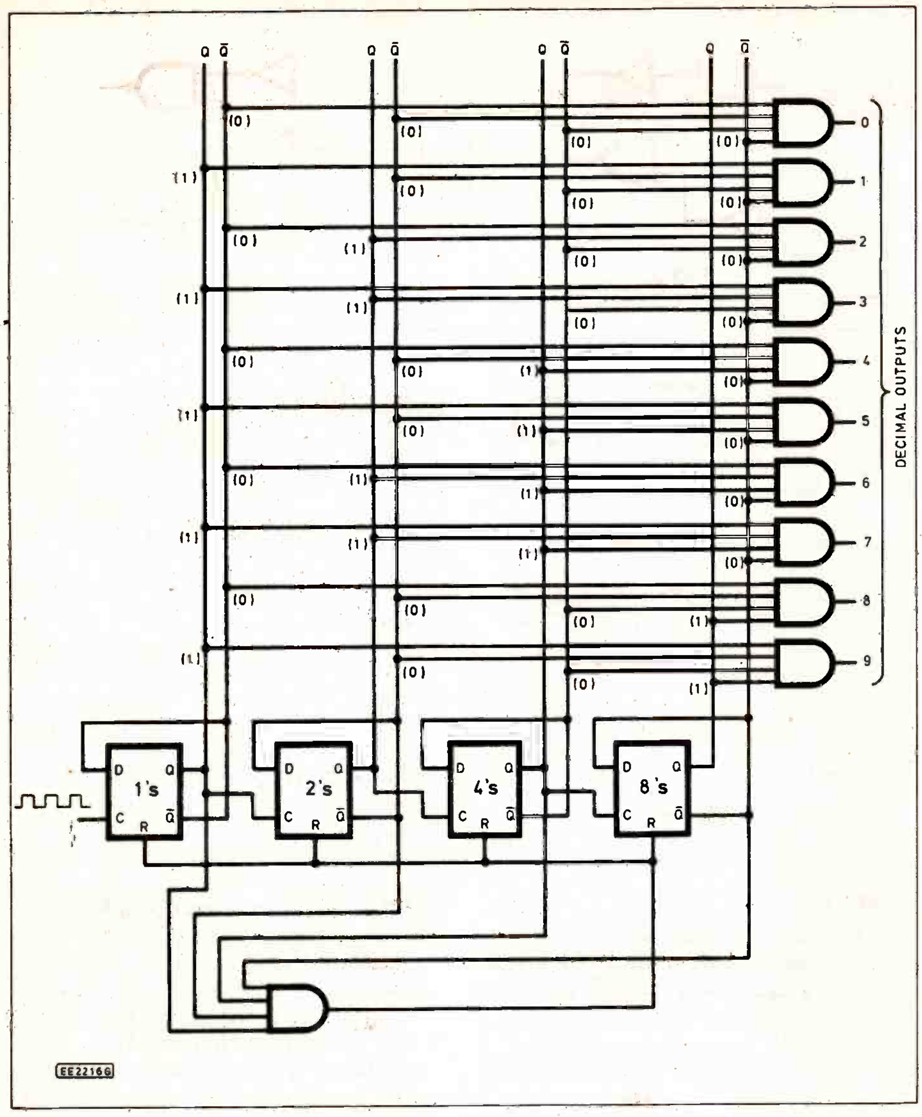


Fig. 12.21. Binary to decimal decoder

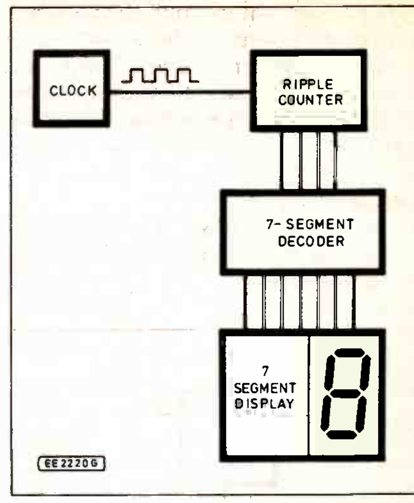


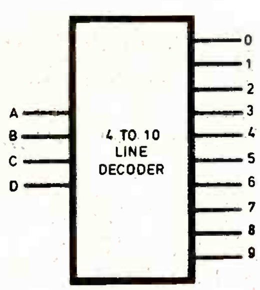
Fig. 12.24. A simple denary number generator

lexers, comparators and arithmetic circuits that are beyond the scope of the course.

A Final Word

We have come a long way since our first steps into electronics in Part 1 almost a year ago. Even so, we have only scratched the surface of digital electronics and we hope that the course will encourage you to study more advanced and specialised reading matter on the subject.

In the twelve articles of the series we have only deviated from the syllabus in areas where, in our opinion, it made learning easier or more interesting. The set questions and exercises at the end of each lesson, however, have not at any time departed from what is required for

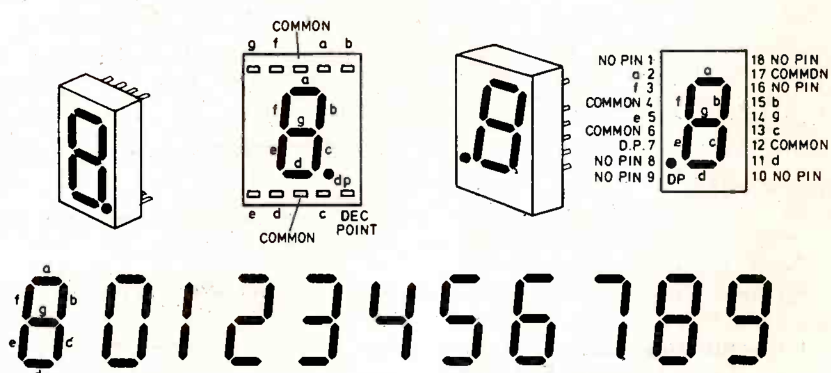


TRUTH TABLES

D	C	B	A	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	1	0	0	0	0	0	0	0	0	1	0
0	0	1	0	0	0	0	0	0	0	0	1	0	0
0	0	1	1	0	0	0	0	0	0	1	0	0	0
0	1	0	0	0	0	0	0	0	1	0	0	0	0
0	1	0	1	0	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	0	1	0	0	0	0	0	0
0	1	1	1	0	0	1	0	0	0	0	0	0	0
1	0	0	0	0	1	0	0	0	0	0	0	0	0
1	0	0	1	1	0	0	0	0	0	0	0	0	0

EE22176

Fig. 12.22. A 4 to 10 line decoder



TRUTH TABLE

DENARY DIGIT	BINARY CODE				OUTPUT SEGMENTS(1=ON) a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

EE22186

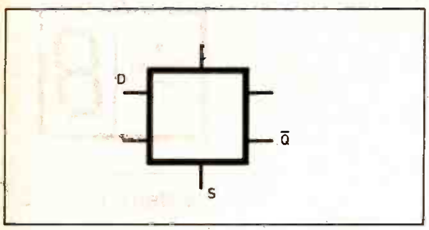
Fig. 12.23. Operation of a seven segment display

self-assessment of your comprehension of the course material only.

