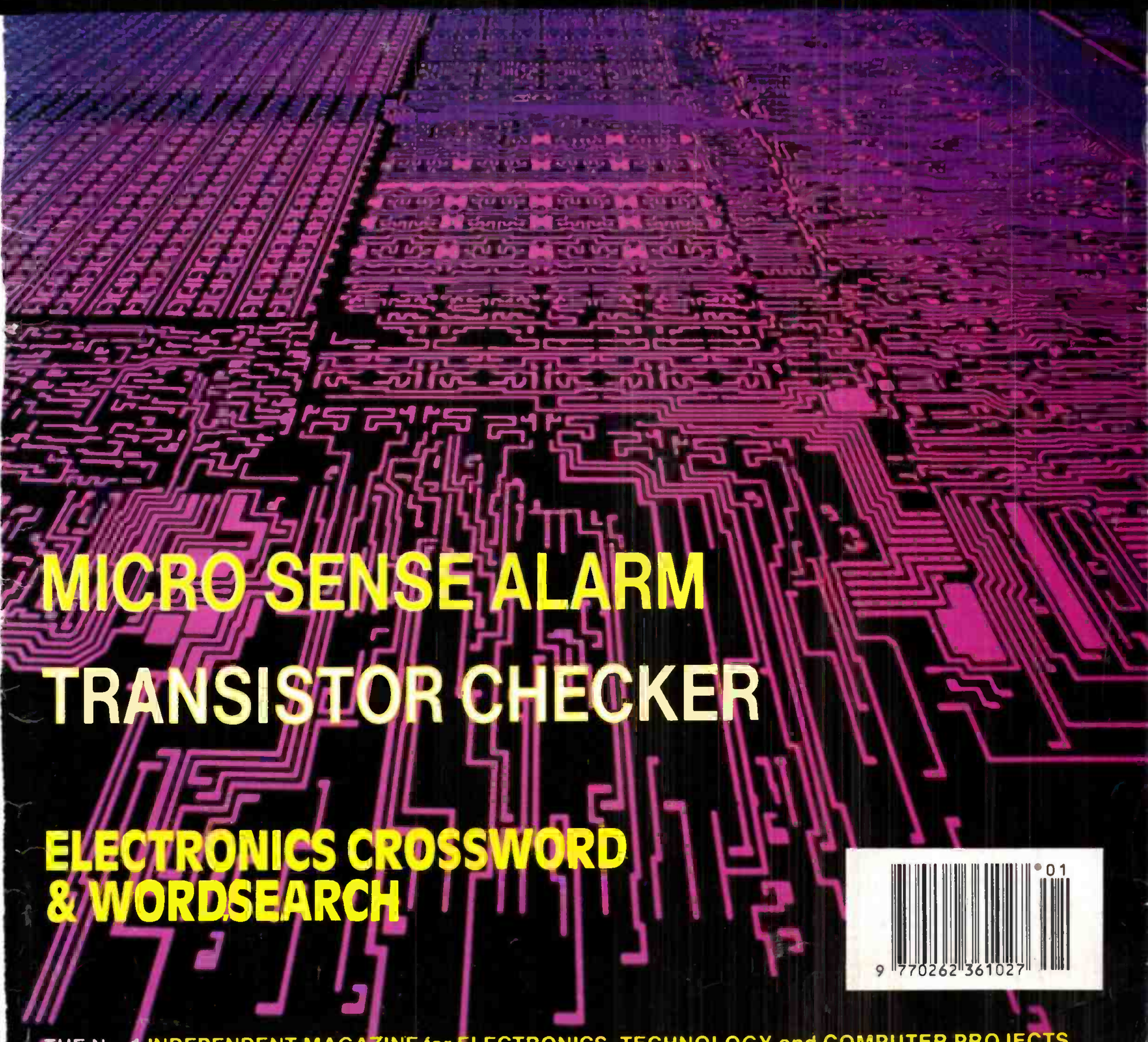
EVERYDAY ELECTRONICS

JANUARY 1992

INCORPORATING ELECTRONICS MONTHLY

£1.60

STEPPING MOTOR DRIVER/INTERFACE



MICRO SENSE ALARM

TRANSISTOR CHECKER

ELECTRONICS CROSSWORD & WORDSEARCH

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THE No. 1 INDEPENDENT MAGAZINE for ELECTRONICS, TECHNOLOGY and COMPUTER PROJECTS

VOL. 21 No. 1 JANUARY 1992

EVERYDAY ELECTRONICS

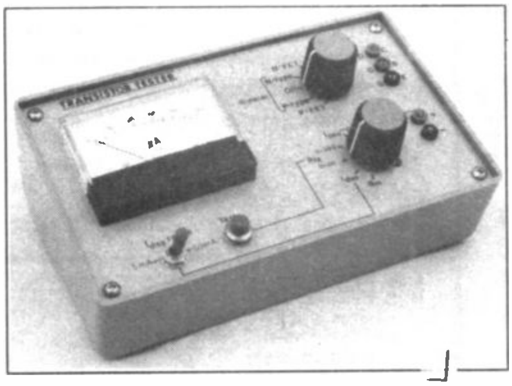
INCORPORATING ELECTRONICS MONTHLY

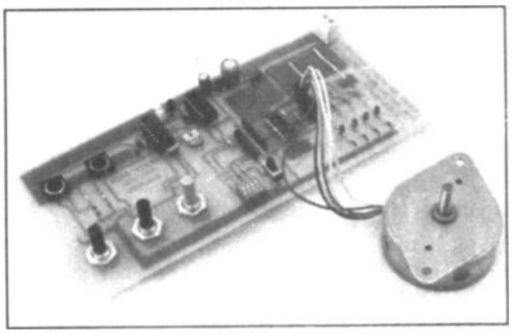
ABC

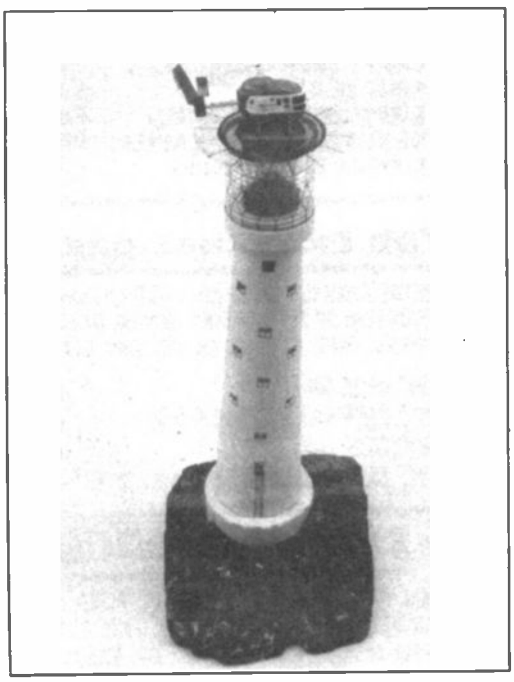
The No 1 Magazine for Electronic & Computer Projects

ISSN 0262 3617

PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .







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NEXT MONTH

FREE INSIDE

BULL ELECTRICAL

40 PAGE CATALOGUE

SPINNING HEART

A novelty circuit to impress your loved one on St. Valentines day. Novelties to tell your sweetheart how you feel are often expensive. Here is a clever little circuit that is bound to get the message over and impress the one you love. The spinning heart consists of 24 red l.e.d.s arranged in the shape of a love heart. The lights appear to move around the heart giving a spinning effect which looks very effective.

TELESOUND

If you find your personal hi-fi is a little too personal at times – in a hotel for instance. Then this little gadget is for you. The Telesound plugs into your personal stereo and into the aerial socket of a TV set and hey presto! your tapes can be played through the TV set

PROGRAMMABLE TIMER

A simple, easy to construct unit that will give time periods from microseconds to hours. The timer has unlimited uses such as; TV sleep timer; alarm bell duration timer; lamp flasher; process or cooking timer etc.

EVERYDAY ELECTRONICS

FEBRUARY ISSUE ON SALE FRIDAY 3rd JANUARY 1992.

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SN75136N	3.10
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SN75150P	1.62
SN75151N	5.02
SN75152N	6.36
SN75154N	1.88
SN75155P	1.36
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SN75162BN	11.76
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SN75173N	4.56
SN75174N	3.25
SN75175N	5.28
SN75176AP	1.80
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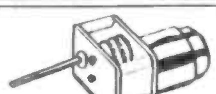

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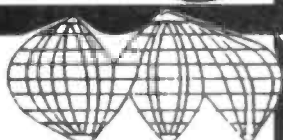

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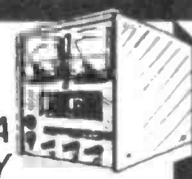

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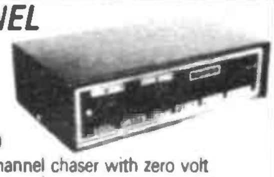

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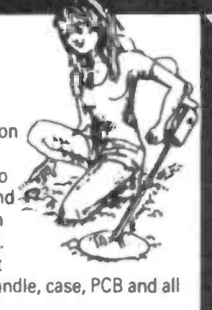

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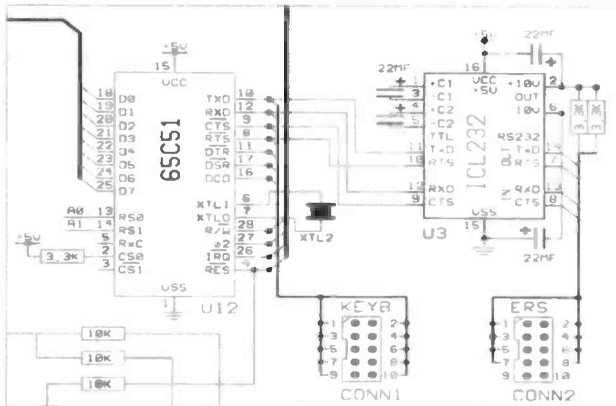

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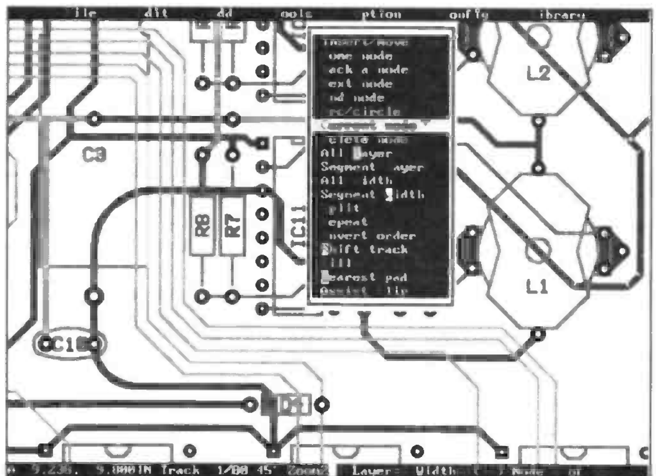

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EVERYDAY ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

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Editorial Offices:
EVERYDAY ELECTRONICS EDITORIAL,
6 CHURCH STREET, WIMBORNE,
DORSET BH21 1JH
Phone: Wimborne (0202) 881749
Fax: (0202) 841692. DX: Wimborne 45314.
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HOLLAND WOOD HOUSE, CHURCH LANE,
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COMMITMENT

A recent visit to Philips at Southampton (see our news pages) made me realise just what level of financial commitment is now necessary for the development of "consumer electronics" chips. What is perhaps even more interesting is the level of development that takes place in the UK, and the importance of Philips in the world market for i.c.s and consumer electronics in general.

We all know the brand name but what is perhaps less obvious is the vast number of Philips chips that appear in equipment made by a wide range of other manufacturers from all over the world. Worldwide semiconductor sales are dominated by American and Japanese companies with Intel and Philips keeping the European flag flying. If you just look at dedicated consumer i.c.s Philips are the third largest supplier behind Toshiba and Sanyo and during 1990 (1991 figures are not yet available) they gained ground on both of them.

MADE IN JAPAN

We tend to think of consumer electronics products as coming mainly from the Far East, it is good to know that much of that product contains chips that were designed, developed and made (but often not packaged) in Europe.

With the gradual overlapping of consumer, electronic data processing and communications markets the development of "consumer" electronics has a greater impact on the overall electronic product market. Home computers are now virtually the same machines as those used in industry and communications systems are no longer obviously for just home or office use. So while IBM (the largest electronics company in the world – based on sales in financial terms) are very much an electronic data processing market manufacturer many of the smaller companies are finding their consumer electronics base is spreading more and more into traditional "business" equipment areas.

DEVELOPED IN THE UK

Many of the innovative products that we will be buying in the future marked "Made in Taiwan" will be based on the technology and chips that were "invented", designed and developed – in association with their manufacturers – by UK engineers working in Southampton. This is thanks to an investment of £6.8 million and one of the largest single concentrations of electronic engineering expertise in the UK.

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Secretary: PAMELA BROWN

Deputy Editor: DAVID BARRINGTON

Business Manager: DAVID J. LEAVER

Editorial: WIMBORNE (0202) 881749

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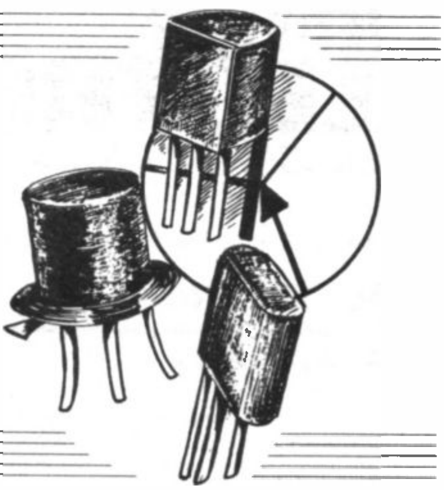


TRANSISTOR CHECKER

STEVE KNIGHT

Check out your collection of "suspect" and unmarked transistors, including f.e.t.s, with this tester.

TRANSISTORS, both of the bipolar and field-effect varieties, particularly when they have been used over and over again in experimental set-ups, (and schools and colleges are in the forefront of such situations) are apt to find themselves in circuit systems where the operating conditions are not always to their liking. Reversed and excessive applied voltages are old established favourites on the road to ruin, and eventually there arrives the day when a box or a drawer full of assorted devices of dubious antecedence are left for the pupil or the student to take his or her pick, and (when the experiment doesn't do what it should) ruminate on whether the trouble is due to their incompetence, the circuit design or the bits they are using.

Some transistors pack up completely and it doesn't take too long to spot the cause of the trouble. However the main problem usually arises from those transistors that give the appearance of working but have in fact poor gain or excessive leakage, so that things half function and the circuit designer (if he is being followed) gets a lot of unwarranted stick.

But dubious devices apart, it is frequently necessary to select transistors from perfectly good collections for, perhaps, high gain, or to pick out pairs having close gain and current figures for matching purposes, and so on. A transistor checker is then a useful piece of test equipment.

REQUIREMENTS

What is needed is not a complicated box of tricks which will provide us with every parameter a transistor possesses, most of which the amateur experimenter would have no use for, anyway, but a simple checker that will provide, in a few seconds flat, those reassuring functional checks on diodes and transistors before they are incorporated into equipment.

There have been a number of simple testers published in magazines over the years since the transistor put in an appearance, but I have not seen any which cater for field-effect devices (f.e.t.s) as well as the "ordinary" bipolar types. The circuit to be described will cater for all diodes and both sorts of small-signal transistors as well as, of course, differentiating between *npn* and *pnp* bipolars and *n*- and *p*-channel f.e.t.s.

BASIC PRINCIPLES

The bipolar transistor can usually be summed up for acceptance or rejection by the basic measurements of its *leakage* (saturation) current and its current *gain*. In the case of the f.e.t. the parameters of importance are the *pinch-off* voltage (V_p), the value of the drain current (I_{DSS}) with the gate voltage (V_g) set to zero, and the mutual transconductance (g_m). Diodes, of course, can be checked simply by noting the effectual forward and reverse resistance.

COMMON EMITTER

Starting with bipolar transistors, the effect of leakage becomes most important when the transistor is used in the common-emitter configuration. Suppose in Fig. 1 that an *npn* transistor is connected to collector and base supplies but has its emitter (e) left open-circuited.

A meter included in the collector circuit might be expected to record zero collector current, but actually a small leakage current will flow across the collector-base junction even though it is reverse biased. This leakage is composed of minority carriers (holes in this case) which move across the junction in the direction collector-to-base. But such a movement of holes from collector to base *inside* the device is equivalent to a movement of electrons (as recorded, *outside* the device) in the direction base-to-collector.

This current therefore shows itself in the external circuit as an *addition* to the collector current I_c which will flow normally when the emitter is reconnected. This unwanted part of I_c is designated I_{CBO}, and is temperature dependent. In a silicon transistor it amounts to only a few nanoamps under normal conditions, but can be considerably higher in a germanium device.

If a transistor is now connected as shown in Fig. 2, this time with the base (b) left open, the leakage current I_{CBO} which still

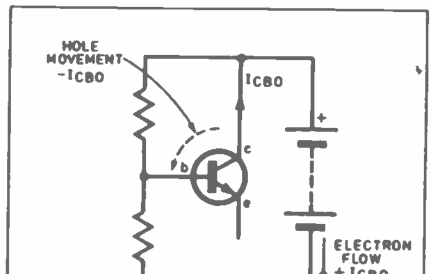


Fig. 1. The effect of leakage current.

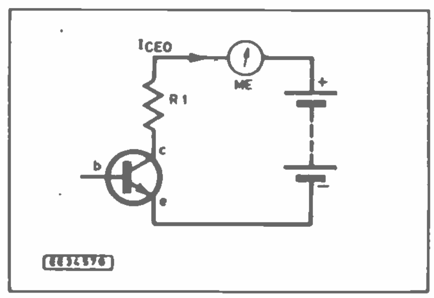


Fig. 2. How leakage is amplified by transistor action.

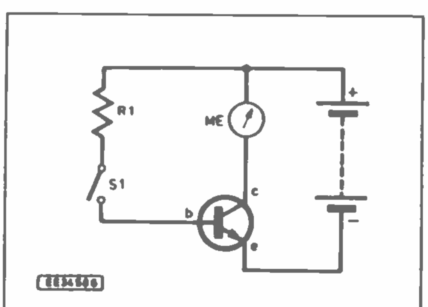


Fig. 3. Method of measuring static current gain.

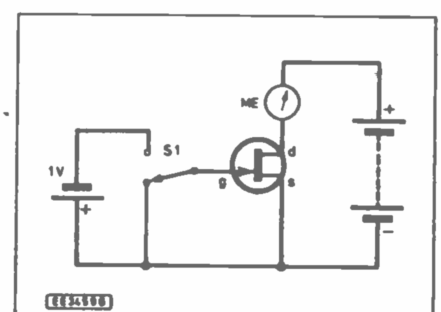


Fig. 4. Method of measuring transconductance.

flows, will be treated as a base input signal and will be amplified by the transistor to give a collector current expressed as I_{CEO}. This current may well be several hundred times the value of I_{CBO} and hence may be significant in determining the thermal stability of an amplifier when it becomes an unwanted part of the main collector current.

The checker will measure I_{CBO} and the effect of its amplification in the common-emitter configuration, that is, the value of I_{CEO}. The I_{CEO} is simply measured by using the basic circuit of Fig. 2.

The transistor under test has its base connection left "open circuit" and the amplified leakage is shown on a microammeter ME1 (protected to full scale deflection (f.s.d.) by resistor R1) wired into the collector circuit. In a good silicon device the current, even though amplified, will normally be negligible but in a poor example it may run to several microamps.

Germanium transistors have relatively high I_{CBO}'s even when perfectly good, and I_{CEO}'s up to 100μA are not uncommon, particularly in some of the older types. Anything over this figure should certainly be rejected.

CURRENT GAIN

Turning now to the measurement of current gain, the d.c. gain of a transistor (or its static common-emitter amplification factor h_{FE}) is a figure indicating how many times the base current is effectually contained in the collector current. In other words, how well is it amplifying?

This is determined by measuring the change in collector current resulting from a known change in base current. Fig. 3 shows a common method (there are others); here resistor R1 is selected so that when switch S1 is operated, the current flowing through R1 into the base is some precise figure, say, 10μA.

By suitable scaling, the collector current as measured on the meter ME1 will indicate a direct value for the current gain. This gain figure is for purely *d.c. conditions:* the a.c. gain or dynamic gain figure (h_{FE}) when a load resistor is used in the collector circuit, is always less than the static gain, in general about 10 per cent smaller.

CHECKING F.E.T.s

For the f.e.t., the diagram of Fig. 4 shows the basic circuit arrangement for the measurement of I_{DSS} and g_m. With switch S1 in the position shown, the gate (g) of the f.e.t. is "earthed" and the milliammeter ME1 gives a direct reading of I_{DSS}. When the switch is changed over, the gate (g) is biased by −1V and the drain current falls.

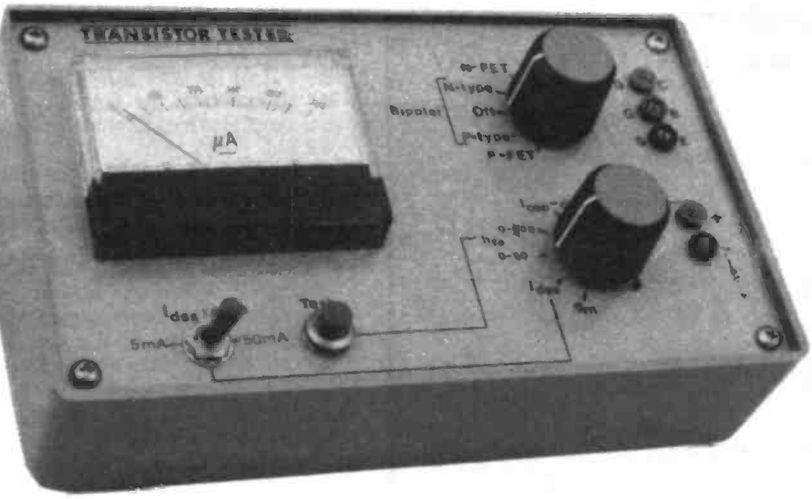
The mutual transconducante g_m is a measure of the change in drain current divided by the change in gate voltage. Since the gate change is one volt, the change in the meter current gives a direct indication of g_m, that is, so many milliamps-per-volt or, as it is usually expressed, so many milli-siemen.

A close approximation to the pinch-off voltage is obtained from a simple relationship between I_{DSS} and g_m which will be given later.

The above descriptions have been made assuming *npn* transistors and *n*-channel f.e.t.s. For *pnp* transistors and *p*-channel f.e.t.s, all supply voltage polarities are simply reversed. We are now ready to combine these basic systems into the complete checker.

CIRCUIT DETAILS

The complete circuit diagram of the Transistor Checker is shown in Fig. 5, and this



contains all the forms of the basic systems discussed earlier under Fig.2, Fig.3 and Fig.4.

The amount of switching might seem off-putting at first sight, but provided the work is approached in a logical way, things are not so fraught as they might appear. There are two main switch assemblies involved; S1 having three wafers each of 2-pole, 5-way; and S2 made up of two wafers, each also 2-pole, 5-way.

One of the poles on S2 is not used. For both these switches, 2-pole, 6-way wafers are used but the mechanism is stopped off at the 5-way position.

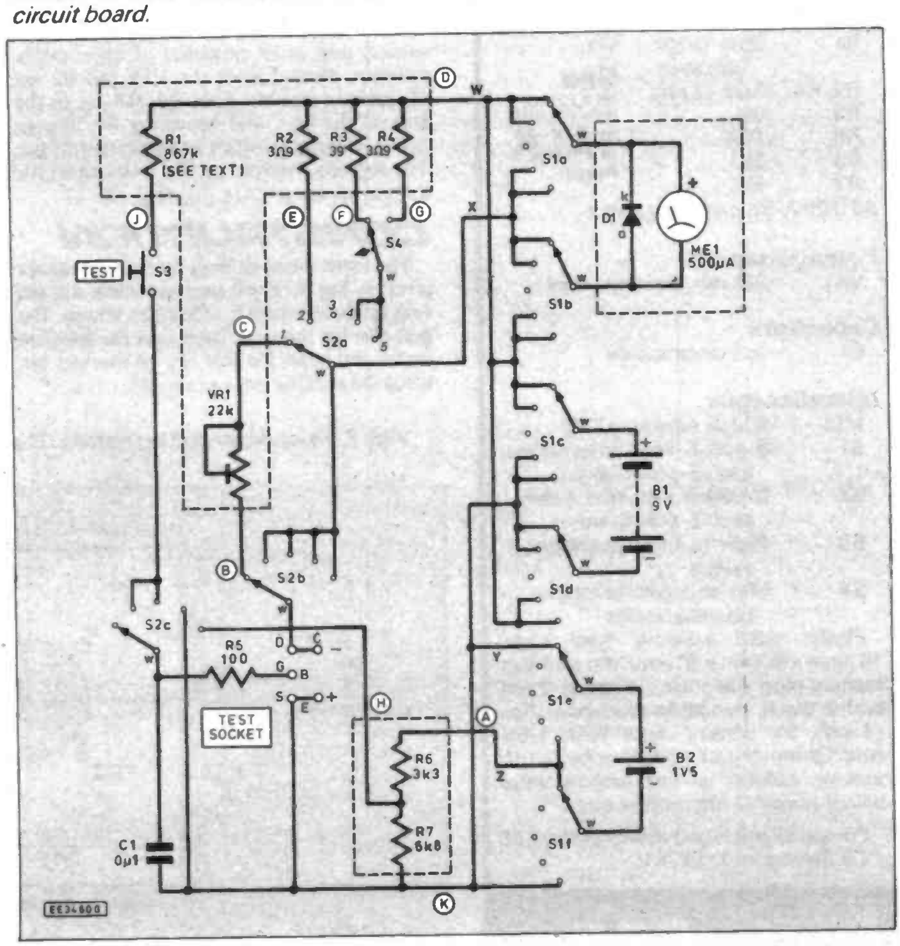
The only other components are seven resistors, a preset potentiometer, a capacitor, a 500μA moving coil meter ME1, diode D1, a biassed toggle switch and a push-to-make push button switch S3, plus coloured terminals and knobs. Most of the resistors go on to a simple circuit board for convenience and this is fitted directly to the terminals of the meter.

The whole assembly is consequently built on to a single aluminium panel which fits into a small "console" type ABS plastic case measuring 159mm by 91mm by 61mm. Any alternative style of case may of course be used provided it has adequate space.

POLARITY SWITCHING

The first wafer of switch S1, that is, S1a and S1b, are simply reversing switches for the meter ME1. The meter terminals are changed over to suit the polarity when either *npn* or *pnp* (or *n*- or *p*-channel f.e.t.s) are being tested.

Fig. 5. Complete circuit diagram for the Transistor Checker. Switch S1 is shown in the N-FET position and S2 in the I_{CEO} – Diode position. Components enclosed in dotted lines are mounted on the p.c.b. Circled letters refer to connections on the circuit board.



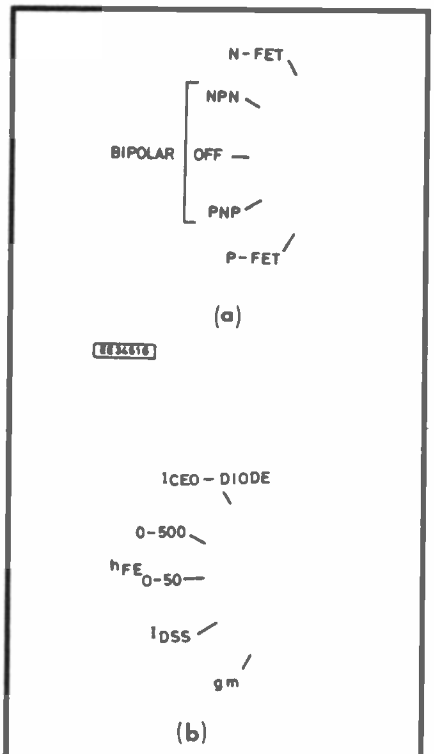


Fig. 6. Front panel legends (full size) required at 30 degrees indexing for Polarity switch (top) and Function switch (above).

COMPONENTS

Resistors

R1	867k (820k + 47k, (see text)	
R2, R4	3Ω9 (2 off)	
R3	39	
R5	100	
R6	3k3	
R7	6k8	

See SHOP TALK Page

All 0.25W 5% carbon or better

Potentiometer

VR1 22k min. skeleton preset

Capacitors

C1 0µ1 ceramic disc

Miscellaneous

ME1	500µA Altai type T23
S1	6-pole 5-way, three wafers each 2-pole 5-way
S2	3-pole 5-way, two wafers each 2-pole 5-way
S3	Push-to-make pushbutton switch
S4	Min. changeover toggle, biased one side

Plastic ABS console type case, 161mm x 96mm x 61mm/39mm; 1mm wander plug and socket, 1 green, 2 red and 2 black; miniature crocodile clips (3 off); 9V battery, type PP3; 1.5V cell; 19mm (¾in.) collet knobs, 2 off; various colours of connecting wire; solder pins (12 off); solder etc.

Printed circuit board available from *EE PCB Service*, code EE781.

Approx cost guidance only **£35** *excl. batts.*

Similarly, the second wafer, S1c and S1d, reverses the polarity of the 9V supply (battery B1) for the same reason. Wafer S1e and S1f also reverses the polarity of the f.e.t. gate supply battery B2 when f.e.t.s are being checked.

The relevant functions of the switch positions are indicated in Fig. 6(a). Use this as your lettering guide on the front panel.

FUNCTION SWITCH

Switch S2 selects the various measuring modes after S1 has been set to suit the type of device being tested. Looking at the circuit diagram, in the position shown (I_{CEO}-Diode), the meter is connected in series with preset potentiometer VR1 (wired as variable resistor) and the transistor (or diode) under test.

For a transistor, the base connection is an open-circuit and hence the meter will read the leakage current I_{CBO}. For a diode, the forward conduction will be indicated.

The second and third positions of S2 give an indication of current gain, h_{FE}, after the manner shown earlier in Fig. 3. On the second position resistor R2 shunts the meter and converts it to read 5000µA (5mA) f.s.d.; in the third position the meter is left unshunted.

When the pushbutton switch S3 is pressed, 10µA flows through resistor R1 into the base (b) of the test transistor, hence the meter indicates either a maximum h_{FE} of 500 (position 2) or 50 (position 3). This last sensitive position should only be used for cases of h_{FE} which fall below 50 on the 500 range.

The fourth and fifth positions of the switch are reserved for f.e.t. testing; on the fourth position I_{DSS} is shown on the meter (now shunted by resistor R3 to read 50mA f.s.d.). If the reading is very small, an auxiliary switch S4 converts the f.s.d. to 5mA; this switch is normally biassed to the least sensitive position.

The fifth switch position (as per Fig. 4. earlier) puts a 1V potential of appropriate polarity, derived from the 1.5V cell B2 via the resistor divider chain R6, R7, on to the gate of the f.e.t. and hence, by the change noted in I_{DSS}, provides an indication of g_m. The legends required on the front panel for this switch are given in Fig. 6(b)

CONSTRUCTION

The front panel drilling measurements are given in Fig. 7. These measurements suit the original panel which is 155mm by 90mm. The hole size for the meter also suits the specified meter; the holes for this can be marked out using the packing piece as a guide.

All the front panel lettering should be added after drilling but *before* any of the components are mounted. The switch positions are indexed out at 30 degrees intervals on a radius from the fixing hole which suits the knobs you are going to use. Collet, 19mm (¾in.), type knobs were found to be best as there is then no problem with the alignment of the pointer-mark when they are fitted and no precise orientation of the switches on the panel is necessary.

SWITCH WIRING

It is best to wire up the wafers of switches S1 and S2 before fixing them to the front panel. If each wafer is wired up systematically and interconnections made where necessary between the wafers, there is no real problem about the job; all that is needed is a logical progression from each wafer to the next.

If you look again at the main circuit diagram Fig. 5, there are connections from the wipers (w) of each of the three wafers of S1 which go to: (i) the meter, (ii) the 9V battery, (iii) the 1.5V cell. Solder distinctive coloured wires on the switch wipers for easy identification.

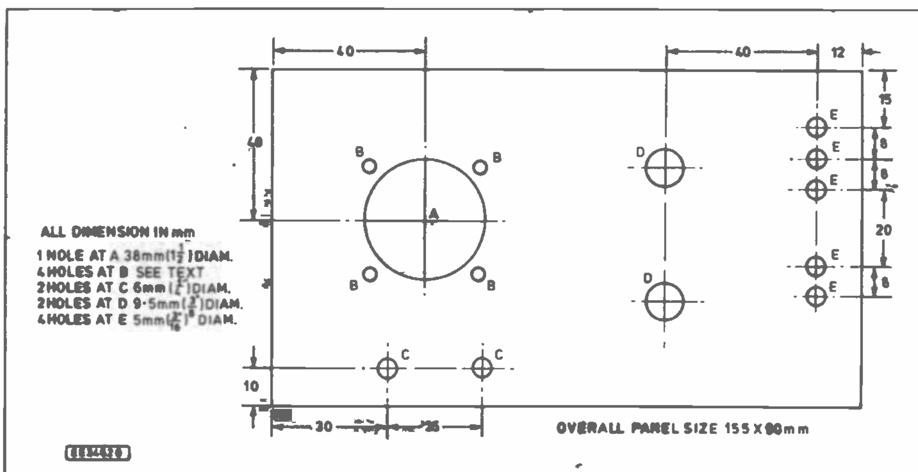
Again looking at the diagram, notice that there are only *four* leads which actually come from these wafers to connect with the remainder of the circuit; these are indicated by the letters *W*, *X*, *Y*, *Z*. Once the interconnections between wafers have been made, the switch can be mounted on the front panel.