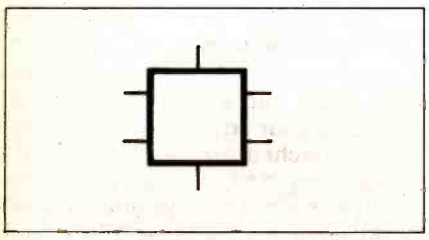
Thankyou for staying with us throughout the course and, for those of you taking the examination, good luck!

Questions

1. Enter the three missing input labels into the D-type flip-flop symbol below.



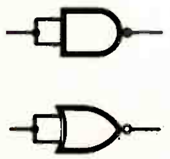
2. Connect up the following D-type flip-flop as a divide-by-two frequency divider.



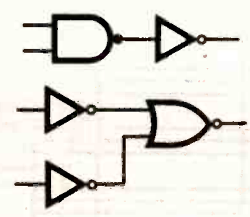
3. Explain the difference between combinational and sequential logic.
4. Explain the operation of the D-type flip-flop.
5. Is the denary number generator of Fig. 12.24 a combinational or sequential circuit. Give reasons for your answer.
6. After completing Exercise 1, below, describe your observations with regard to all of the gate arrangements.

Exercises

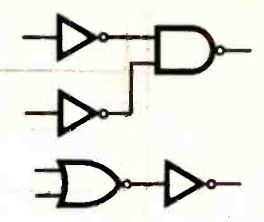
1. Construct all of the gate arrangements in Sets 1 to 4 below on a logic tutor and draw a truth table for each. Note that one of the arrangements (as marked*) forms the larger part of the binary half-adder needed for Exercise 2 below; you may wish to build this last.



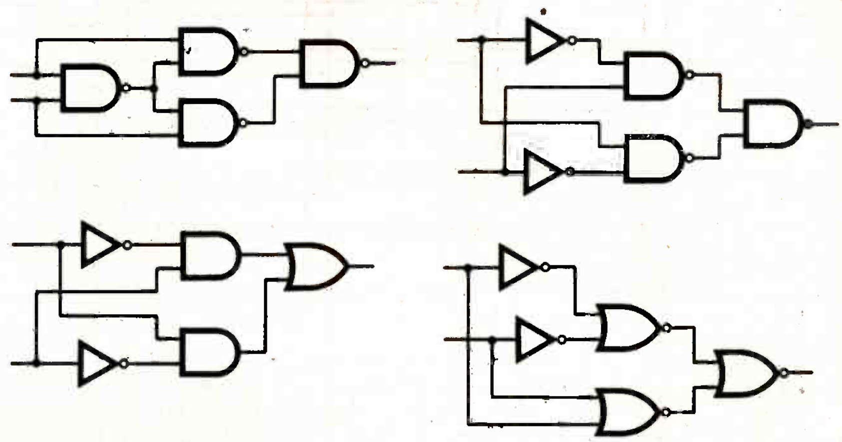
SET 1



SET 2



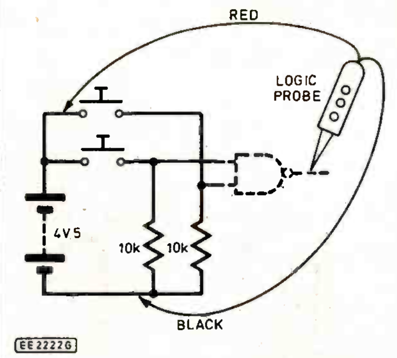
SET 3



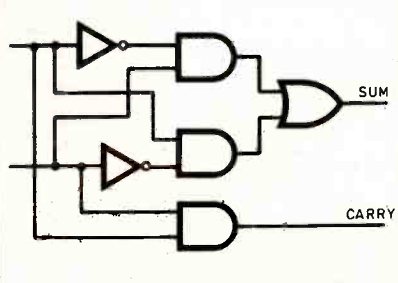
SET 4

Note.

If you do not have access to a logic tutor use the following circuit and an oscilloscope, meter or logic probe for this exercise.



2. Construct the following binary half-adder circuit and verify its operation (an explanatory note follows).



The binary Half-adder

The binary half-adder is used in calculators and computers. This is a basic arithemetic circuit and is easily extended to perform subtraction, multiplication and division.

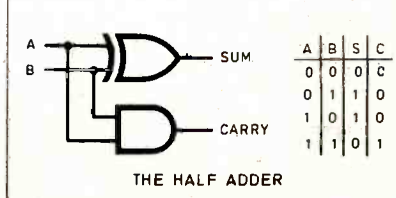
The half-adder is capable of adding two one-bit binary numbers together:

0	0	1	1
0+	1+	0+	1+
0	1	1	10

The carry in the last sum is performed as in normal arithmetic but (as explained last month) after 1 instead of after 9. We can transfer this series of sums into a truth table.

A	B	Carry	Sum
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

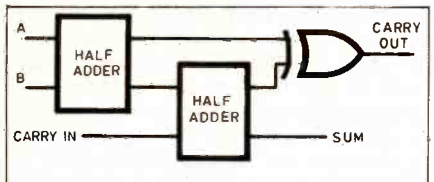
Look at last month's Table 11.7 and determine which basic gate performs the carry function (0001) and which performs the sum function (0110). It is the AND gate and the EXOR gate respectively. Put the two gates together, thus:



THE HALF ADDER

and we get the binary half-adder (the half-adder you constructed uses a combination of basic gates [as directed by the C&G objective 7.1.3] for the EXOR).

For addition of binary numbers of more than one bit long, half-adders are connected together taking carries from the previous stage into account. Circuits which have carry-in and a carry-out are called full-adders:

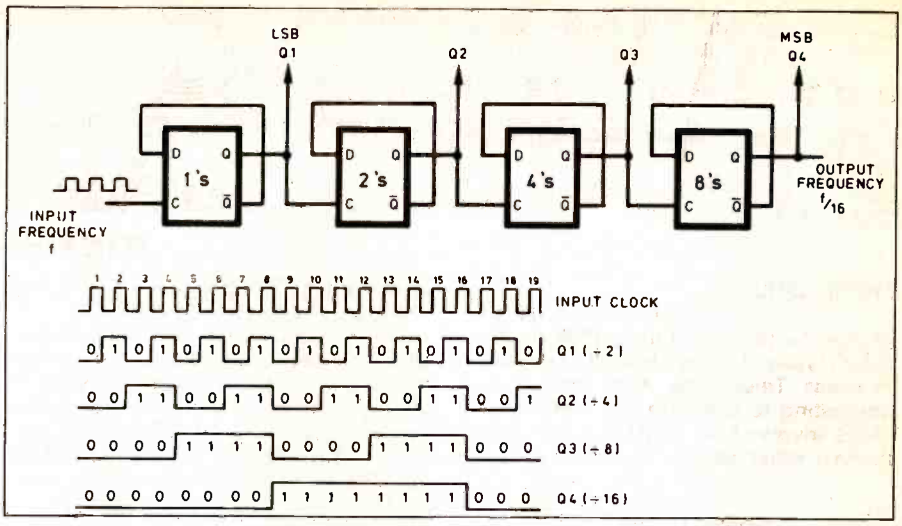


THE FULL ADDER

CIN	A	B	S	C
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

3. Construct the following up counter on a logic tutor using TTL devices and verify its operation. Connect the clock input to "clock out" on the interconnect socket and the common connected reset lines to a "pulser" push button. Connect the Q outputs to the "logic indicators".