The same procedure applies to switch S2; most of the outgoing wires (in this case shown as circled letters on the circuit diagram) go off to a small printed circuit board (p.c.b.) which will be described in a moment. Again, the use of coloured leads will avoid confusion.

The pushbutton switch S3 and the biassed changeover switch S4 are mounted immediately below the meter, while the input test sockets are fitted on the right of the panel as the photographs show. The group of three sockets are for bipolar and field-effect transistors and are marked D-C, G-B and S-E, representing either drain, gate, source or collector, base, emitter inputs respectively. The two lower sockets are for diode testing and are marked + and − (plus and minus) respectively.

The terminals used are 1mm type coloured sockets which are bought together with matching 1mm plugs. You can use spring

Fig. 7. Front panel drilling details. The meter hole drilling depends on unit used.



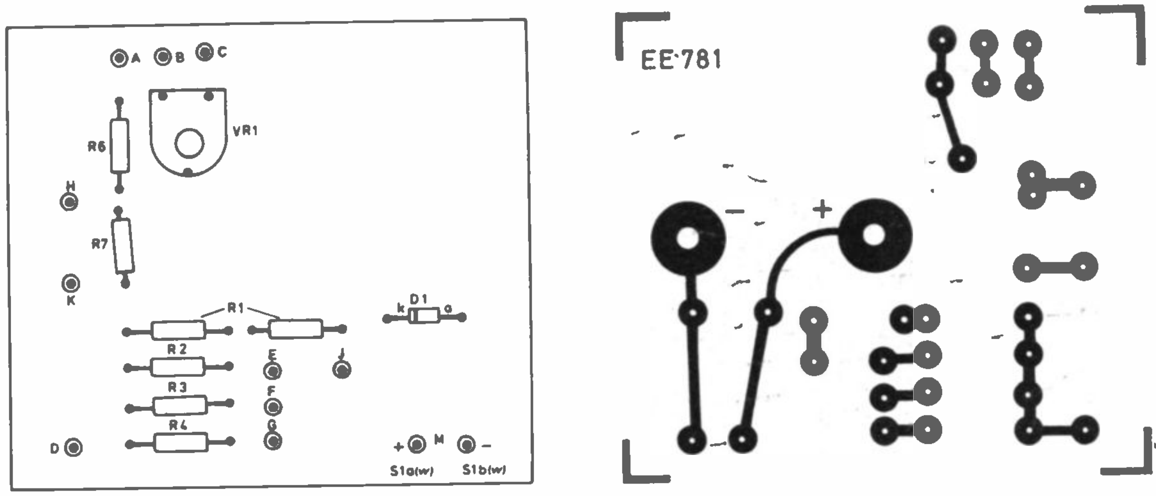


Fig. 8. Printed circuit component layout and full size copper foil master pattern. Resistor R5 and capacitor C1 are wired directly between switch wafer and output sockets.

type terminals as an alternative but watch the available space.

The method of connecting transistors adopted by the author utilises three miniature crocodile clips connected by short flexible leads to the 1mm plugs which then go into the appropriate sockets. Some of the older transistors had leads sufficiently long to plug directly into the sockets but these are now few and far between; using croc' clips will accommodate practically every style of transistor output configuration.

CIRCUIT BOARD

Apart from the switches and sockets, most of the remaining discrete components are mounted on a small printed circuit board; the exception being resistor R5 and capacitor C1. This board is available from the *EE PCB Service*, code EE781.

The p.c.b. is screwed directly on to the meter's rear terminals and carries all the resistors except R5 which, along with capacitor C1, is hard wired directly between switch wafer S2c wiper or pole contact and the appropriate sockets. The full size copper track layout and component dispositions are given in Fig. 8 where the lettering refers to that shown on the circuit diagram; this makes the interwiring from the switch leads and the connections to switches S3 and S4 relatively easy.

Preset potentiometer VR1 should at this point be set to its maximum resistance position, fully anticlockwise. It is important to note in passing that the values of the shunt resistors R2, R3 and R4 apply *only* to the specified meter and will have to be modified if you use an alternative meter.

Resistor R1 is actually made up from an 820k in series with a 47k; we need 10µA to flow into a transistor base when switch S3 is pressed but the base-emitter voltage drop is different for silicon and germanium devices. Assuming the battery p.d. is 9V, then about 8.4V is available for a silicon device and about 8.75V for a germanium one.

Hence, to get 10µA to flow a compromise is necessary in the value of resistor R1. So 867 kilohms seems reasonable, though there is not much point in being pedantic about this, bearing in mind the tolerance of the resistors, and the variation in the potential barrier voltage of different transistors.

The two batteries are located beneath and to either side of the circuit board. They are fixed to the front panel with double-sided sticky pads. The 9V supply battery is positioned nearest the wafer switches, see photographs.

With the simple p.c.b. used here, it is no problem to use either etch-resistant transfers or a Dalo pen to map out the tracks. The only critical spacing is that for the meter fixing holes which must be exactly 25.4mm (1in.) apart. Use solder pins as the connecting points for the incoming wires.

SETTING UP

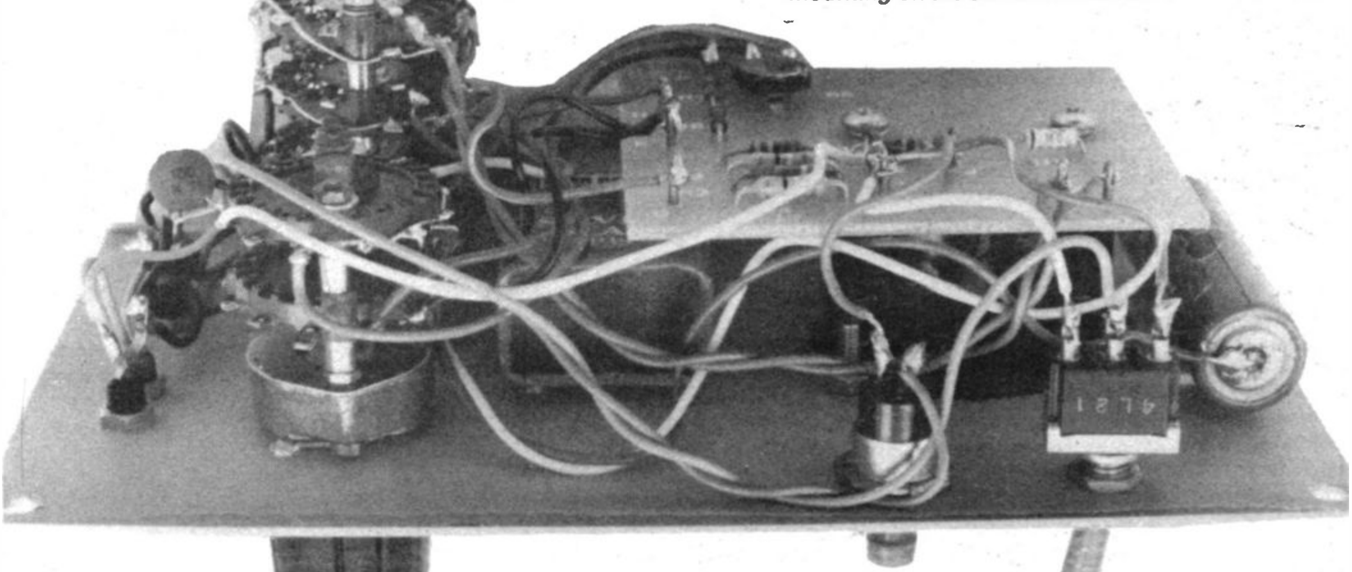
With the project assembled and with the batteries in place, a quick preliminary check can be made. This is quite simple as only preset VR1 needs adjustment to give the meter a full-scale reading on the available battery voltage.

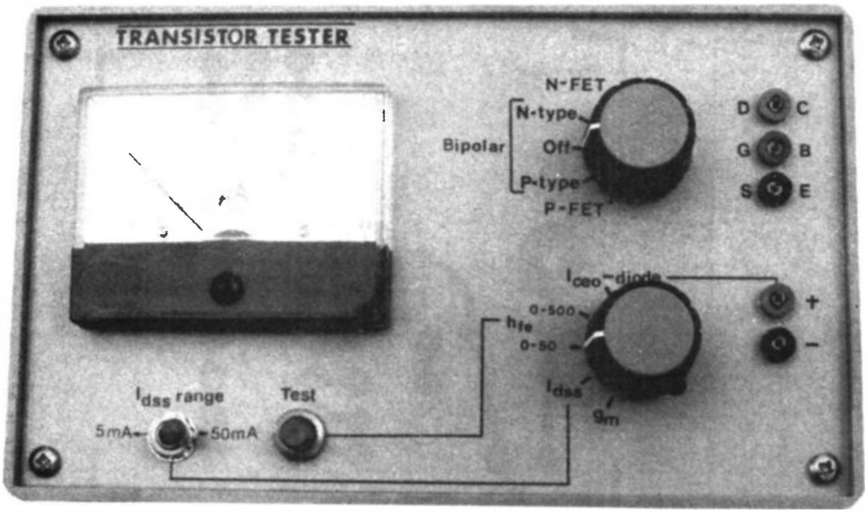
With S1 set to OFF and S2 set to I_{CEO} Diode, short out the input sockets C and E. Then switch S1 to either the *npn* or *pnp* position and adjust VR1 to provide a full-scale reading on the meter.

This completes all that is strictly necessary for the operation of the tester but you can if you wish check on the accuracy of the meter shunting for the h_{FE} ranges. To do this, connect a 47 kilohms (or thereabouts) variable potentiometer, resistance fully in, across the C-E terminals.

Switch S1 to either *npn* or *pnp* and switch S2 to the h_{FE} 0-50 range. Adjust the pot carefully to give f.s.d., then turn switch S2 to

Components mounted on the rear of the front panel. The switch wafers are pre-wired before mounting on the switch mechanism.





Front panel layout and lettering.

the 0-500 range. Check that the meter now reads 50 on this 0-500 range. For any *serious* error, say, a reading outside 45-55, resistor R2 will need adjusting.

OPERATION

Here is a brief summary of the procedures for testing diodes, bipolar and field-effect transistors. Always start with the instrument switched OFF and with the Function switch set to I_{CEO}-Diode.

Diodes

To check a Diode: Connect the marked end of the diode (the cathode (k)) to the negative terminal and the anode (a) to the positive terminal. With S2 on I_{CEO}-Diode, switch S1 to the PNP position; the meter should then indicate the forward conduction of the diode, generally close to a full scale reading.

Switch now to the NPN position on S1. The meter will now indicate the diode reverse leakage which for a good diode should be undetectable.

Transistors

To check a bipolar transistor: Assuming an *npn* device, connect the collector (c), base (b) and emitter (e) leads to the appropriate terminals. Set the function switch to I_{CEO}-Diode and the polarity switch to NPN.

The meter will now indicate the open-base *leakage* current I_{CEO} on a 500µA full-scale deflection. For a good silicon transistor this reading should be negligible but for a germanium transistor a current of 100µA might not be unusual, particularly for some of the older types.

To check the *gain*, switch to the h_{FE} 0-500 position and press the Test button S_3. The meter will indicate the static current gain directly; if the reading is less than 50, switch to the 0-50 position.

In cases where the leakage is appreciable, make a note of the meter reading *before* pressing Test switch S3; *deduct* this reading from that obtained when S3 is pressed to get a true value for h_{FE}. It is the *change* in the current which matters.

To determine whether a transistor is *npn* or *pnp* use can be made of the diode terminals. Put the collector lead into the + socket (plus) and the combined emitter and base leads, *shorted together*, into the − socket (minus). Switch the function switch alternately to PNP and NPN; then the position which produces the full-scale reading (or very close to it) is that which suits the type of transistor under test.

Field Effect Transistors

To check a f.e.t.: Assuming an *n*- channel f.e.t. connect the drain (d), gate (g) and sources (s) leads to the appropriate terminals. Set the Function switch to I_{DSS} and the polarity switch to N-FET.

The meter will now indicate (on a 50mA f.s.d. range) the drain current for zero gate volts. If the reading is below 5mA, operate the biassed switch S4 to give a 5mA f.s.d. range. Note this reading.

Switch now to g_m; the previous I_{DSS} reading will decrease, a bias of 1V now being applied to the gate. The *change* in the current will give an indication of g_m either in mA/V or millisiemen.

To evaluate V_p (the *pinch-off point*) use the simple relationship:

$$V_p = \frac{-2I_{DSS}}{g_m}$$

Thus, for example, if I_{DSS} = 4mA and g_m = 1.5mA/V (or 1.5 millisiemen) then:

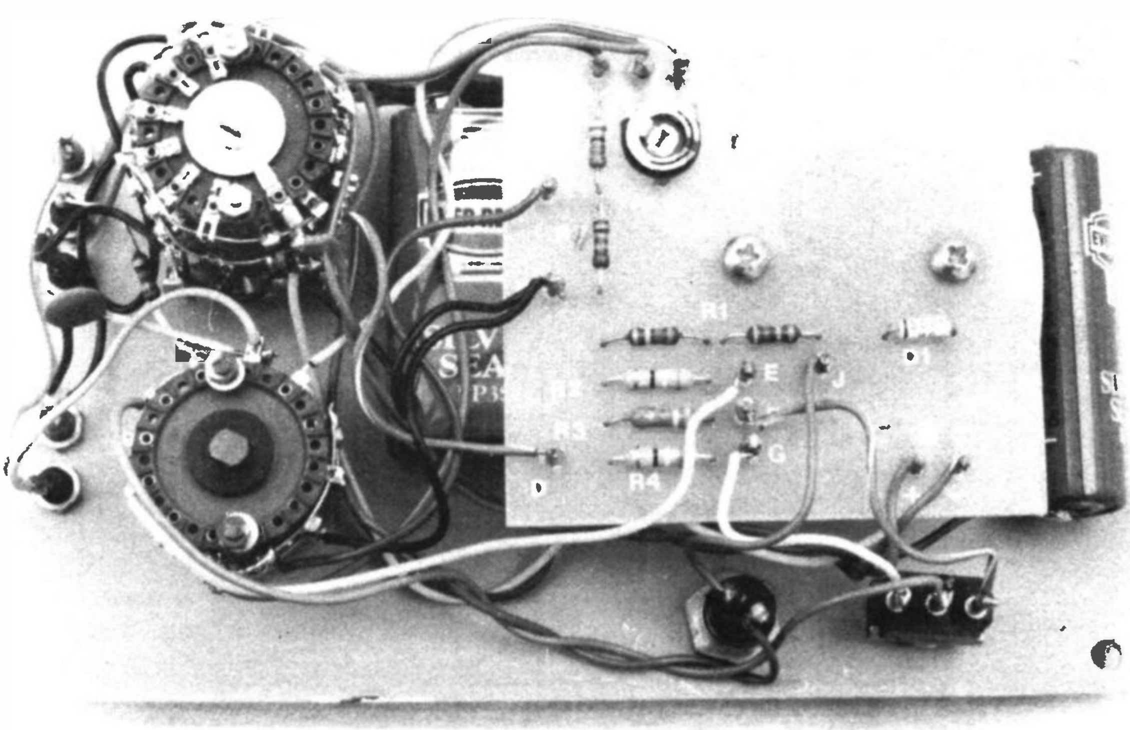
$$V_p = \frac{-2 \times 4}{1.5} = -5.3V$$

PRECAUTIONS

At all times, when carrying out tests, make sure that the clips to the "transistor under test" do not short together *before* switching the unit on; failure to do this could lead to the meter "cracking" over and the result could be a bent pointer. *Always* return switch S1 to OFF before connecting or removing a transistor.

Most small-signal type transistors and f.e.t.s can be checked on this instrument, as can most *small* power silicon types: *high* power types *cannot* be tested accurately because of the low collector currents used. □

The completed tester showing the two batteries secured (with double-sided sticky pads) beneath the circuit board. The resistor R5 and capacitor C1 can just be seen on the left.



Constructional Project

MICRO SENSE ALARM

JASON SHARPE

A comprehensive alarm that can protect any object, particularly electronic equipment, uses piezo sensors combined with tilt switches, if required, stuck onto the equipment.

THANKS to modern technology electronic goods keep becoming smaller and more portable, unfortunately this also makes life easier for the thief. This alarm was designed to protect computers and their peripherals from being removed while unattended.

Items are protected by fixing piezo transducers to them, with self adhesive foam pads. When an attempt is made to remove the sensor a voltage is produced by the piezo crystal as it is distorted, which will set off the alarm. If the security loop is cut or short circuited the alarm will also be set off, tilt switches (and other types of switches) may be connected in series and parallel with the loop and fixed to the back of the sensors for even more security.

The source of the last trigger pulse is shown by three l.e.d.'s, this feature is useful in the case of false alarms to detect what caused the error, also when the alarm is first switched on it will show if the loop is open or short circuited. Features of the alarm are:

★ Uses sensitive piezo transducers
★ Three state security loop
★ Trigger source indicators
★ Status indicator
★ Auto turn off sounder

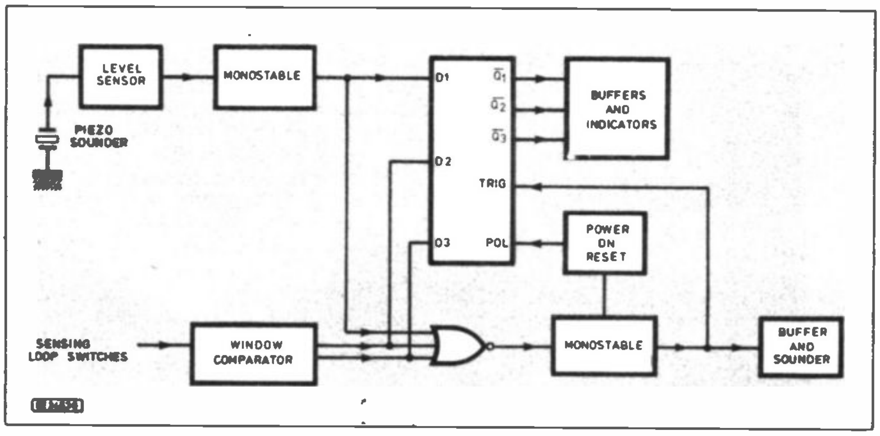
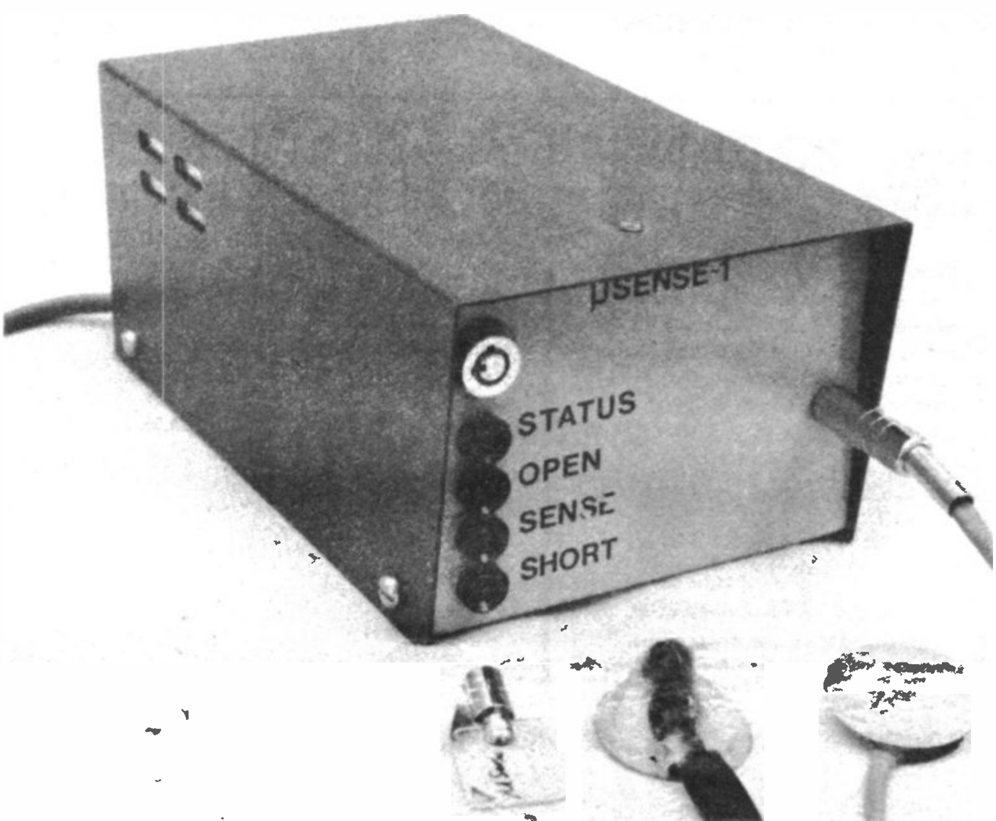


Fig. 1. Block diagram of the Micro Sense Alarm.



A block diagram of the Micro Sense Alarm is shown in Fig. 1 and Fig. 2 shows the full circuit diagram without the power supply unit.

The output from the piezo transducers is fed into an inverter arranged as an amplifier, the input sensitivity is set by VR1 and R1, the higher their combined resistance the higher the input sensitivity. The output of the amplifier is fed into another inverter which translates the analogue signal into a digital high or low.

Components R3, TR1, R4, C1 and a further inverter form a monostable which has the affect of "stretching" the short pulse received from the piezo transducer. If the input becomes high (i.e. a trigger pulse has been sensed) C1 is discharged via TR1, when the input goes low again C1 starts to charge via R4, the inverter squares the output to produce a high pulse which is longer than the input pulse.

Most security loops are just wire loops, which means they can be shorted out and disabled, the security loop on this alarm has an 18k resistor from the loop input to ground, which is fixed to the last sensor in the chain. Inside the alarm the input has an 18k resistor connected to positive, this

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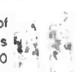

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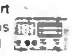

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BENCH POWER SUPPLIES Superbly made fully cased (metal) giving 12v at 2A plus a 6V supply. Fused and short circuit protected. For sale at less than the cost of the case! Our price is £4.00 ref 4P103R

SPEAKER WIRE Brown twin core insulated cable 100 feet for £2.00 REF 2P79R

MAINS FANS Brand new 5" x 3" complete with mounting plate quite powerfull and quite. Our price £1.00 ref CD41R

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HEX KEYBOARDS Brand new units approx 5" x 3" only £1.00 each ref CD42R

PROJECT BOX 5 1/2" x 3 1/2" x 1" black ABS with screw on lid. £1.00 ref CD43R

SCART TO SCART LEADS Bargain price leads at 2 for £3.00 ref 3P147R

SCART TO D TYPE LEADS Standard Scart on one end, Hi density D type on the other. Pack of ten leads only £7.00 ref 7P2R

OZONE FRIENDLY LATEX 250ml bottle of liquid rubber sets in 2 hours. Ideal for mounting PCB's fixing wires etc. £2.00 each ref 2P379R

QUICK SHOTS Standard Atari compatible hand controller (same as joysticks) our price is 2 for £2.00 ref 2P380R

VIEWDATA SYSTEMS Brand new units made by TANDATA complete with 1200/75 built in modem infra red remote controlled qwerty keyboard BT approved Prestel compatible, Centronics printer port RGB colour and composite output (works with ordinary television) complete with power supply and fully cased. Our price is only £20.00 ref 20P1R

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COMPUTER JOYSTICK BARGAIN Pack of 2 joysticks only £2.00 ref 2P382R

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BUGGING TAPE RECORDER Small hand held cassette recorders that only operate when there is sound then turn off 6 seconds after so you could leave it in a room all day and just record any thing that was said. Price is £20.00 ref 20P3R

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286 MOTHER BOARD WITH 640K RAM FULL SIZE METAL CASE, TECHNICAL MANUAL, KEYBOARD AND POWER SUPPLY £139 REF 139P1 (no i/o cards or drives included)

35MM CAMERAS Customer returned units with built in flash and 28mm lens 2 for £8.00 ref 8P200

STEAM ENGINE Standard Mamod 1332 engine complete with boiler piston etc £30 ref 30P200

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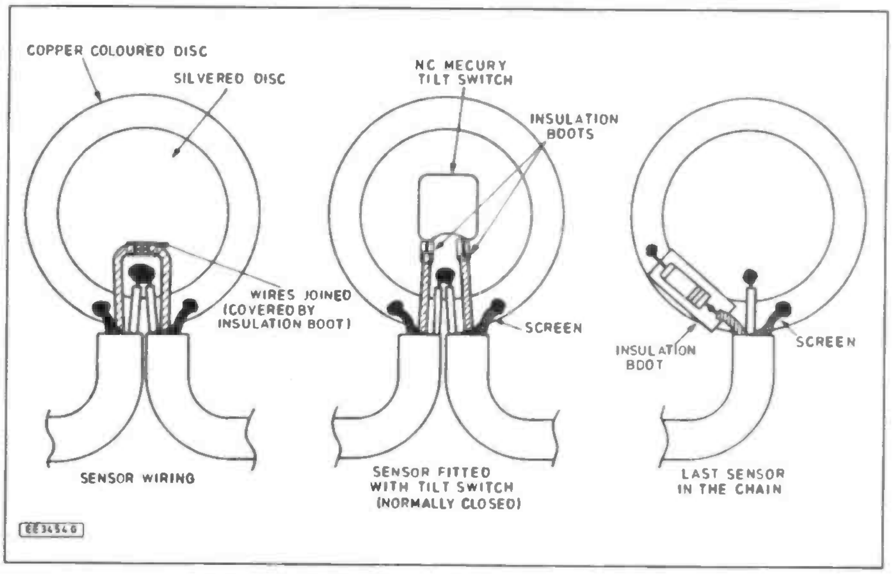
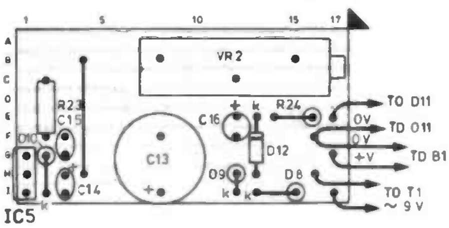
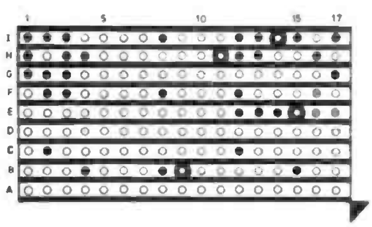
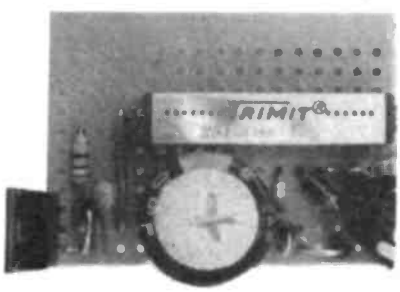


Fig. 4. Construction and wiring of the sensors.

Fig. 5. Wiring of the p.s.u. stripboard.







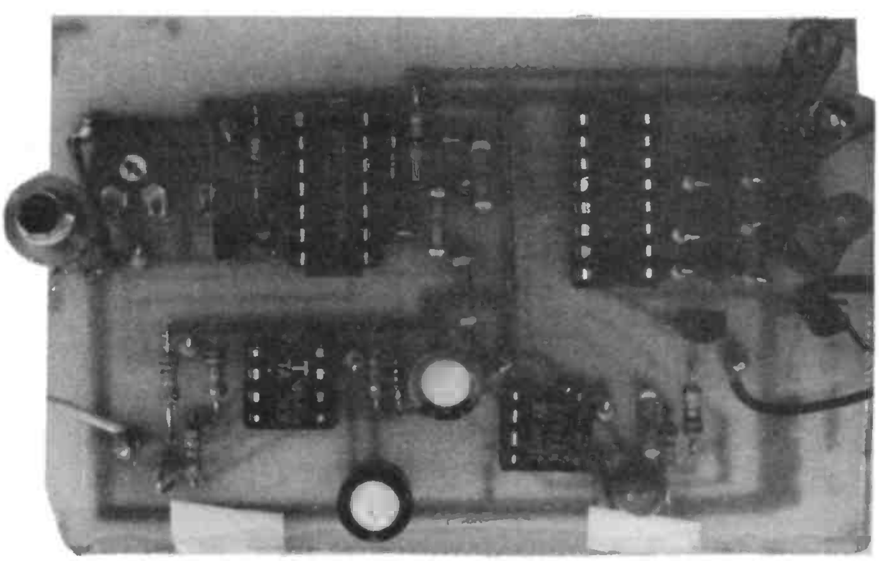
cable of required length, and a chain of piezo transducers to the other, solder the copper outside part of the transducer to the cable screen and connect other wires as shown in Fig. 4. Be careful not to get the sensor to hot, especially the silvered disc as this will begin to desilver if it gets to hot.

The last sensor in the chain should have an 18k resistor soldered between the security loop wire and ground (outer disc). When the unit has been tested (see Testing section) the sensors can be given extra protection by applying silicon rubber on the solder side of the sensors.

CONSTRUCTION

The Veroboard layout for the power supply is shown in Fig. 5, construction is quite simple, but check the polarities of the capacitors and diodes. In the prototype IC5 (7805) was used to fix the board into the box, and was mounted on a heatsink insulator.

When the case has been drilled the transformer can be fixed in place, and the mains lead connected (the Earth of the mains cable should be connected to the case), the output leads can then be connected to the power supply board which is fixed in place by means of a screw through the regulator tag.



COMPONENTS

Resistors

See **SHOP TALK** Page

R1	100k
R2	1M
R3	6k8
R4	27k
R5, R6, R8	18k (3 off)
R7, R13	2k2 (2 off)
R9, R10	4k7 (2 off)
R11	47k
R12, R15 to R19	10k (6 off)
R14	2M2
R20 to R22	390 (3 off)
R23	100
R24	680
R25	220

All ¼W ±10% carbon film.

Potentiometers

VR1	2M2 skeleton preset
VR2	500 multiturn preset

Capacitors

C1	2µ2 tantalum 35V
C2, C3	3n3 poly. layer (2 off)
C4, C8	1n poly. layer (2 off)
C5	47µ radial elect. 16V
C6, C9, C11, C12, C14	0µ1 ceramic (5 off)
C7	47µ tantalum 10V
C10	100µ radial elect. 16V
C13	2,200µ radial elect. 16V
C15	1µ tantalum 35V
C16	22µ radial elect. 16V

Semicondutors

IC1	4069UBE Hex inverter
IC2	LM393 voltage comparator
IC3	555 timer
IC4	4042 quad clocked D-latch
IC5	7805 +5V 1A voltage regulator
TR1 to TR5	BC548 *npn* silicon (5 off)
D1 to D4, D12	1N4148 (5 off)
D5 to D7	high brightness red l.e.d. (3 off)
D8 to D10	1N4001 1A 50V rec. (3 off)
D11	tri-colour l.e.d.

Miscellaneous

S1	s.p.s.t. microswitch
S2	s.p.s.t. key operated switch
X1 to Xn	piezo transducers number as required
T1	9V-0-9V 20VA mains transformer
B1	6V 1AH sealed lead acid battery

Stereo jack plug and socket as required to connect sensors; l.e.d. mounting clips; 14 pin d.i.l., 16 pin d.i.l. and 8 pin d.i.l. (2 off) i.c. sockets; metal case approx 102mm x 102m x 180mm; p.c.b. available from the *EE PCB Service*, order code EE783; stripboard, 9 strips by 17 holes; sticky pads as required for sensors; tilt switches as required – see text.

Approx cost guidance only **£28** *Excluding battery*

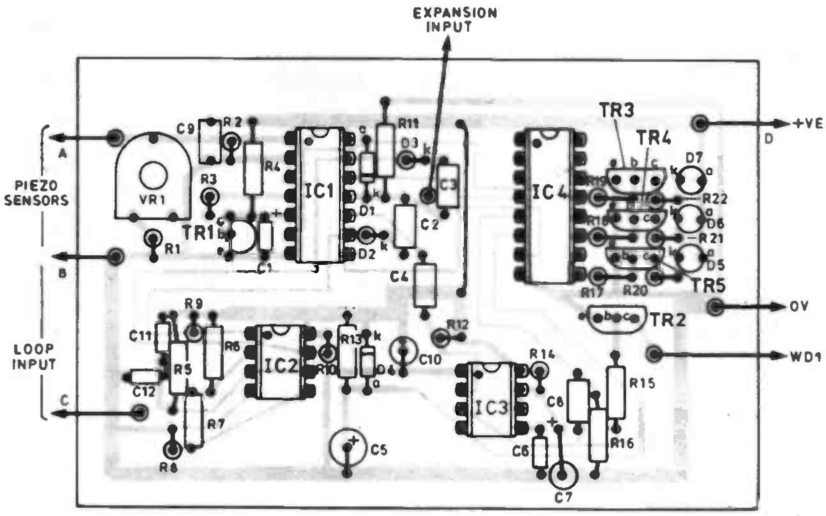
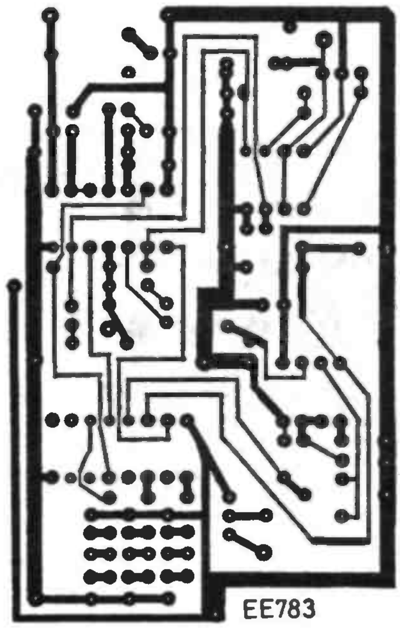


Fig. 6. P.C.B. layout and wiring for the Micro Sense Alarm.