Answers next month



ANSWERS TO PART 11

1. This is an EXOR arrangement:

A	B	OUT
0	0	0
0	1	1
1	0	1
1	1	0

2.

A	B	C	OUT
	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	1

3. OR
4. The i.c. is a "B-series" buffered device
5. 4.75V to 5.25V
6. 3V to 15V
7. 0V to 0.8V
8. 2V to 5V
9. Less than approximately:
   (a) 1.5V
   (b) 3V
   (c) 4.5V
10. Greater than approximately:
   (a) 3.5V
   (b) 7V
   (c) 10.5V
11. This is the equivalent of the EXOR gate — see answer 1
12. (a) 4.75V to 5.25V
   (b) 3V to 15V

...REPORTING AMATEUR RADIO...

TONY SMITH G4FAI

PROSECUTIONS

The DTI recently published a list of prosecutions made during 1988 covering all types of licence issued under the Wireless Telegraphy Acts, and it is interesting to compare the number of cases involved in amateur radio with those in other categories as follows:

Category	Prosecutions	Convictions	Warning Letters
CB AM	59	59	92
CB FM	47	47	589
Unlicensed Broadcasters	117	111	7
Cordless phones	6	6	73
PMR	15	15	104
Amateur	5	5	2
Marine	2	2	91
6.6MHz	5	5	-
Others	14	14	7
TOTALS	270	264	965

The five successful prosecutions relating to amateur radio involved four licensed amateurs (one class A and three class B) and one unlicensed operator. There were 28 offences in all and each defendant was convicted of a number of them.

These included communicating with an unlicensed station, failure to use a call sign when transmitting, failure to keep a log book as required by the regulations, monitoring of RAF communications, disclosure of US Navy aeronautical communications, aiding and abetting the use of, and using, an unlicensed transmitter attached to a helium balloon, deliberately interfering with a US Navy aeronautical network causing the network to go on alert.

Other "activities" included inciting others to illegally monitor certain radio frequencies by publishing a frequency list, monitoring of police communications and disclosing the content of these, aiding and abetting the use of a 6MHz unlicensed broadcasting station, and unlicensed use of an amateur radio station.

The defendants were fined a total of £8,750. Costs were awarded against them totalling £2,230 and a significant amount of equipment was forfeited. The licensed amateurs subsequently had their licences revoked.

Radio amateurs as a whole, are a reasonably law-abiding community who have to be familiar with the regulations, and are tested by examination, before they can obtain a licence. They are well aware that the practice of their hobby is a hard-earned privilege which can easily be taken away if it is abused.

PROJECT YEAR

Plans for the Radio Society of Great Britain's Project YEAR. (Youth into Electronics via Amateur Radio) are progressing well although its abbreviated name is rather misleading, suggesting a one year activity when it is really a long-term project aiming to increase the size of the amateur population.

The Society hopes to put its proposals for a new Student (Novice) licence to the DTI by mid-summer this year. It also plans to publish twelve small books to take the absolute beginner through the Student Licence course and to assist him/her in assembling low-cost kits as an introduction to the practical side of the hobby.

Realistically, it is felt that such a scheme to introduce amateur radio to beginners cannot succeed without a drastic reduction in the cost of starting off. The Society is therefore currently developing the necessary basic kits, and is encouraging others to do the same.

A recruitment video tape is to be prepared with professional (volunteer) assistance and a major TV company will be sponsoring post-production work to the tune of £150,000. TV weatherman, Jim Bacon, G3YLA, will act as linkman in the production, and ICOM UK Ltd will be sponsoring part of the cost of distributing the video to every RSGB affiliated club in the UK.

THAI UPSURGE

In contrast to the situation here, amateur radio is increasing in popularity in countries where it was previously seldom found except among foreign expatriates. In *Morsum Magnificat* last year a story by an Indonesian amateur described how, when formal examinations were introduced in 1981, only 10 per cent of the 2,000 entrants were successful, and how, by 1985 his own pupils were achieving a 90 per cent pass rate.

A recent report from Thailand is even more dramatic. Last August what was probably the world's largest radio examination took place when 15,732 prospective amateurs sat for the country's VHF licence. 9,513 candidates passed and joined the 3,500 plus "old hands" who have held their licences since the beginning of 1988.

There is a lot of concern among national societies around the world that the number of radio amateurs will decline in future years, hence the current emphasis by the RSGB and others in trying to interest the young in amateur radio. After hearing about the Thai experience I'm beginning to wonder if the main problem for amateurs in the future may not be diminishing numbers after all, but finding somewhere to squeeze in the bands as the hobby is discovered and taken up enthusiastically in other countries.

FREQUENCIES UNDER THREAT

It appears that a World Administrative Radio Conference (WARC) may be held in 1992 or 1993, earlier than expected. At such conferences, among other things, international frequency allocations for all users are agreed. In 1979 amateurs gained three new h.f. bands but it is expected that h.f. as well as v.h.f. allocations will be under pressure at the next meeting. There will undoubtedly be demands for more frequencies for commercial services and for the military who now recognise an increasing need for h.f. communications as a back up for vulnerable satellite defence services.

Although there are interntional allocations, national administrations can vary these if they wish. Last August, for example, the Federal Communications Commission (FCC) decided to allocate 2MHz of the 220MHz band, currently occupied by American amateurs, for commercial use by the giant United Parcel Service (UPS) who have already spent over $3M in setting up a narrowband radio service.

Feelings are running high in the amateur community as the FCC is accused of ignoring protests and submissions by the American Radio Relay League (ARRL), the National Communications System (set up by President Kennedy as a result of shortcomings in emergency communications during the Cuban Missile Crisis, and which includes the Department of Defence), the organisers of amateur emergency services who play a part in NCS, and over 5,000 individual protesters.

GOVERNMENT ENQUIRY

On May 11, according to *THE W5Y1 REPORT*, an amateur radio news report published in the USA, the matter came before a sub-committee of the Congressional House Committee on Government Operations whose brief was to look into charges that the FCC may not have followed proper administrative procedures; may have acted arbitrarily; and disregarded thousands of comments.

At the time of writing the enquiry remains open to enable witnesses to respond to written questions from the sub-committee and the outcome is uncertain. The report on the hearing makes fascinating reading, with NCS which meets the telecommunication needs of 23 Federal agencies, including the National Security Agency, the CIA and NASA, asserting that national security and emergency preparedness favoured retention of an amateur presence on the threatened frequencies.

ARRL's written evidence ran to 40 pages and UPS, in response, presented a bound book of evidence, complete with index, weighing nearly two pounds. One wonders if similar, very expensive, protests involving legal and public relations representation could be taken to such lengths in this country.

What is clearly demonstrated in all this is the need for a strong national society when amateur radio is threatened.

Pocket Money Project

FUSE TESTER

CHRIS BOWES

A simple, inexpensive and unambiguous method of checking the condition of your fuses.

ALTHOUGH a simple fuse tester can be made very easily by connecting a l.e.d., through a suitable dropping resistor, to a battery via the fuse under test the output does need a little bit of understanding (i.e. to work out that an illuminated l.e.d. means a working fuse). In order to both make the understanding of the result of the test easier and to make the project a little more interesting this circuit has been designed to produce an unambiguous result by using two l.e.d.s., one of which signifies a good fuse whilst the other signifies a blown fuse.

HOW IT WORKS

The Fuse Tester described here makes use of the operation of two simple operational amplifiers (Op.Amps.) used as comparators. All op. amps have an inverting and a non-inverting input. These are identified on circuit diagrams with a minus sign and a plus sign.

Normally op. amps are used with a feedback resistor between the output and the amplifiers inverting input. This is used to set the gain of the amplifier. If this "feedback" resistor is omitted then the amplifier has basically an infinite gain, limited only by the voltages of the power supply available to it.

The amplifier then amplifies the difference between the voltages available at the inverting and non-inverting inputs by a factor determined by the value of the feedback resistor. Because the infinite gain of an op. amp used without a feedback resistor, the output voltage swings from the most negative voltage available to the most positive voltage available depending upon whether the inverting input or the non-inverting input is at the higher voltage. In this project the voltage of the non-inverting input of both op. amps is set to half the battery voltage, so that voltage presented to the inverting input are used to control the operation of the op. amp.

CIRCUIT DESCRIPTION

The circuit diagram for the Fuse Tester is shown in Fig. 1. IC1a and IC1b are each one half of a CMOS operational amplifier type CA3420.

This integrated circuit contains two individual op. amps which are pin compatible with other dual op. amp integrated circuits. These particular op. amps are however designed to work from a single power supply, such as the 9V battery which we are using for all of the "*Pocket Money*" projects.

Resistors R1 and R2 are used to set the input voltage to the non-inverting input of IC1a (pin 2). Because they are of equal value the voltage available at pin 2 is approximately 4.5V (50 per cent of the battery voltage). Similarly resistors R5 and R6 are used to set the voltage at the non-inverting input of IC1b (pin 7) to 4.5V.

IC1a is used as a comparator to detect whether the voltage at its inverting input (pin 1) is at a higher or lower voltage than the reference voltage at the non-inverting input. Resistor R3 is used as a pull up resistor which sets the voltage at pin 1 of IC1a to the battery supply voltage when the fuse under test is an "open circuit".

In this condition the voltage at the inverting input is greater than the voltage available at the non-inverting input. This causes the output voltage of IC1a to be forced to 0V.

If the fuse under test is in good condition it presents a "short circuit", which causes the voltage available at pin 1 of IC1a to be "pulled down" to 0V. In this condition the voltage at the inverting input is less than the voltage at the non-inverting input and the output of IC1a is forced to the battery voltage.

This allows a current to flow through D1, and its associated series resistor R4, and D1 glows. Resistor R4 is included in this circuit to limit the current flowing through D1 to its safe value of approximately 10mA.

The second stage, IC1b acts as an inverter in that if the output from IC1a is at 0V then the voltage at the inverting input of IC1b (pin 6) is less than the voltage at the non-inverting input (pin 7). This causes the output of IC1b to rise to the battery voltage causing a current to flow through D2 in the same way as does the current through D1.

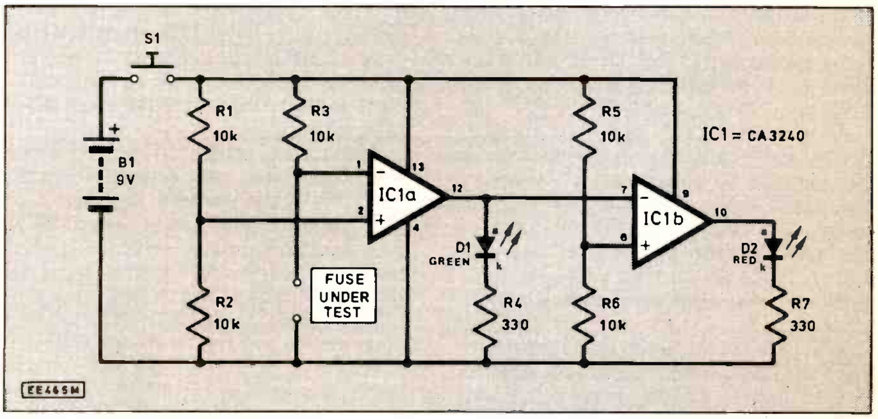


Fig. 1. Complete circuit diagram for the Fuse Tester.

If the output from IC1a is at the battery voltage this causes the input voltage at the inverting input of IC1b to be greater than the voltage at the non-inverting input. This causes the output voltage to be at 0V and no current can flow through D2. The effect of this arrangement is that D1 is illuminated when the fuse under test is sound and D2 is illuminated when the fuse under test is blown.

Switch S1 is a push-to-make type which is incorporated in the circuit so that the circuit only becomes active when S1 is operated. This reduces battery wear by making sure that the battery is only used when a fuse is actively being tested.

CONSTRUCTION

The Fuse Tester is constructed on a piece of stripboard and the component layout and breaks required in the underside copper tracks is shown in Fig.2 and the photographs. You will probably find it useful to look at these whilst you are constructing the project.

The first stage of construction is to cut a piece of stripboard 20 holes by 20 strips. The four mounting holes shown in Fig.2 should be drilled in the board using a 4mm drill bit.

The next task is to carefully make the track breaks in the area where the integrated circuit is to be mounted, as shown in Fig.2. These can be made by using a stripboard cutter or alternatively a suitable size drill bit may be used. It is very important that these breaks in the tracks are made completely and that you ensure that there is not even the most minute trace of cconductive material left to bridge the sections between the broken tracks.

Once the board has been prepared then the components may be inserted and soldered into position. The operation of the circuit is not affected by the order in which the components are installed on the circuit board but you will find it easier to handle the board if the components are inserted in ascending size order.

The first components to be inserted are the four link wires shown in Fig.2. These links are made with insulated wire, which you will need to "tin", pre-solder, before installing. If you are using stranded wire you should carefully twist the exposed strands between your finger and thumb so as to make a neat compact end to the stripped wire before "tinning".

To install the wire link it is neccessary to count up or down along the edge of the board until you find the correct strip and then count along that strip until you find the correct hole where the link should be inserted as shown in Fig.2. Once you have found the correct place to insert the wire link then the prepared end should be passed through the appropriate hole on the board, the board turned over and the link soldered into place.

The next components in ascending order of size are the resistors. Insertion of these components is made easier if the leads are first bent at 90 degrees with a small pair of long-nosed pliers, at the correct places where they need to pass through the holes in the board as indicated in Fig.2. It is important when soldering any components onto a stripboard that the soldering iron should be left in contact with the component wire *and* copper track long enough for the applied solder to flow and make a good joint between the component and the connecting strip.

Now insert the i.c. holder and l.e.d.s in the position shown. Care should be taken with the i.c. socket to make sure that the notch on the holder points towards the top of the board as shown in Fig.2. This also applies to the l.e.d.s, you will find that the l.e.d. carries a flat on the otherwise circular base of the components; this flat is nearest to the cathode (k) connection, see Fig. 2.