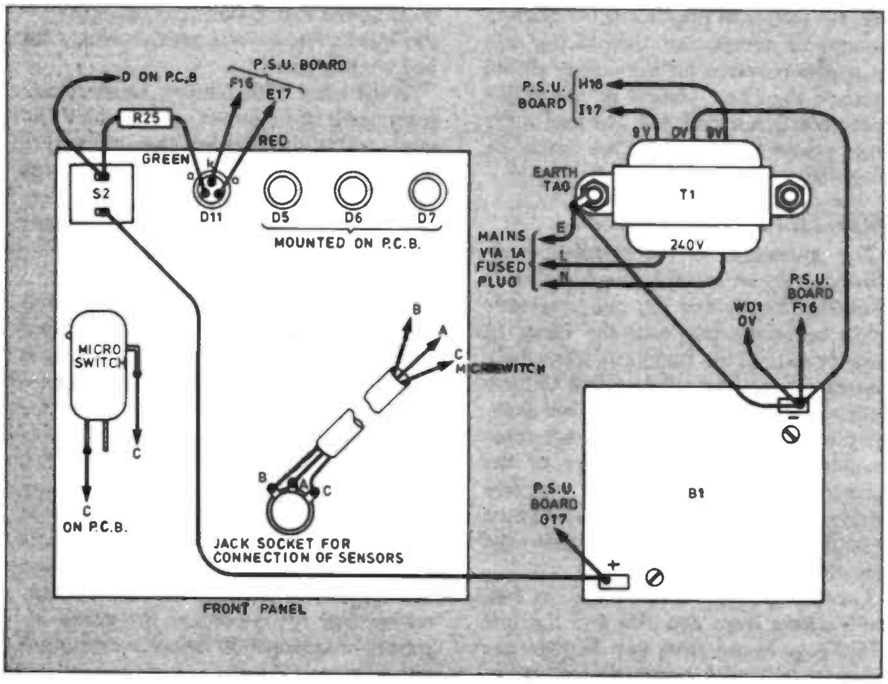
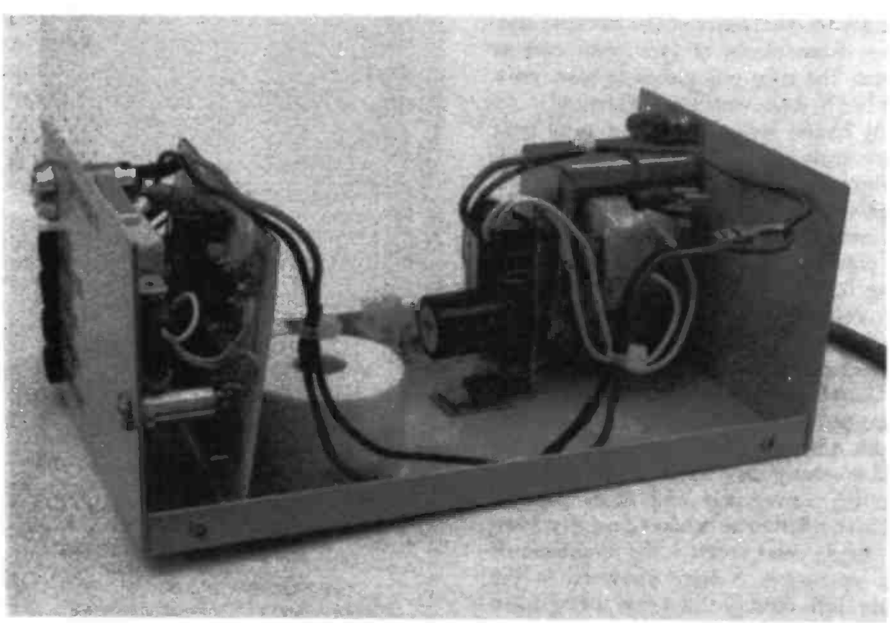


Fig. 7. Interwiring of the off-board components in the alarm.

Internal layout of the prototype alarm. The lead acid battery B1 has been removed to show the p.s.u. board and transformer.



ALARM BOARD

Assembly of the p.c.b. is quite straightforward (Fig. 6), insert the i.c. sockets and link first, then the diodes and resistors, and then the transistors, capacitors and Veropins. Before inserting the l.e.d.'s place insulation boots (or insulation stripped from some wire) ≅2.5cm long onto their leads and insert them into the p.c.b., also solder the large tag (screen) of the stereo socket firmly to the 0V pin (between the loop and sense inputs), connect the other leads and the buzzer.

After testing the board may be fixed into the case (see Fig. 7 for wiring information). The case used for the prototype was made of steel and is not recommended as it is quite hard to work with, cases of similar style made of aluminium are generally available.

POWER SUPPLY TESTING

When the power supply has been assembled in the box, you should check that the case is connected to earth, using an ohmmeter. When the mains is connected to the unit the output from the board should be set to 6.8 volts, by adjusting VR2.

Connect the sensors to the alarm board, and also a power supply (≅5V). Try connecting the security loop input to ground, and also disconnecting the wire from the input, both of these actions should cause the alarm to sound and the appropriate l.e.d.s to light, to reset the alarm remove and reconnect the power (**NOTE:** when testing the alarm it might be a good idea to cover the hole in the sounder with tape to lower the sound level slightly).

Tapping the piezo sensors with a small metal object should also set the alarm off. Adjust the sensors to the required sensitivity using VR1. When the unit has been tested it can then be installed in the drilled case as shown.

Switch S1 is a microswitch arranged so that it is held closed when the case is fixed together. Thus anyone opening the case will trigger the alarm. The unit is now ready for use. □

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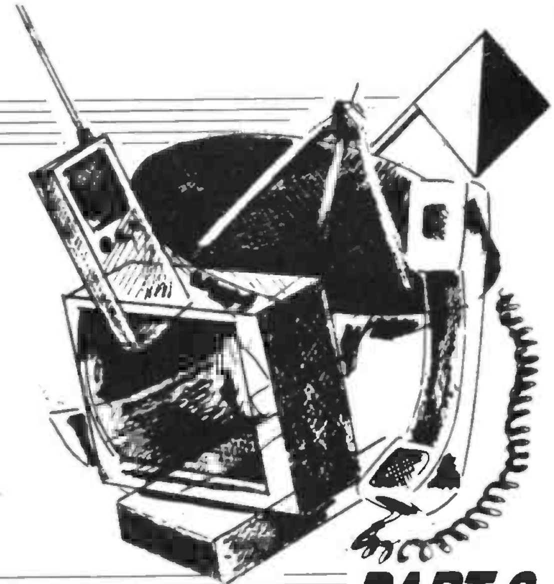


T. R. de VAUX BALBIRNIE **PART 3**

THIS is the third article in a 12-part series concerning Communication, Information Storage and related matters in the Science National Curriculum. Readers who have not been following the series are advised to read the first article (in November's issue) – this gives some background information which will be found useful. This month we will look at the topic of *Information Storage*.

Children should know that information in the form of number, text, pictures (graphics) and sound may be stored electronically using various everyday devices such as tape recorders and computers.

STORAGE OF INFORMATION

It often happens that information is only useful for a short while. For example, an invitation to a party the following day is unlikely to be of much value in a month's time. However, there are times when information needs to be *preserved* so that it may be *retrieved* at a later date. If you have money in the bank, the amount you have needs to be stored and the information updated whenever some is taken out or more is put in.

In ancient times, people stored information in the only way they knew how – by making drawings on the cave walls where they lived. Animals and everyday objects of the time were depicted painstakingly and in great detail. Man always seems to have had an urge to preserve the things in his daily life for others to see. Perhaps he saw this as a type of diary.

When man learnt to read and write, a far more versatile means of storing (by writing) and retrieving (by reading) information became possible. Some of the earliest writing has been found on clay tablets and dates from around 4000 BC. Later, large amounts of information were stored in the form of books.

The earliest books had to be written by hand using quill pens, usually by monks or scribes, and were only seen and used by the educated few. The work in producing them was so slow that only a few copies of a book could ever be made. Books could be collected together in libraries, much as they are today, to give access to massive amounts of information. One of the sadder stories concerns the burning of all the books in the Great Library of Alexandria by the Muslims in 642 AD. The loss to the world caused by this single act cannot be calculated.

PRINTING

The invention of the printing press allowed many copies of books to be made relatively cheaply and this put large-scale access to information into the hands of more people. There had been some early attempts at printing – the ancient Chinese made wood-cuts of characters, inked them, and pressed them on to paper. It was then possible to make several copies of the same small piece of information relatively quickly and easily. However, for something as large as a book this would have been very difficult.

The first printed books were, in fact, *scrolls* dating from 896 AD and the first folded page books, from 949 AD. No one knows exactly who invented "real" printing – and there certainly were some very early printed books. However, Johannes Gutenberg in the 15th century is accredited with producing the first practical printing press using moveable type. He made moulds for each letter of the alphabet and, from these, pieces of type were cast in metal. The type was placed in rows on a flat bed to make words and sentences.

By careful design, all the pieces of type were made the same height so they could be inked, gently pressed on to paper and a high-quality copy of a whole page made in one operation. His greatest task was to print the Bible in Latin – the "Gutenberg Bible" – this consisted of over 1200 two-column pages of 42 lines each (see photograph). Two hundred copies of the Gutenberg Bible were printed in 1456.

Gutenberg's basic printing method remained more or less unchanged for 400 years. Although of great importance, it was still relatively slow and not well suited to printing newspapers and other material which needed to be produced quickly. Even so, single news sheets – the forerunner of the newspaper – were produced in the early 16th century using this method and in 1622 the first commercial newspaper – *The Weekly News* – was printed using a flat bed printing press.

In the early 19th century, an automatic press using steam power was invented and this greatly speeded up the printing of sheets of newsprint – *The Times* was produced in this way. However, it was still slow by today's standards because the paper had to be manipulated in the machine sheet by sheet.

In the mid-19th century, the *rotary printing press* was invented and this, in modified form, is still used today – here the type is not set out on a flat bed as in the Gutenberg press but formed on the surface of a cylinder instead. The paper is in the form of a large roll. As the cylinder rotates, the paper rolls over it producing one copy after another very rapidly. The paper is then cut into sheets and folded. This is basically how newspapers (and magazines like *EE*) are printed today but modern technology has revolutionised the actual assembly of information before presenting it for printing.

The Gutenberg Bible
(Photo courtesy of The British Museum)

BOOKS

Books, of course, remain a vital form of information storage and modern technology has not reduced the importance of the printed word. The advantage of a book is that it is convenient, does not need a power supply and the information may be retrieved (by reading it) more or less anywhere. Moreover, once a person has learned to read, the whole world of books is available. No further specialized knowledge is needed.

This may be compared with information stored on a computer. A person must first learn to be *computer literate* but, unlike reading, this literacy needs to be constantly updated as new equipment becomes available. On the other hand, books are large compared with the amount of information stored. A complete set of telephone directories – about 100 books – for the United Kingdom is extremely bulky. This same information may be stored using a computer database in a very much smaller space. Moreover, the use of a database would enable you to find the telephone number you wanted far more quickly.

With books, it may be difficult carrying a large amount of information from one place to another. Also, the weight of a book may mean that the information would be costly and time-consuming to send long distances – by post.

Books are versatile in that they can store text, images (pictures and diagrams), numbers and music (in the form of a score). Until fairly recently banking was carried out manually by writing down all the details of deposits and credits in the various accounts in a ledger. This job is now done electronically using computers. Computers do the job faster, far more accurately and with the support of fewer people.

Most important of all, the information can be turned into electrical signals and sent along telephone wires from one computer to another. Money (in the form of electrical signals) may then be deposited or withdrawn automatically. Since a complete telephone network already exists, the signals may be sent from one bank to another – even in another country – conveniently and in practically no time at all.

STORING PICTURES

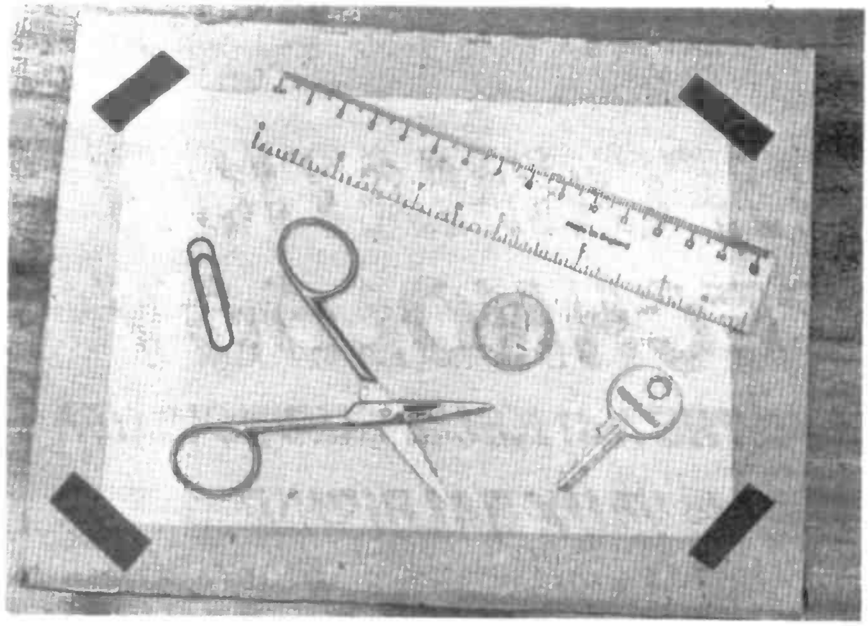
Photography enables man to store accurate visual information – a scene, person, etc. Previously, these had to be drawn or painted by hand. Painting was not always accurate – the painter often flattered the client because he or she was paying the fee! Like printing, no one actually invented photography – there had been several early experiments using chemicals which darken when light shines on them.

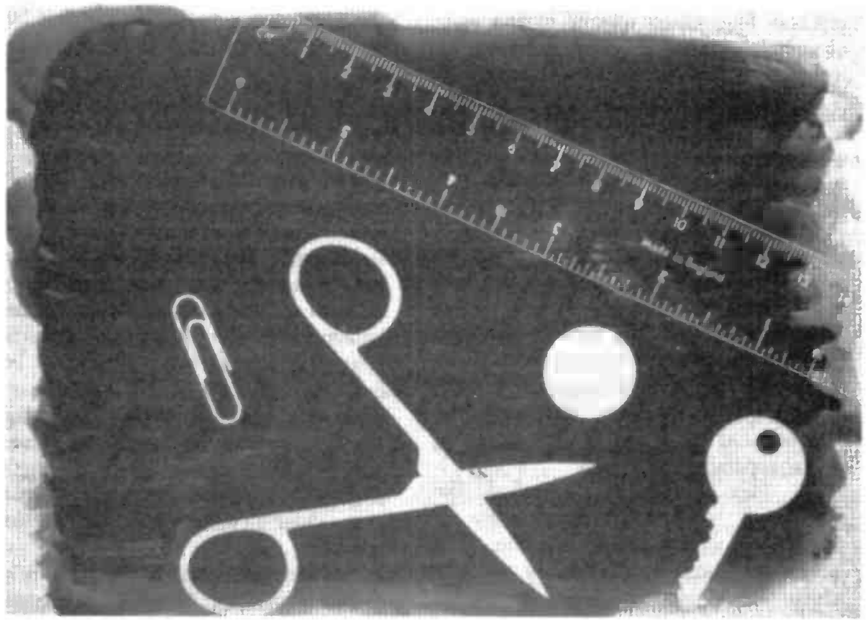
Joseph Niepce produced a successful photograph in 1826 but Henry Fox Talbot (1800-77), a British botanist and physicist, invented a photographic process using a *negative* which would be recognized by photographers today.