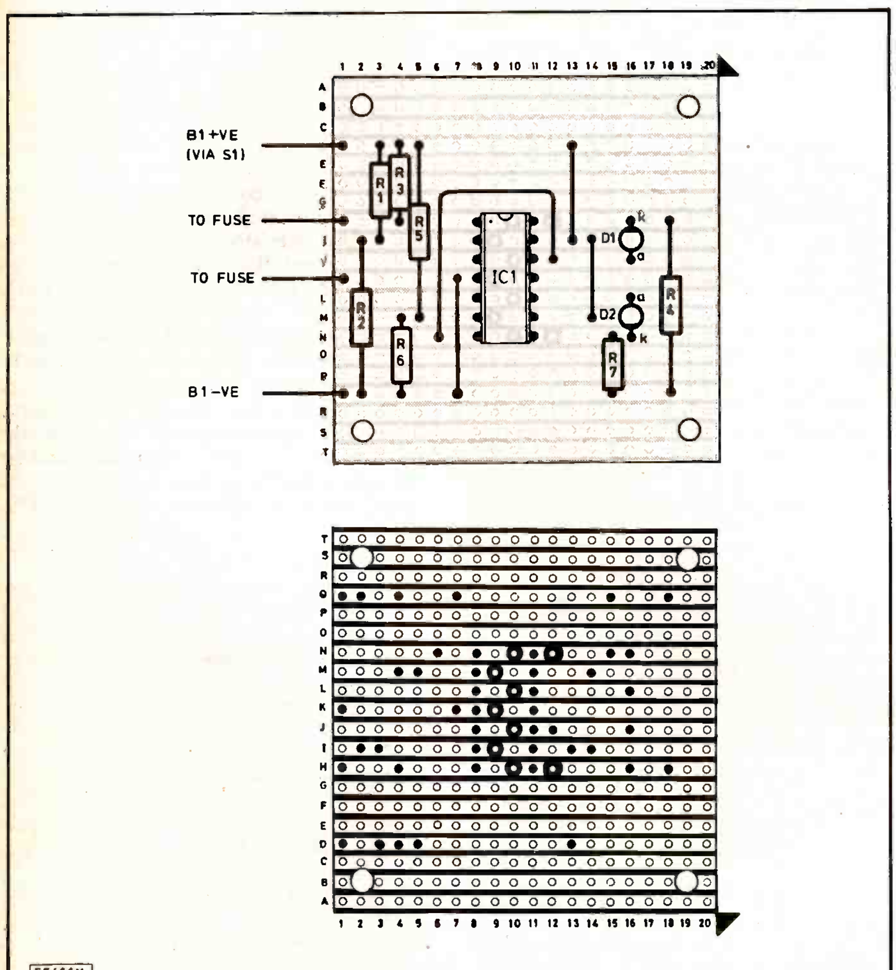
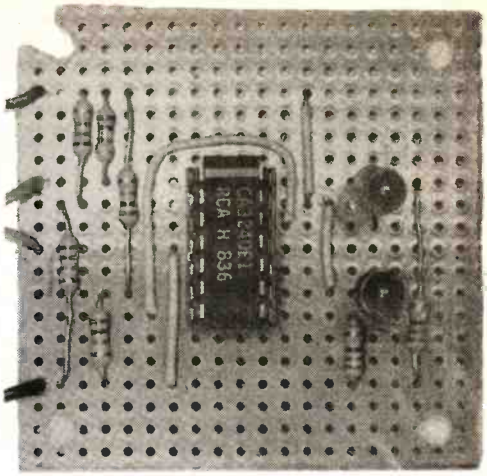


Fig. 2. Stripboard component layout and details of breaks required in the underside copper tracks.



Completed circuit board showing the four insulated link wires.

The final stage before inserting the integrated circuit is to connect the battery connections and the wires leading to the fuse carrier. The easiest way to connect the battery to the circuit board is to use a suitable battery connecting clip.

The red (positive) wire from the battery clip should go to one of the two connecting tags on the push-to-make switch (S1). Another piece of wire will be required to go from the other connection of S1 to the point marked B1 +Ve on the board, as shown in Fig.2.

The two connections to the fuse carrier are made with two wires terminated at the points marked "To fuse" on Fig.2. You will find it easier to make the connections to the fuse carrier "brackets" at a later stage if these wires are each fitted with a small solder tag prior to the other ends being connected to the board.

TESTING

Before connecting the battery and installing the board in a suitable case it is adsvisable to check the underside of the board to

COMPONENTS

Resistors
R1, R2, R3,
R5, R6 10k (5 off)
R4, R7 330 ohms (2 off)
All 0.25W 5% carbon

Semiconductors
D1 Standard green l.e.d.
D2 Standard red l.e.d.
IC1 CA3240E-1 Dual CMOS op.amp

Shop Talk
See page 578

Miscellaneous
S1 Single-pole push-to-make switch
B1 9V battery (PP3 type)
Stripboard, 20 holes × 20 strips; 14-pin i.c. socket; plastic case; self adhesive stand-offs (4 off); battery connector; solder tags (2 off); aluminium angle, for fuse carrier (see text); solder; connecting wire etc.

Approx. cost guidance only £7.50

ensure that there are no solder blobs shorting out adjacent tracks or breaks in the track where you do not wish them to occur. It is also advisable to check that IC1 and the two l.e.d.s. are inserted into the board with the correct orientation.

Assuming that all is correct here then the circuit should work as soon as the battery is connected and S1 is operated.

The test sequence, with the battery correctly installed, is to operate S1 with the two wires going to the fuse carrier held apart.

As soon as S1 is operated then D2 should light. When the two wires going to the fuse carrier are shorted together with S1 operated then D2 should be extinguished and D1 should light.

If the circuit does not operate as described above then it will be necessary to start fault finding. It is really impossible to fault find on this circuit without access to a d.c. voltmeter or alternatively a multimeter.

A simple meter will however be suitable for all the fault finding processes necessary for this circuit.

FAULT FINDING

The first stage in fault finding is to repeat the visual check described earlier in the testing section. If this visual inspection produces no signs of anything wrong with the construction of the circuit then it is advisable to check that the battery connections are the correct way round.

This will probably be most easily done by connecting the voltmeter across the strips carrying the positive and negative battery supply along the stripboard and pressing S1. If all is well with the battery and the connections then the voltage read on the voltmeter should be the same as that produced by the battery.

If no voltage, or a very low voltage, is measured across these rails when S1 is pressed then the positive probe of the voltmeter should be connected to the contact on S1 which is connected to the battery. The battery voltage here should be the same as that produced by the battery irrespective of whether S1 is depressed or not.

If the battery voltage is present when S1 is not operated but disappears when S1 is pressed then this indicates that there is a short circuit on the stripboard and this should be examined carefully, especially the area around IC1.

If this inspection produces no enlightenment then IC1a should be removed from its socket and the test repeated. If the removal of IC1 cures the problem then it would indicate that this component is faulty and it should be replaced.

COMPARATOR TESTS

Following on the fault finding procedure, check that the comparator formed by IC1a and its associated components is functioning correctly. If S1 is operated with an open circuit across the fuse carrier wires then the output from IC1a should be 0V.

When the two wires going to the fuse carrier are shorted out and S1 is operated then a voltage, approaching the battery voltage, should be measurable at pin 12 of IC1a. If this does not occur then the voltages at pins 1, 2, 3, 4 and 13 of IC1a should be checked.