This experiment shows that chemicals containing silver darken when light shines on them and this can be used to produce a simple form of photograph called a "shadow photograph". *Note that this experiment should not be performed by young children and should be demonstrated. Since silver nitrate is poisonous and causes staining of the skin, rubber gloves should be worn throughout.*

You will need a small amount (about 10ml) of freshly made 2 per cent silver nitrate solution, a small artist's paintbrush and some writing paper. You will also need some scrap paper to work on. Keeping away from bright light, "paint" the silver nitrate solution on to the writing paper to make a 10cm square. Place the paper in a warm, dark place to dry. When it is dry, arrange some flat objects such as paper clips, scissors and a plastic rule on it.

Carefully carry the paper with the objects on it to a place where bright light – preferably sunlight – can shine on it. Do not allow the objects to move during the exposure. The paper will darken to a deep brown colour but the paper beneath the objects will remain white. This will happen in a few seconds in bright sunlight but may take several hours in weak daylight. If the objects are removed in a dim part of the room, their outlines will be clearly seen (see photograph). Unfortunately, the paper will darken all over and the images will fade in time.



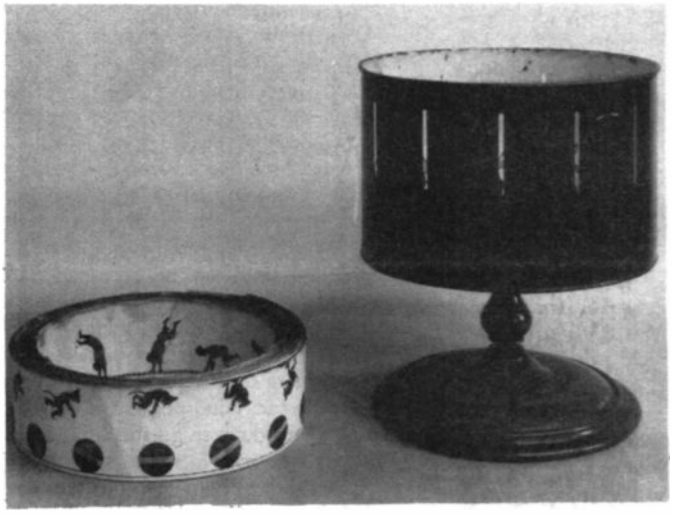


Making a shadow photograph (top) and the finished result (bottom).

MOVING PICTURES

To make *moving pictures* was an early dream of man. Some simple inventions appeared to show birds flying and other similar things by flashing drawings rapidly before the eye. The Zoetrope (see photograph) had a paper cylinder with a series of pictures painted on the inner surface. When the cylinder was rotated, and the pictures viewed through slits in the body of the device, the subject seemed to be moving naturally. However, this was nothing more than a toy.

Movie film (cinematography) remained a problem. Again, there was no one inventor but the French Lumiere developed a camera and projector



The Zoetrope a simple form of "moving pictures".
(Reproduced by permission of the Trustees of the Science Museum)

Thomas Alva Edison and his phonogram (1888) some cylinder recordings are shown.
(Reproduced by permission of the Trustees of the Science Museum)

celluloid film which worked in the style of modern equipment. They demonstrated their process in 1895. Here, information is stored as a succession of still pictures on transparent film. By projecting these in quick succession on to a screen, the impression of smooth movement is obtained.

STORING SOUND

Another of man's dreams was to preserve *sounds* – the spoken word and music. It was through Thomas Alva Edison's work with the electric telegraph (see last month's article) – recording the dots and dashes of the Morse code – which convinced him that speech itself could be recorded and subsequently replayed using similar apparatus.

His idea – which he called the *phonograph* – was to speak near a diaphragm which would vibrate. The diaphragm would be attached to a needle which would also vibrate. The needle would rest in a piece of tin foil wrapped around a revolving cylinder. The vibrating needle would produce a spiral groove in the tin foil and the modulations of this groove would carry all the information of the sound. To reproduce the sound, the needle would be placed at the beginning of the groove and the cylinder turned again. The needle would be made to vibrate by the undulations in the groove and hence the diaphragm would vibrate in sympathy. The original sound would then be reproduced.

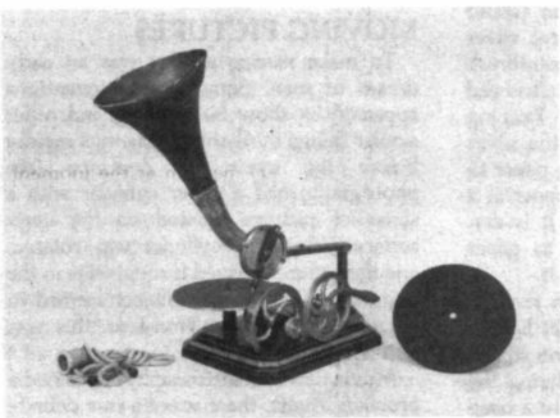
Edison successfully tested his phonograph in 1877 by speaking the words, "Mary had a little lamb". The oldest surviving cylinder recording in the BBC record library dates from 1884.

Although this method worked after a fashion, tin foil was found to be a poor material for the job and Edison made an improved version of the phonograph in 1888 using wax instead. Very soon, Emile Berliner replaced the cylinder with a flat disc rather like a present day record. Wax-covered cardboard was used and different needles were used for cutting and playing. The device was now known as a *gramophone* – a name which survives to this today.

The original records were "one-offs" and made for curiosity. To make more than one copy, it was necessary for the performer to speak or sing into a funnel from which several rubber tubes would radiate to a number of phonographs, each making its own record! To be an effective storage medium, records needed to be copied in bulk and pressing techniques for this were soon developed using a plastic material. These copies did not wear out as quickly as the wax master from which they were made.

With the triode valve having been invented by Lee de Forest (see last month's article), it became possible in the 1920's to use electronic techniques to make recordings. For this, a microphone turned the sounds into electrical signals which held all the information. These signals were magnified using a valve amplifier and the resulting output made to vibrate the needle of an electric cutter. Non-electric methods, however, were still used for playing the records back. The sound was made loud enough for household listening by playing the vibrations of the diaphragm into a large horn.

Early records had a very short playing time because they rotated at high speed – 78 r.p.m. (revolutions per minute). The playing time was increased by the invention of the long-playing record in the 1940's. This rotated at a far slower speed – 33 r.p.m. or 45 r.p.m. – and the grooves – *microgrooves* – were much closer together. In the meanwhile, inexpensive valve-operated record players became common in the home. These gave a better quality of reproduction as well as much louder sound compared with an *acoustic* gramophone. It is interesting to look at the groove of an old record using a low-power microscope.



Berliner disc gramophone (1890)
(Reproduced by permission of the Trustees of the Science Museum)

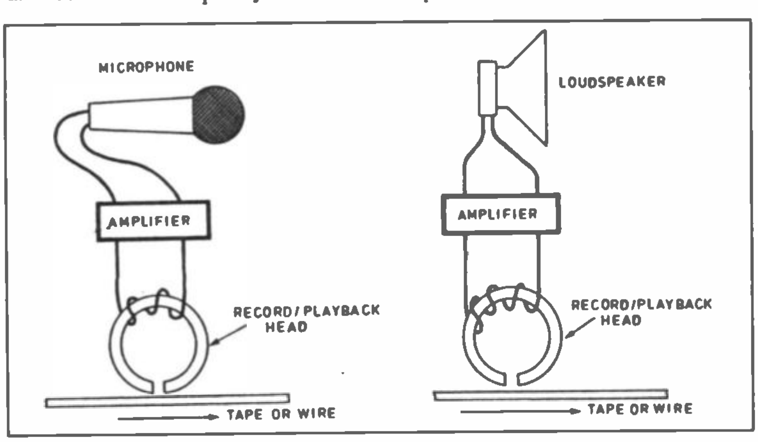


Fig. 1. Basic method of magnetic recording and replay.

RECORD EXPERIMENT

This experiment needs an old "useless" record and a sewing needle or pin. The needle is threaded through a small piece of paper to act as a diaphragm and held gently between the fingers of one child. Using a pencil or pen in the centre hole, another child turns the record steadily. The needle is now rested in the groove. The sound will be heard and the paper felt to be vibrating. This non-electric method clearly shows how the record groove produces vibrations which reproduce the original sound.

MAGNETIC RECORDING

A more recent advance is making sound recordings on *tape*. This method is widely used today – almost every home has a cassette recorder often combined with a radio. This method developed from early experimental recorders using steel wire which were tried at the turn of the century. In these, sound was picked up by a microphone and the electrical signals passed through a coil of wire wound on an iron core with a narrow gap (see Fig. 1).

The iron core was magnetized and the strength of its magnetization followed the pattern of the original sound. Steel wire was passed across the iron core and this picked up the magnetization. Steel – unlike iron, retains it magnetism so along the length of the wire was a magnetic imprint whose strength followed the sound pattern.

To replay the recording, the wire was rewound to the beginning and passed over the iron core again. Now the coil produced an electrical signal which reproduced the original sound in an earphone. This invention was ahead of its time and was waiting for Lee de Forest to invent the triode valve. This enabled the weak electrical signals to be amplified and fed to a loudspeaker.

Steel wire was found to be a poor material for the job and specially made tape was later used. Early magnetic tape used a paper base but this was easily damaged and later tape used a plastic material. In an improved form this is still used today. The base material is coated with a very thin layer of iron oxide (or similar magnetic material) which behaves like the steel wire described earlier.

Tape recorders began to appear in the 1940's in the home, for entertainment, and in offices as dictation machines. The original machines used *spools* of tape (open reel recorders) and similar open reel machines are still used by professional operators. Cassette recorders are more convenient and have largely replaced open reel recorders for household and semi-professional use but the principle of operation and type of recording tape used is the same.

One advantage of tape recording is the ease with which the recording may be erased and the tape used again (unlike disc recordings). Also, with open reel equipment, editing may be carried out – the tape cut in places, parts spliced in or removed, re-arranged, etc. Thus, a radio interview can have all the hesitations and mistakes removed before broadcasting it.

SOUND MOVIES

It is interesting to see how the two techniques – film making and sound recording came together to make sound movies. In some early films, the sound was recorded on a large diameter disc. However, it was difficult to keep accurate synchronization between the sound and picture (the lip movement and words fell out of step). Also, if the needle jumped or was knocked, synchronization was lost. This often happened and caused great amusement in the audience. Sometimes the only way to proceed was to start the reel of film again from the beginning!

Warner Brothers kept to this system even after optical sound recording had been perfected. Good quality optical sound recording was the invention of Lee de Forest (the inventor of the triode valve)

Fig. 2. An optical sound track running down the side of a film.

and he demonstrated his system in 1923 although there had been some unsuccessful attempts using similar methods previously.

In his system, the sound track ran along the edge of the film itself. This meant that there were no synchronization problems and the quality of the sound was much better. Fig. 2 shows the appearance of an optical sound track.

When the film was projected, light from a separate small lamp – the *exciter lamp* – shone through the sound track. The light passing through would then flicker in sympathy with the original sound. This light was picked up using a light-sensitive cell which produced varying electrical signals. The result was fed into the input of a valve amplifier and hence to a loudspeaker. In this way, the original sound was reproduced. Using this method *The Jazz Singer* was shown in 1928 and was an instant success.

Today, sound is stored using magnetic stripes on the film itself (see under Magnetic Recording).This has several advantages. Firstly, the quality is much better. Also, by using more than one track, *stereophonic* sound can be recorded and played back through more than one loudspeaker. With modern wide-screen films the sound will then appear to come from the actors themselves as they move across the screen. Loudspeakers all around the auditorium add even greater realism.

With the development of television, film-makers found themselves in competition with it and many improvements – some of them merely gimmicks – were used in an attempt to lure the audiences back to the cinema. Colour films succeeded because these could be shown in the cinema before colour television was available at home. Also the quality and breadth of the sound coupled with the large screen made the experience more realistic.

There were even attempts at 3D (three-dimensional) films. These involved the audience wearing special pairs of glasses without which the picture was simply a jumble; these were not popular.

VIDEO RECORDING

In the late 1950's special tape recorders succeeded in recording not only sound information but *television pictures* too. For technical reasons this is a difficult job and was waiting for more advanced technology to be developed. Before then, television programmes had to be made "live" and any recording made on film.

With video recording the programme could be recorded several times as necessary to produce a perfect result. Also, the tape could be edited like audio tape. This made programme production much simpler because all the scenes at one particular location could be made in one recording session, videotape editors could then assemble the whole programme in the right order and this is the technique used today. Now, videocassette recorders are familiar pieces of equipment.

A recent storage medium is the *Compact Disc*. This is usually thought of as being a *sound* storage medium. However, it may be used to store *text* and *pictures* too. In the future it will be used for much bulk storage of information – for example, maps and telephone directories. Unfortunately, the information stored on it cannot be updated – it is a *read only* medium at the moment. The Compact Disc is an important advance because it uses *digital technology*. The meaning of this will be explained in a future article.

CLOCKS AND WATCHES

A further modern device using digital technology is the electronic watch or clock. This is set with the correct information – the day, date, time and so on and this is updated automatically. The information may be retrieved by looking at the display (for the time) and by pressing various buttons (to recall the day, date, etc).

It would be useful for children to use a digital stop clock or watch for simple timing operations. You will probably find that they are better at setting these devices than you are!

STORING INSTRUCTIONS

Sometimes the information we wish to store is a *set of instructions* for a machine to follow. The most powerful way of doing this is by using a computer as we shall see later. However, it is worth mentioning "punched card" systems which are still in use today. Anyone who has looked around the back of an old fairground "steam" organ will have noticed that the music is stored in the form of holes punched in card. This rolls through the machine.

Today, we would call the information on the card a *program* since it tells the playing mechanism what to do and when to do it. Some Victorian table-top organs stored similar information on discs where raised protrusions on the surface pressed keys and allowed air to blow the pipes inside. Punched cards were used by Joseph Jacquard in the early 1800's to control the pattern of weave in his loom.

Today, car-wash machines often use a form of punched card which is fed into the machine and provides the instructions for exactly what kind of wash has been paid for. Early cash dispensers outside banks used punched cards. Today, these have been replaced by cards with magnetic striping. Here, information about the account is read from the card using a device similar to a tape recorder.

Today, a computer (the *hardware*) needs instructions (the *software*) to tell it what to do. We often store these instructions as a *program* on a *magnetic disc*. We shall be looking at some simple examples of this next month.

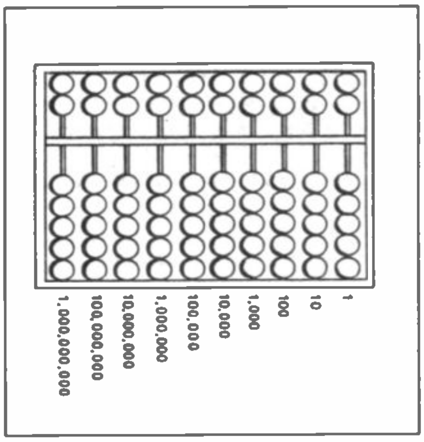
CALCULATOR

As well as text (writing), pictures and sound, we often need to store and work with *numbers*. We can enter a number in an electronic calculator and that number will remain in the calculator's memory. However, to use a calculator simply to store a number is a waste of a calculator's power. The same job could be done by writing it down on a piece of paper.

The advantage of a calculator is that as well as *storing* numbers, it can perform *calculations* on them too. Calculations which would be too time consuming for a human to do can now be done easily by an electronic calculator and with much less likelihood of error.

The first calculator was an *abacus* and although this has been around for some 5000 years it is still commonly used in China, the Middle East and Japan. It is likely that the abacus developed from the idea of making marks in a tray of sand with the finger. In use, beads are slid up and down rods.

In the most common type of abacus, the Chinese *suan pan*, there are several columns of beads with a cross piece to divide them into columns of two beads above and five below (see Fig. 3). In the right-hand column, the lower five beads represent *units* and those above the division *fives*. The next column represents *tens* and *fifties* and so on. By sliding the beads on the rods, a skilled operator can add and subtract numbers more quickly than by using an electronic calculator.



A Chinese abacus – these are still used in China.

In 1642, Pascal invented a calculating machine where numbers could be added together by entering them on dials at the front of the machine. In 1617 Leibnitz produced a calculator which could perform multiplication using toothed wheels. This type of technology was used until relatively recently. William Oughtred invented the *slide rule* which is still sometimes used today. This has a *cursor* which can move along the various scales on the ruler to perform multiplication and division. Someone is certain to have one of these at home.

These devices have the advantage of needing no power supply. However, there are many types of calculation which are not well suited to them, especially where very large or very small numbers are involved and the inexpensive electronic calculator is much faster and a great deal more versatile.