The voltages at pins 1, 2 and 13 should be measured with the negative connection of the voltmeter connected to any contact of the 0V track. The voltage at pin 13 should be at the battery voltage for as long as S1 is operated. If this does not happen then the link between pin 13 and the strip carrying the Batt+ connection should be checked.

Now check the voltage between the positive battery input to S1 and pin 4 of IC1a. Again the battery voltage should be measurable when S1 is operated.

If either of these checks produced no voltage reading at all then it is necessary to check back along the connections to the stripboard, battery and S1 until you find the place where the battery voltage appears. The fault will be found to be immediately after that point.

With the voltmeter's negative probe connected to a suitable 0V point, the voltages at pins 1 and 2 of IC1a should be checked. The voltage at pin 2 should be approximately 4.5V. The precise voltage measurable at this point is not *critical* as long as it is somewhere in the range between 3V and 6V.

If this voltage is not measurable or is considerably higher or lower than the range given then the potential divider formed by resistors R1 and R2 is the most likely cause of the problem. The voltage at the positive end of resistor R1 should be the battery voltage (when switch S1 is pressed) and 0V at the negative end of R2.

The voltage at the junction of resistors R1 and R2 should be approximately 4.5V and this voltage is connected, via the appropriate line on the stripboard, to pin 2 of IC1. If the voltage at the junction of R1 and R2 is considerably higher than 4.5V then it is most likely that the connection between R1 and R2 or that the connection of the 0V end of R2 are not properly made.

Similarly if the voltage at the junction of R1 and R2 is considerably lower than 4.5V then either the connection between R1 and R2 is faulty or the positive connection of resistor R1 to the positive power supply rail is faulty. In all of these cases it is advisable to check the quality of the joints, and if necessary, remelt the joints by applying the soldering iron once more at that point.

FUSE CARRIER

The voltage at pin 1 at IC1a is determined by the state of the two wires which connect to the fuse carrier. When two wires going to the fuse carrier are connected together pin 1 of IC1a is effectively connected to 0V. When the two wires going to the fuse carrier are *not* connected together then the current from the positive battery rail flows through resistor R3 to pin 1, causing the voltage at this point to be at battery voltage.

The voltage at pin 1 should be monitored under both of these conditions with S1 pressed. If the battery voltage at pin 1 remains at 0V, irrespective of whether the fuse carrier wires are shorted out or not then the fault is most likely to lie with the connections to resistor R3. If the battery voltage is always present at pin 1, irrespective of the connection or disconnection of the two wires going to the fuse carrier then the connections to the fuse carrier, via the wires and the appropriate strips on the stripboard should be checked carefully.

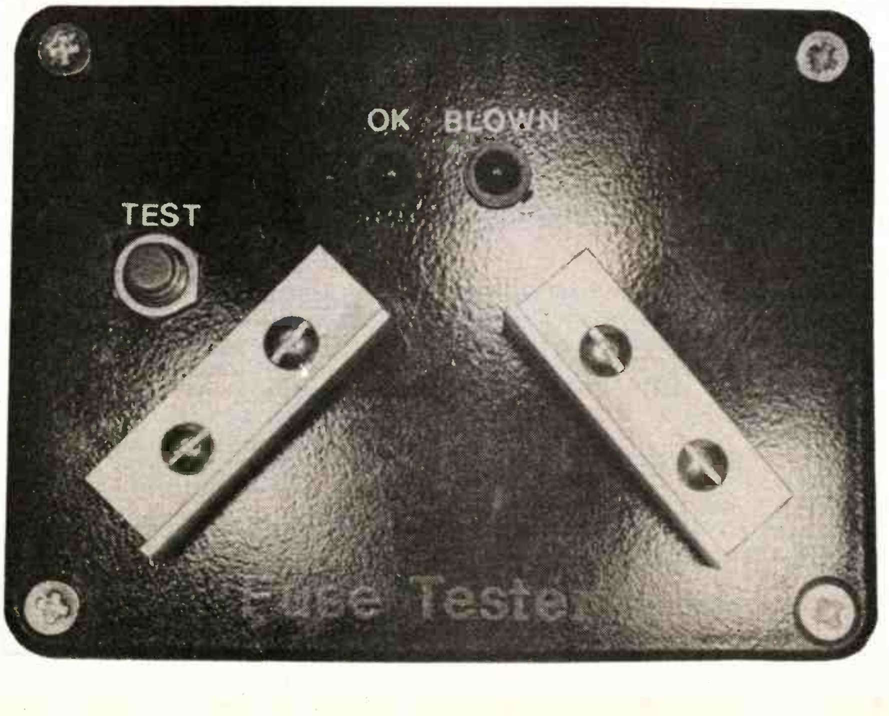
If all of these tests give the correct result then the output at pin 12 of the i.c. should be determined by the voltage measured at pin 1 of IC1a. If pin 1 is at 0V when S1 is pressed then there should be battery voltage present at pin 12. If pin 1 is at the battery voltage when S1 is pressed then the output voltage at pin 12 of IC1a should be approximately 0V.

If this does not occur then the connections to pins 12 and 6 of the i.c. and in the vicinity of D1 and resistor R4 should be carefully checked to ensure that there is no inadvertent short of the output of IC1a to 0V. If no short circuit is found then IC1a must be suspected of being faulty and should be replaced.

If an output voltage approaching the battery voltage is produced at pin 12 of IC1 but D1 does not light then the next stage is to check through the connections from pin 12 of IC1 to the anode of D1, from the cathode of D1 to resistor R4 and from R4 to the 0V line of the stripboard should be checked for continuity.

One of the most likely causes of the failure of D1 to illuminate is that it may well be connected in the wrong way round so

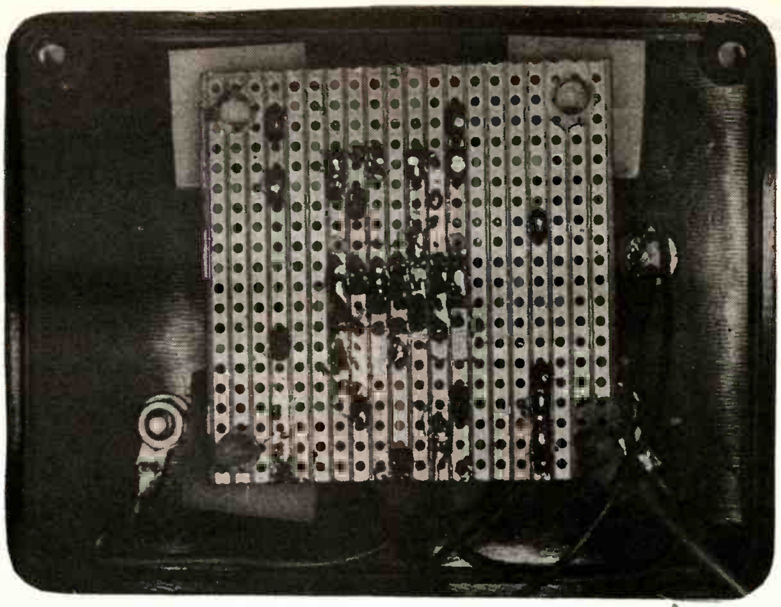
Completed Fuse Tester viewed from the top showing the l.e.d.s, push-to-test switch and the fuse carriers made out of aluminium angle.



the first stage of the fault finding is to make a visual check to ensure that the flat on the l.e.d.s base is adjacent to resistor R4. If all is found to be correct then an l.e.d. which is known to be working can be connected across D1, taking care to ensure correct polarity is maintained. If the substituted l.e.d. works then D1 should be removed and replaced.

If D1 illuminates correctly and D2 does not then the circuitry associated with IC1b should be checked in the same way as details for IC1a. The positive supply connection to IC1b is a separate one to that connected to IC1a so the voltage between 0V and pin 9 should be checked. When S1 is pressed the voltage measured between pins 4 and 9 of IC1b should be the battery voltage.

The second difference to check is that the voltage at the inverting input (pin 6) of IC1b is the same as that at pin 12 of Ic1a. This should be checked with a voltmeter and if the two voltages do not correspond then the connections between these pins should be checked. Apart from these differences IC1b can be fault found in the same way as IC1.



Underside of the case lid showing the circuit board mounted on self-adhesive plastic stand-offs and solder tags under the fuse carrier mounting nuts.

CASE

The fuse tester is designed to be mounted inside a case and for this reason the l.e.d.s. have been positioned so that the board can be mounted on the back of the case lid, with the l.e.d.s protruding through the front of the case. The fuse carrier has been designed to be made from two small pieces of aluminium angle strip drilled in such a way that they may be mounted on the front of the case as shown in the photograph. The two strips are mounted at an angle to each other, so that a number of different lengths of fuse may be tested.

The first task is to cut two pieces of one centimetre aluminium angle aprroximately three centimetres long. Two holes sufficiently large to accommodate the mounting bolts you intend to use should be drilled into one side of each of the pieces of aluminium angle.

Place the aluminium angle and the push to test switch (S1) in the lid of the case, taking care to ensure that there is sufficient space underneath the lid to accommodate the stripboard. Once appropriate places have been determined for the components these should be marked on the case and the holes of the correct size drilled.

You will notice in the photographs that the position of switch S1 is relatively close to one of the aluminium angles. This has been deliberately done so that one handed operation may be achieved by holding the fuse against the fuse carriers with two fingers and using the thumb of the same hand to operate the push-to-test switch.

Once the appropriate holes have been marked and drilled the case may be lettered with rub down lettering which may then be protected by the application of several layers of clear varnish. Once the varnish is dry carefully mount the fuse carriers with nuts and bolts, ensuring that there is sufficient clearance between the end of the bolt and board when mounted underneath the case.

The two l.e.d. clips should now be positioned in their appropriate holes in the case. The stripboard should be mounted on the underside of the lid in such a way that the two l.e.d.s fit into the two clips.

Ideally the board should be held in place by means of self-adhesive stand-offs. These should be placed, from the component side, in the holes drilled in the strip board to accommodate them. The protective backing should then be peeled off the sticky pads and the board carefully offered into place, ensuring the l.e.d.s fit through the holes in the case front.

When the position of the component board has been accurately determined then the sticky pads should be pushed firmly onto the surface of the case so that they stick firmly on the case lid. Once the pads are in place then the board should be carefully removed and the connections made to the two fuse carriers.

If solder tags have been attached to the end of the two wires which connected to the fuse carrier then connection becomes simply a matter of placing the solder tag of one of the wires underneath one of the two bolts holding each of the two fuse carriers. Switch S1 can also be installed and the wire connections made to it, at this stage.

The final stage of fitting the project into its case is simply a matter of placing the rings which secure each of the l.e.d.s in to its clip, around each of the two l.e.d.s and offering the stripboard into its position on the already attached stand-offs. Care should be taken to ensure that the l.e.d.s fit neatly through the two clips already installed in the case before sliding the securing rings around the base of the clip to lock them into position.

The battery can then be attached to the battery clip and the circuit checked for correct operation, as described above. This check should, of course, be carried out before fitting the back of the case onto the lid and securing the lid to the case with the four fixing screws.

IN USE

The Fuse Tester is very simple to use. All that is necessary to do is to place the suspect fuse so that it makes good contact with the two strips of aluminium angle, which form the fuse carrier, and press the test button (S1). One of the two l.e.d.s should illuminate indicating whether the fuse is sound or not. □

PLEASE TAKE NOTE

EE TREASURE HUNTER

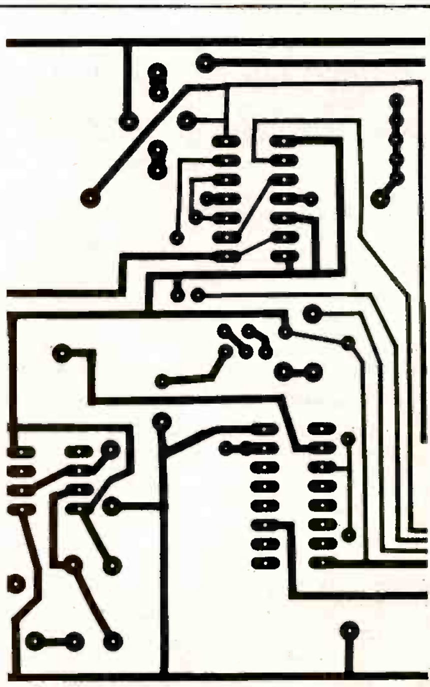
(August '89)

In Fig. 3 the two capacitors close to IC1 are incorrectly designated, C3 should be C4 and C4 should be C5.

LIGHT SENTINEL *April 1989*

Page 233, Fig.2. Pin 13 of IC5 should be connected to Pin 1 of IC5, NOT as shown. Pin 3 of IC5 should only connect to Pin 5 IC5 and Pin 13 of IC4. The circuit diagram should show IC5 as a NAND gate.

The "master control" printed circuit board copper track (Fig.5), page 235 should be amended as shown in the diagram:



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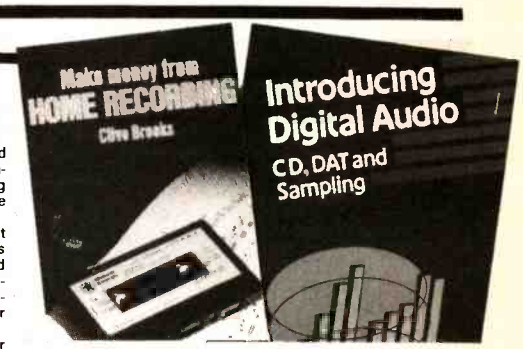

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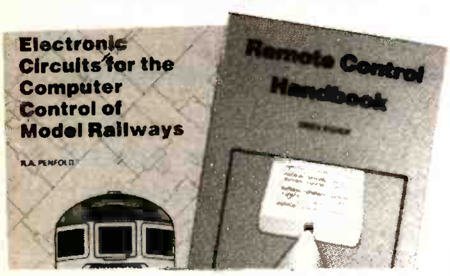