Calculators can only deal with numbers but computers can deal with text, images (graphics) and sound. In reality, a computer can only store *numbers*. Even when you think it is storing text or pictures it is really storing numbers. Every letter of the alphabet, upper and lower case, also punctuation marks and so, on, are turned into a code of numbers and it is really these which the computer is storing. When we recall the words we are recalling the numbers and the computer turns them back into letters of the alphabet. When storing a picture, it breaks the image into thousands of small squares (pixels) and stores these as numbers.

COMPUTERS

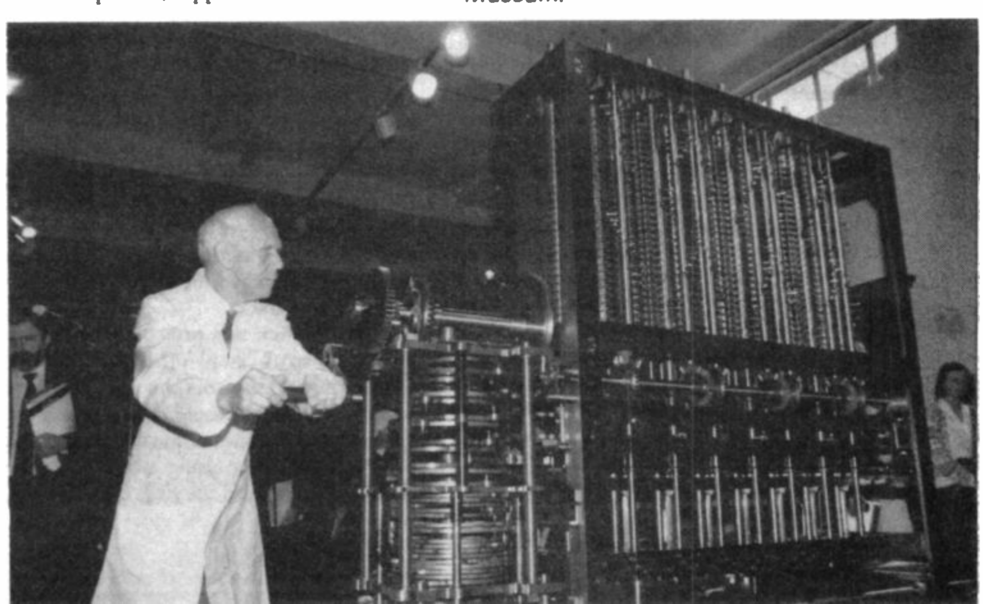
The first designs for machines which could be called true computers were made by the English mathematician Charles Babbage (1791-1871). In 1833 he designed his "Difference Engine No. 1" and in 1847 his "Difference Engine No. 2". He went on to design other machines – notably the "Analytical Engine". Unfortunately, none of his machines were ever completed because of the limitations of machine tool technology at that time.

Although the machines would today be classed as computers, they were designed long before the electronics age and were to be purely mechanical devices. The Second Difference Engine has recently being constructed using the original plans at the Science Museum in London. This uses 4,000 (excluding the printing mechanism which has not been built) parts and weighs approximately 3 tonnes. The total cost of building the machine and mounting a six month exhibition is £500,000. This exhibit demonstrates that these machines would have worked had it been possible to build them in Babbage's day.

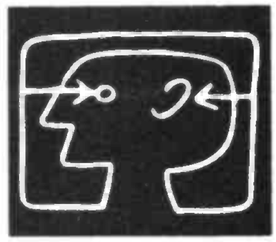
Similar but simpler mechanical devices were used until fairly recently for such calculations as insurance premiums and betting odds for dog races. By today's standards, mechanical computers are complicated, relatively slow, expensive, heavy and bulky. Also, because they were mechanical, parts would wear out so constant maintenance was required.

Next month we shall complete this topic by looking in more detail at the computer as a storage medium and also explore the range of microelectronic devices which are now found in everyday life.

Babbages Second Difference Engine being demonstrated at the Science Museum.



EUROPEAN INTERNATIONAL AUDIO and VIDEO FAIR



Barry Fox reports from Berlin on the latest trends in home entertainment on show at the Funkausstellung '91 exhibition.

EVERY two years since 1924, with only the war years missing, the city of Berlin has staged a radio show or Funkausstellung. The radio show has now become an international "world of consumer electronics" exhibition taking in TV, video, satellite, telecommunications, computers, games, hi fi and electronic gadgetry.

Manufacturers from all round the world now see the *Internationale Funkausstellung*, or IFA, as the prime pad for launching new products into Europe. This year IFA was bigger than ever, with 571 exhibitors from 29 countries spread through 25 enormous exhibition halls. Despite an entry fee to the public of 15 German marks (around £5 pounds) the organisers expected nearly a million visitors during the ten day show.

For the first time since 1961, visitors came over from the East. Where the Berlin wall once stood, there is now just a strip of land with not a trace of the concrete obscenity which for thirty years split the city in two. In fact the only trace of the wall are the pieces of rubble which street merchants now sell off as souvenirs.

Significantly, satellite aerials are now sprouting over the drab concrete appartment blocks and old housing (some still bomb-damaged and shell-pocked) in the Eastern sector.

IFA saw the usual crop of electronic novelties, and the emergence of several distinct trends in the consumer electronics industry.

Whats Up Mac

In the run-up to opening-day all eyes had been on Philips and Sony who were due to try and build confidence in their new home digital recording systems, Digital Compact Cassette and Mini Disc. There was also clearly a row brewing between the satellite broadcasters, such as BSkyB, who want to continue transmitting in PAL, and European electronics companies who have invested heavily in the development of MAC and high definition MAC technology. As the show opened a temporary truce between Philips and Sony collapsed and the simmering bitterness between the PAL and MAC factions flared into open warfare.

By 1992 the Eureka 95 team of 1000 engineers will have spent over £500 million pounds on an HDTV system to broadcast the Olympics to 1000 HDTV sets across Europe. The HDTV system is a 1250 line version of the 625 line MAC system developed for satellite. If MAC fails, so does HD-MAC. Most satellite broadcasters, like Rupert Murdoch's BSkyB, are scorning MAC and using the terrestrial PAL system.

In Berlin Peter Bogels, President of the EU-95 HDTV directorate, blamed the European Commission for leaving PAL loopholes in its 1986 MAC Directive.

"There was a flaw, a hole in the law, that let people start PAL transmissions", said Bogels. Despite the magnitude of the EC's mistake no one in the HDTV directorate can say who in the EC was responsible.

EC Telecommunications Commissioner, Filippo Maria Pandolfi recently met Rupert Murdoch in Brussels and joined German Telecommunications Minister, Christian Schwarz-Schilling in Berlin to announce the EC's latest plan. This doubles, to 1Bn ECUs, the European tax payers' money available for simultaneously broadcasting PAL programmes in MAC until January 1994. Any new broadcaster now starting in PAL must switch to MAC in 1994 and will not be paid the sweetener to simulcast.

Pandolfi has now asked a Working Group to report by 15 September on whether there will be enough satellite transmitters in orbit to cope with simulcasting.

Eight German broadcasters (ARD, ZDF, RTL Plus, Sat I, Pro 7, Tele 5, Premiere and VPRT) issued a statement saying "No" to the proposal because "it is not fair for the EC to make this law and not friendly for the consumer or for owners of satellites or receivers in Europe".

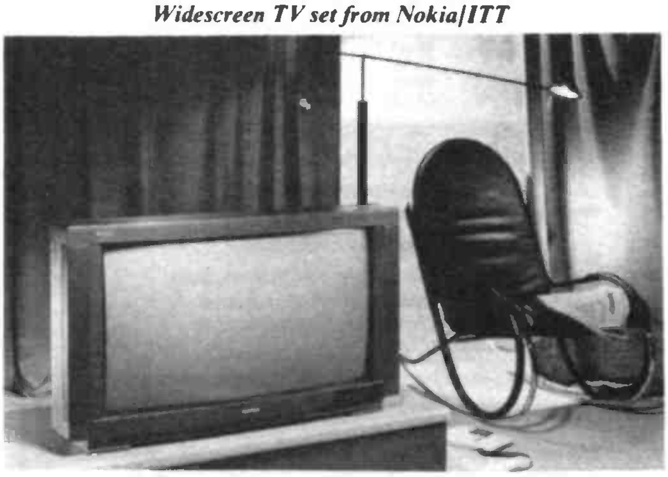
Although demonstrations of the 1250 line HD MAC system at Berlin were impressive, parallel demonstrations intended to show how HDTV signals can also be received on 625 line MAC sets were disappointing.

Although this was due to technical defects in the cable relay system used on the enormous exhibtion site, no one told the million visitors expected. Whereas the ditigal circuits in a full-blown HDTV set can compensate for spurious echo signals, other sets cannot.

The first demonstration of a wide screen PAL system, PAL Plus, which Grundig, Nokia, Philips, Thomson and European broadcasters have been developing in parallel with HDTV, gave better pictures than the MAC demonstrations. To avoid undermining MAC's credibility, the PAL Plus designers stress that their system is intended only for terrestrial use. But they admit it could equally well be used by satellites.

To transmit PAL Plus, the broadcaster feeds a 625 or 1250 line wide screen picture signal through a digi-

Widescreen TV set from Nokia/ITT



The HK33 LD multi-media laser-disc system from Sharp brings all the fun of "Koraoke" into the home. The system is claimed to allow anyone to "sing-along" with the video clips of their favourite stars.

tal filter. This reduces the number of picture scanning lines by a quarter. The remaining three quarters appear on a conventional 4:3 aspect ratio PAL TV set as a letterbox picture, with black borders at the top and bottom.

The filtered information is converted into a digital "helper" signal like teletext. This helper is buried in the black borders of the letterbox picture as a signal which conventional TV sets treat as pure black. So the helper code is invisible on conventional sets. A PAL Plus receiver decodes the helper to rebuild a 625 line picture which fills the full area of a 16:9 wide aspect screen. Demonstrations given at Berlin prove that the "helped" signal is clearer than the orginal.

Behind Closed Doors

Pre-show leaks had Philips and Sony doing a cross-licencing deal on their new, rival, home digital recording systems, Digital Compact Cassette (Philips) and Mini Disc (Sony). There were no such deals. And both companies badly fumbled their pitch. It is a measure of the strength of DCC that the format still looks likely to prevail over MD.

The show opened with no sign of MD or DCC on Sony's public stand. Upstairs, in a closed room behind a wall of bureaucratic security the trade and press could see MD, with descriptive plackards and literature round the room. A DCC player (one of the many hand-built models made by Philips) sat on a shelf, without any descriptive material, like an unwelcome corpse.

The was no sign of DCC or Mini Disc on the Philips stand either. This in itself was a surprise bearing in mind the considerable amount of advance publicity which DCC has generated. Upstairs, and behind similarly bureaucratic security, Philips demonstrated DCC in a studio room and had four units in a glass case. The top end DCC-900 will be launched in the spring, the mid-range DCC-300 in the late summer along with the DCC-180 "portable personal", and a car player due towards the end of 1992.

At Sony's press conference Kozo Ohsone, Senior Managing Director of Sony and Jack Schmuckli, Chairman of Sony's European operations, claimed that Mini Disc was being "endorsed by major players in the software industry such as EMI, Warner and Sony's own CBS group". Sony also distributed a document which clearly promised that Sony, EMI, Warner, Virgin and BMG "will support Mini Disc". A question and answer session proved this to be pure wishful fantasy.

Said Christian Jorg, BMG's Manager of New Technologies (representing RCA, Ariola and Arista), "We are interested in Mini Disc. We would like to evaluate it. But we are quite a way from introducing it. It does not have our full support at this point. No decision has yet been made about it and when we will release material on Mini Disc".

BMG's Chairman Michael Dornemann had already written to Michael Schulhof, President of Sony Software, CBS. "Clearly BMG needs more information on Mini Disc before we can begin to consider marketing and manufacturing preparations".

A spokesman for EMI was equally vague. "We have an open mind to every carrier ....". Geoff Holmes, Senior Vice President of Time Warner, (Warner, Elektra and Atlantic) was equally reserved. "It is too early to talk. We are evaluating MD". The man from Virgin never showed up.

Back in London Virgin confirmed there had been no deal with with either Philips or Sony.

"If the public wants it we will sell it" said Virgin.

No Endorsement

Prior to the show there had been agreement between Philips and Sony that each would exhibit each other's format. "I don't know what they've done with ours", admitted Schmuckli. In fact Philips had sent it straight to Eindhoven for technical evaluation.

Around 500 people attended the Philips' press conference and many left bitterly disappointed. Completely misreading the predominantly technical environment at Berlin, Philips sailed in with a patronizing presentation that centred round a clumsy audio-visual show anchored by Peter McCann, described by Philips Audio MD Wim Wielans as from the BBC's Tomorrow's World. As a matter of record, McCann left TW in June.

Both McCann and Wielans repeatedly used the slogan "everybody is supporting DCC". Even with the qualification which McCann later added, "by which we mean everyone in the whole chain of the music industry who is of importance", this claim is patently and blatantly untrue.

BASF are committed to tape production. For hardware, Grundig, B&O, Thomson, Sanyo, Sharp and Yamaha are on board with Matsushita (Panasonic/Technics) and Tandy.

Philips has much stronger software support than Mini Disc, but missed the trick of bringing this out at the press conference; there was no Question and Answer session.

Whole strings of Japanese electronics companies, including Sony, Pioneer, JVC, Denon, Mitsubishi, Akai, Trio-Kenwood and Toshiba have not yet signed to support DCC. Neither have tape companies TDK or Maxell.

The rest of the industry may very well back DCC in the future, but at present for Philips to say that "everybody is supporting DCC" is as inaccurate and foolhardy as the origial slogan Philips coined for CD, "perfect sound for ever". As proved by the poor quality of early CD players and the scare over discs which failed because the air got to the aluminium reflective layer, nothing is perfect and nothing lasts for ever.

Mobile Library

Although Philips looks likely to win the battle for a new *de-facto* home digital audio standard with DCC, Sony is surely onto a winner with Data Discman, launched last July in Japan. Tagged "Tomorrow's Mobile Library", this is a portable CD player with an LCD screen and small Qwerty keyboard. It plays 8cm CD-ROM discs which contain reference works, text books, foreign language dictionaries and encyclopaedias. The 8cm disc has a storage capacity of 200 megabytes. Although this is only one-third the storage capacity of a full size, 12cm CD-ROM, it is more than enough to hold several volumes of an encyclopaedia.

Data Discman has been a success in Japan with over 130,000 units sold and 35 disc titles now available. The Discman ROM discs are incompatible with existing CD-ROM computer systems and with the CD-Interactive system to be launched next year. Also, although the portable unit can be connected by video lead to a TV screen for clearer display there is no socket for connection to a computer. This is deliberate policy. It prevents users downloading text or data from an electronic book. This restriction has encouraged publishers to support the format.

Data Discman will go on sale in Germany this November, for around 1000 DM (around £350) with 14 electronic books including Langenscheidt's English/German dictionary and the Bertelsmann Universal Lexicon. Sony plans a launch in the UK early next year with English language titles.

Data Discman could finally make electronic publishing a reality. Although many electronic books and databases are already available on 12cm CD-ROM, a mish-mash of standards requires that the set-up for a Personal Computer with CD-ROM drive must be fine-tuned to run each CD-ROM in turn, with the set-up for one disc not working for another. By creating a new standard for Data Discman Sony guarantees the user buy-and-play simplicity, while protecting the publisher from piracy.

Travelling Light

Every year it seems that manufacturers cannot possibly make video camcorders any lighter or any smaller. Virtually all now use a tiny solid state image sensor (CCD chip, less than 1cm in size) behind the lens instead of the bulky tube sensors used in early video cameras. But every year the rival manufacturers manage to shave off a few more grams and centimetres. This brings its own penalties. Panasonic now builds an electronic image stabilizer into its Palmcorder, a VHS-C camcorder with 12:1 zoom lens weighing 700 grams. The image stabilizer compensates for the unsteadiness in pictures shot with a light camcorder that fits in the palm of a hand.

Sony now claims the record for the smallest and lightest camcorder in the world. The new Traveller TR-705 weighs just 590 grams and will sell for under £1000. The remarkable feature of the Traveller is that it is a Hi-8 recorder, the 8mm video equivalent of Super VHS.

The VHS-C NV-35 Palmcorder from Panasonic weighs in at only 700grams.

Pictures are better than broadcast quality. The Traveller also records sound in stereo.

Hitachi is now introducing new technology which will let camcorders get even smaller and lighter in the future. Its new 8mm models VM-23 and VM-25 convert the analogue signal which comes from the image sensor into digital code. All the processing work which must be done on the picture signal before it is recorded can now be in the digital domain. This reduces the amount of circuitry needed because it much easier to integrate digital systems into a single chip than analogue systems. Witness the way watches and claculators have got smaller and cheaper, with more and more facilities.