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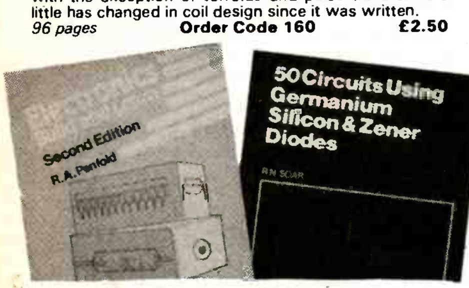

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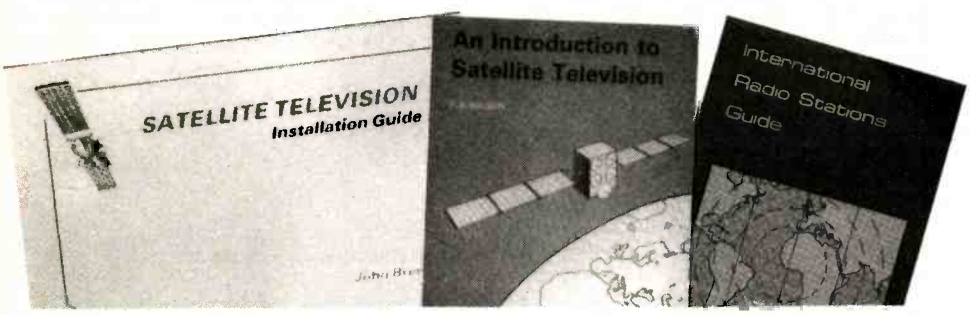

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NIGEL CLARK

RESOURCES

The question of adequate resourcing is left unanswered in the final report of the Design and Technology Working Party of the National Curriculum Council. After making special mention in its interim report of the need for sufficient resources being available to cover training and extra equipment, no direct reference is made to it in the final report.

There are some references to possible problem areas but it seems anxious to downplay their seriousness. For example in the interim report it was thought there would be a need for considerable in-service training "on a scale outweighing that for other foundation subjects" to help teachers used to working within their own specialisations adapt to design and technology which draws expertise from a wide range of subjects. However in the final report, although still saying that there would be a need for training "which helps teachers to become familiar with the different emphases which are possible in design and technology" it is thought that much of the training could be done on the job with experienced teachers passing on their knowledge to others.

IT

In the area of information technology (IT), on which the working party was also asked to advise, it felt the need to limit the levels of expertise which pupils could achieve because of the wide spread of knowledge of teachers and level of equipment provision. "We have borne these factors in mind in preparing our recommendation which we consider within the reach of all schools."

However, the report added that it was expected that the recommendations would have to be revised in the near future because of the rising level of teaching expertise and increased provision of equipment. How this was to be achieved without extra money was not mentioned, bearing in mind that the present situation had been reached despite Government sponsored efforts to increase the level of equipment in schools over a number of years.

The response of Kenneth Baker, Secretary of State for Education, to the resource question posed in the interim report appeared to be that there were sufficient funds to meet the introduction of the subject and be reviewed "in the light of experience" later.

"Support of this kind will be available through education support grants and through the LEA training grants scheme, while the phased introduction of attainment targets and programmes of study will enable the Government to monitor the resource implications for later stages of implementation".

LINKS

Another area which could affect the benefits to be gained from the subject is the links with industry. The report said: "We consider that strong permanent links are needed between schools and industry for the full potential of work-related activities to be realised at the least cost and with the greatest benefit to both parties".

It was also noted that while the present state of affairs was impressive in many respects, lack of coherence and fragmentation in developments was a cause for concern. And there has been recent concern that industry has not been taking as much interest in education as might be wished. Some companies had built up good links but others were reluctant to do anything in this area.

The working party was set up to advise on the setting of attainment targets and programmes of study to be achieved in the design and technology and linked information technology sections of the National Curriculum, which would be introduced into schools in autumn 1990. It was also to look at methods of assessment at 7, 11, 14 and 16 years.

Commenting on the potential of the subjects, the introduction to the final report said that their inclusion was a recognition that the capability to investigate, design, make and appraise was as important as the acquisition of knowledge. The skills learnt would be important to children personally but would also be an essential condition for the future prosperity of business and industry.

"We have been particularly concerned to formulate a curriculum which meets the requirements of the 21st century. It must contribute to pupils' economic and careers awareness but it must avoid narrow vocationalism. It must stimulate originality, encourage enterprise and emphasise quality. It also needs to help pupils to develop a flexible approach to the problems and opportunities they will face in a rapidly changing society."

The report added that activities should be undertaken in a balanced range of contexts including home, school, recreation, community, business and industry.

In the responses to the interim report, quoted by the working party, there was said to be strong support for this broad approach but there were a number of specific suggestions for improving particular areas. As a result there had been a number of adjustments, the main one being the reorganisation of the five attainment targets for design and technology into four.

CRAFTSMANSHIP

A number of comments stressed the importance of developing craftsmanship in pupils' work. But while the working party accepted its importance they felt it was something which should be aimed for only as a way of achieving quality, accuracy and sympathy with the material involved and should be developed throughout a pupil's school life rather than be taught as an end in itself.

ATTAINMENT LEVELS

The main body of the report concerns the detailing of the five attainment levels, four for design and technology and one for information technology each with 10 levels of complexity. At each level in D&T children will be set tasks which will involve the targets of identifying needs and opportunities, generating a design proposal, planning and making and finally appraising. To reach the targets detailed learning programmes are set out for each level of complexity.

On the question of assessment the working party was in favour of its being based on tasks undertaken as part of the normal progression of a pupil's work. "We do not favour a bank of externally established standard tasks which may limit the pupils' chance to identify needs and opportunities."

It was argued that the nature of design and technology meant there could be no single preferred answer to any question. In addition all its aspects were continuously interacting and influencing each other and any attempts to test a particular area in isolation would have no validity. Most important, it was pointed out that it was the application and use of knowledge and skills which were important in the subject not their attainment.

The education department has accepted the working party's views and plans to use them as the basis for the curriculum. Views on the proposals should be sent to the National Curriculum Council by September 22. Copies of the report* can be obtained from the council in York.

**Design and Technology for Ages 5 to 16*, National Curriculum Council, 15/17 New Street, York YO1 2RA.

UNIVERSITY

A reader wrote recently saying that he hoped to work in the field of intelligent robots and asking which university was most active in this field.

I was advised by Dr John Billinsley, professor of Robotics at Portsmouth Polytechnic that the best course to follow would be to avoid trying to specialise too early but to get a good grounding in electrical engineering. Having got a good degree in the general principles behind robotics then it would be possible to specialise.

He also warned to be wary of computer science courses which might be biased towards data processing rather than the control technology needed in robotics.

Readers might be able to help with another request I have received. Clive Randall has bought an Omnibot 2000 which used to be supplied with infra-red and ultrasonic sensors. However he has been unable to find any and would like to get in touch with someone who has.

He can be contacted at Flat 19, Aspen House, 5 Mitton Road, Handsworth Wood, Birmingham.

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Printed circuit boards for certain constructional projects are available from the PCB Service, see list. These are fabricated in glass fibre, and are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to **The PCB Service *Everyday Electronics*, 6 Church Street, Wimborne, Dorset BH21 1JH**. Cheques should be crossed and made payable to *Everday Electronics* **(Payment in £ sterling only)**.

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