TV Mouse

Nokia/ITT is already selling table-top VCRs with a system called ASO (Active Sideband Optimum) which gives clearer pictures from poor recordings, e.g. old tapes. ASO works by cleaning up the f.m. video signal which comes off the tape before it is demodulated and processed by all the conventional circuitry in a VHS recorder. Now Nokia has developed ASO Plus, which goes one stage further.

ASO Plus continually monitors the condition of the f.m. signal coming off tape and applies only the amount of clean-up processing that the signal needs. So the recorder gets the best possible picture from any tape, whether old and worn or brand new.

Japanese company Sanyo uses ASO, but probably only because Sanyo makes Nokia's VCRs under subcontract in Japan. So far no other Japanese company has taken up Nokia's system. Nokia's new slogan is, "The sharpest image VHS video ever had to offer". But JVC, inventor of the VHS video system is not impressed and has no plans to use ASO.

Nokia may have more success with a clever new remote control for a TV set or VCR. It works like a computer mouse. The viewer just presses a couple of buttons to display a cursor on screen and then tilts the control from left to right or up and down to move the cursor and select options from a menu. The control has a tiny roller ball, like a ball bearing, hidden inside. The ball rolls between infra-red diode light sources and light sensors to generate an electrical signal which indicates the physical position of the controller. This signal is then translated into a control signal which moves the cursor on screen.

CD Photos

Over the last ten years portable video recorders and camcorders have completely killed the small gauge, home movie film industry. Kodak no longer even makes Standard 8 movie film and Super 8 cartridges are increasingly hard to find in the shops. Now there is a trend towards electronic still imaging. Kodak argues that electronic still cameras can never match the resolution of 35mm camera slide film and is committed to the hybrid system called Photo CD. At Berlin Kodak confirmed plans to launch this new system in the UK next June.

Photographers will shoot pictures with conventional cameras and conventional film and have it processed in the usual way. Then they will pay a Photo CD centre to convert the pictures into digital code and transfer up to 100 onto a 12cm CD. This Photo CD will play on a Photo CD player, looking like a CD player, which displays the pictures on the screen of any TV set.

The images stored on the disc are of a far higher quality than any TV screen can display (four times the resolution of a high definition TV picture and fifteen times the resolution of a conventional TV picture) so photographers can use their Photo CDs as a storage and quick display medium. They will then pay the Photo CD centre to make high quality paper prints of selected images.

The new VHS cassette from BASF has a sliding record/save tab.

Breakdown of the Nokia TV Mouse controller showing the roller ball between the l.e.d. sensors.

Philips will make Photo CD players for Kodak to sell under the Kodak brand name. Other manufacturers will be able to buy a circuit board which performs all the vital functions. Kodak hopes that this will encourage other firms to start selling their own-brand Photo CD players.

Unlike all other new formats Photo CD has the advantage that it is not dependent on pre-recorded software. Photographers are in effect creating their own Photo CD software.

The big question mark is over price. Kodak may well be able to meet the promised price tag of around £300 for a player (which also plays audio discs) but the predicted prices for transferring snapshots to Photo CD look very over-optimistic. At Berlin Kodak reiterated its pledge that the Photo CD Centre will charge less than £10 to transfer 24 pictures from film to disc. Having in mind the heavy capital investment in transfer equipment (up to £100,000) the cost of blank record-capable CDs (currently around £30 each) and the cost of labour to control the transfer process, it is hard to swallow the £10 price promise.

Kodak says that volume production of discs will drastically reduce their price. But I now have a bet (one pint of beer) with Kodak's head of public relations and legal affairs in Europe, Dr. Karl Steinorth. At Berlin I bet him that the cost of transferring 24 pictures will be higher than the 25-30 DM (well under £10) he pledged at Berlin.

In Japan both Sony and Canon sell electronic still picture cameras which record 50 images on a 5cm (2in.) magnetic floppy computer disc. Both companies launched in the USA but sales were slow. Sony never launched its Mavica system in Europe but Canon went ahead with the Ion. Sales of the Ion have been slow too, for one very simple reason. People like to carry snapshot prints around in their wallets to show to friends. An electronic still camera must be connected to a TV set to display images.

New Trends

At Berlin Panasonic announced a video printer which can connect to a video recorder, or electronic still camera, and make a paper print from the video image. But the Panasonic Movie Printer, which goes on sale this winter, will cost at least £1000, with blank paper as costly as photographic paper.

To solve the cost problem Canon unveiled its "Ion print service" at Berlin. Canon says that by the end of 1992 over 1000 hi fi, video and camera shops throughout Europe will have installed a video printer. Photographers will take electronic snapshots on an Ion camera and then take the floppy disc to their nearest Ion service centre. There they will tell a sales assistant which of the 50 images on the disc they want printed. Each colour print will take around two minutes to make, and cost around 75p. The printer is controlled by a Commodore Amiga computer, which allows some manipulation of the image before printing. Although the system works well print quality is frankly poor – generally inferior to a Polaroid instant picture print.

BASF has a neat idea for a new range of VHS cassettes. It is borrowed from the 8mm video format. On audio cassettes users prevent accidental erasure or over-recording by breaking off a safety tag on the rear edge of the cassette. The same system is used for VHS. The only way then to record on a protected cassette is to stick Sellotape over the gap left by the broken tag, which is inelegant.

Video 8 cassettes have a sliding tag, similar to the sliding tag on 3.5in. computer floppy discs. Now BASF has made a VHS cassette with a sliding tab instead of the usual breakable tag. First prototypes use a red tag but BASF will change it to green, reasoning that it makes more sense to have a "green for go" signal.

Now that wide screen 16:9 aspect ratio TV sets are coming on the market (from Thomson/Ferguson, Nokia/ITT and Philips), manufacturers are looking at ways of using home video as a source of wide screen material. JVC in Japan already sells an anamorphic lens adaptor for its camcorders. This optically squeezes a wide screen image into the conventional 4:3 picture area, just like a Cinemascope cinema film camera. The tape is played back on a conventional VCR, and for viewing is projected onto a screen with an anamorphic lens over it.

The more elegant approach is to squeeze and unsqueeze the image electronically, without the use of extra lenses. This is done by altering the speed at which the picture lines are scanned. A standard already exists for doing this.

At Berlin JVC announced that it will soon start selling a

Super VHS recorder which will electronically compress a wide screen image for replay on wide screen TV sets. The HR-S 4700 also has circuitry which automatically detects whether the image recorded on tape is of conventional 4:3 size or compressed 16:9 wide screen format. It then decodes the picture, depending on aspect ratio.

Initially the HR-S4700 will be of most use for playing back pre-recorded tapes of wide screen films made in compressed format. Thomson/Feguson already has plans to subsidise the duplications of widescreen movie tapes. But the logical next step is a camcorder with the ability to record electronically compressed wide screen images. Although there is so far no VHS camcorder which plays this trick, Hitachi showed the pre-production prototype of an 8mm camcorder which can shoot in either wide screen or conventional 4:3 format.

This Hitachi camcorder has a CCD image sensor which has wide screen, 16:9 aspect ratio. For wide screen filming, the full area of the CCD is used, with the picture electronically compressed into 4:3 format for recording onto tape. For 4:3 shooting, the camera uses only part of the CCD image sensor area. Electronic compression is made easier because the camcorder uses Hitachi's digital signal processing circuitry.

The widescreen pictures shown at Berlin on a wide format back projection screen were very impressive. This must surely be the way amateur video movie making goes in the future.

The new Photo CD discs and player from Kodak. The latest Philips widescreen TV can be seen in the background.

Cinevision

Berlin was seen by the European TV manufacturers as the launch pad for widescreen TV sets, with an aspect ratio of 16:9. The manufacturers have now coined the neat name tag "Cinevision".

There is mounting confusion over just what the various new widescreen sets offer, and what compromises they adopt. To try and clear the air I put together a short summary in the simplest words I could find and then got all three manufacturers, Philips, Nokia/ITT and Thomson/Ferguson to check it for accuracy.

Conventional 625 line TV in Europe displays 50 images a second, each made up from 312.5 lines, vertically staggered so that they interlace to create the illusion of twenty five 625 line pictures a second.

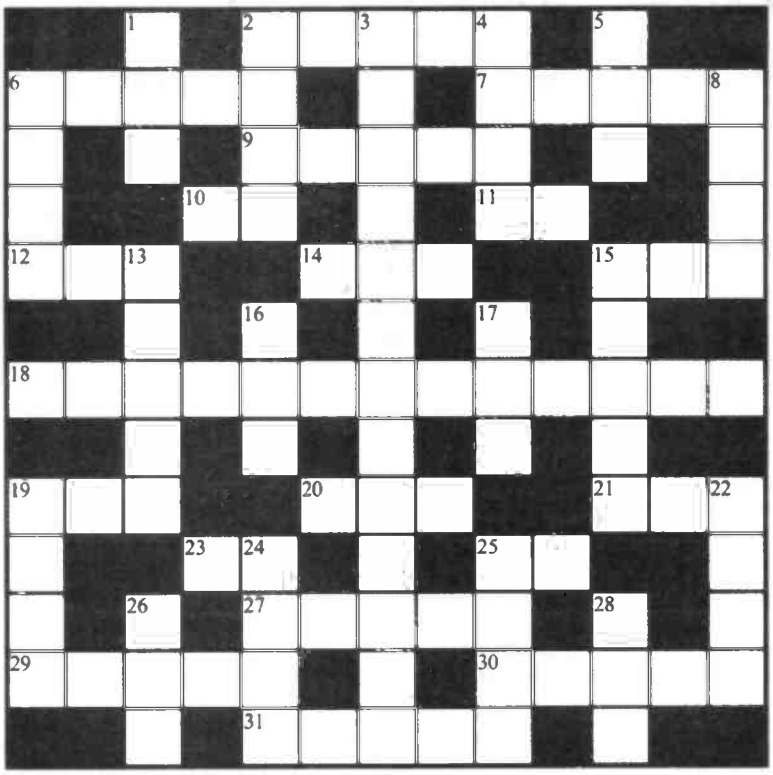
Philips and Grundig are already building 100Hz circuitry into their large screen 4:3 TV sets. Some people, especially if used to North American NTSC TV which has a picture rate of 60Hz, find wide area flicker very noticeable on European 50Hz TV sets. At 100Hz flicker disappears completely.

The Ferguson Space System 16:9 wide screen set, and also Nokia's, doubles the line structure from 625 to 1250 but retains an interlaced structure and retains the 50Hz field rate. So there are 50 images a second, each made up from 625 lines staggered to interlace on screen as a 50Hz, 1250 line picture.

The Philips widescreen set retains the 625 line interlaced structure, but doubles the field rate from 50Hz to 100Hz. So there are 100 images a second, each made up from 312.5 lines, staggered to create the illusion of fifty, 625 line pictures.

Philips will move next to 625 line "progressive" scan at 100 Hz, with 100 images a second each made up from a full 625 lines.

EE CROSSWORD



Across

2 Some call a servant, a shining light,
It's straight and narrow, all right?

6 Very tiny, but just the same,
A thousand micro's this contains.

7 A useful amp, that 741,
So Pam Perkins now has one.

9 Electric pressures rule the game,
I x R equals the same.

10 The initial start I want to see,
Of a rival to EE.

11 Likewise of 10 across,
This time the BEST – the Boss!

12 Current is limited, there's no chance,
But Oh Mum! She has resistance.

14 Transistor's are all the same, some moan,
But this one's in a field of its own.

15 Some words reversed have a value of none,
This little gem is worth a million.

18 Such a variable device, my dear,
To measure one's potency, we hear.

19 Let there be light, and resistance low.
What is it, initially, I want to know.

20 Although not manual, this feedback is able,
It's in my bag contents and keeps me stable.

21 A large source of energy, it can't be seen,
The MP holds it, if you see what I mean.

23 Not NOT, nor NOR, this gate can be,
But any high input, a high output you'll see.

25 No connection, but there should be,
It is a fault? It could be.

27 "Hear this!" he said "The answer's within."
It will provide a thorough grounding.

29 On the end of a 'scope lead, to prod so willing,
But first stop Robert, he holds it within.

30 Electric, water or gas, it could be,
Most likely 240 volts a.c.

31 Is this a golf course, we hear?
Just short connections from there to here.

Down

1 Digital electronics is the order of the day,
Initially, it's an uncommitted logical array.

2 Far from dead, this brown wire be,
Potentially dangerous, go carefully!

3 A burning need that won't melt your heart,
A bit too hot to handle this part.

4 One by any other name, but so appealing,
This holds wires in the ceiling.

5 A memory so lecherous, we hear,
It's random and without Visa. Oh dear!

6 A sound where left and right compare,
Fine if you only have one ear.

8 A male connection and that's a fact,
Just gulp backwards to make contact.

13 Swinging needle or LCD,
It'll measure the same with accuracy.

15 It's a good yardstick for some,
And sounds just like 13 down.

16 All inputs up switch and output too,
This clever gate hides in sand for you.

17 This is motivation initially,
Applied to electronic circuitry.

19 Freed from darkness but still in clamps,
This shining example might draw amps.

22 Some good contacts must be found,
They'll be a snip, the other way round.

24 For wire or solder this can be,
It sounds genuine enough to me.

25 As 12 Across, but plural you see,
A James Bond Movie, initially.

26 It's not paper, you can't write to this,
But you can read, only memory it is.

28 Noah led his animals with this direction,
This i.c. socket will make the connection.

Seasons greetings to all our readers

These puzzles are for fun only. See page 51 for solution.

EE WORD SEARCH

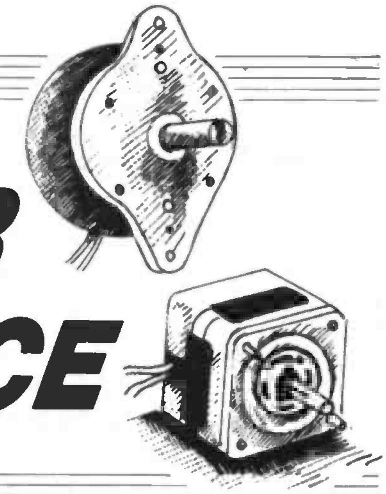
All the words in this Word Search are to do with electronics. When all the words are found, the remaining letters, starting from the top left hand corner, will spell out a familiar title and a name associated with it. Every letter is used.

E	L	B	A	T	S	A	E	O	P	A	M	P
G	V	I	N	F	R	A	R	E	D	E	O	R
A	U	Y	N	D	A	A	G	C	Y	W	S	E
T	W	L	L	E	D	E	E	D	E	W	F	C
L	T	I	P	A	A	R	O	R	I	M	E	N
O	A	I	R	C	S	R	S	T	E	O	T	S
V	M	M	I	E	I	U	C	K	R	P	D	P
S	N	I	P	E	P	H	A	S	E	A	M	E
L	K	E	P	P	O	N	L	E	D	W	C	A
O	H	M	L	K	R	E	E	L	L	T	A	K
Q	R	Y	E	R	A	W	T	F	O	S	D	E
T	I	M	E	R	O	T	S	I	S	E	R	R
R	E	T	E	M	O	I	T	N	E	T	O	P

The words to find are:

ADC
AGC
AMPERE
ASTABLE
CHOKE
DIODE
EMF
INFRA RED
LAMP
LED
LINEAR
MOSFET
OHM
OP AMP
PHASE
PINS
PLUG
POTENTIOMETER
POWER SUPPLY
RADAR
REEL
RESISTOR
RIPPLE
SCALE
SOFTWARE
SOLDER
SPEAKER
SWITCH
TEST
TRACK
TIMER
TOOLS
VOLTAGE
WIRE

Constructional Project



STEPPING MOTOR DRIVER/INTERFACE

MARK STUART

An explanation of stepping motor operation plus a stand-alone demonstration/driver board which also allows computer drive.

STEPPING motors have always provided one of the simplest ways of producing controlled movement in a wide range of hobby, commercial, and industrial applications. Although mechanically very simple, their electrical drive requirements are more complicated, requiring special driver i.c.s which are in turn driven from a computer.

For many applications the computer programming is simple, providing no more than a measured pulse train to the driver i.c. In these circumstances an excessive amount of computer time can be wasted just running the motor to evaluate its mechanical performance. Where computer access is limited, as in a teaching environment, any means of saving computer time is valuable.

This project allows stepping motors to be operated and demonstrated without tying up a computer, but also includes a computer interface which allows full computer control when required. It is an ideal means of testing and evaluating stepping motor applications and projects, and allows excellent classroom demonstrations. The design is the result of many requests from teachers, and others, over the past few years and it is hoped that it meets most of their requirements.

FEATURES

The circuit can drive almost any standard four phase unipolar stepping motor in Full Step, Half Step, or One Phase mode, with variable speed and acceleration, and with continuous l.e.d. monitoring of the winding energisation sequences. Two preset speed controls allow instantaneous Start/Stop operation for low speeds and low inertia loads, and Ramp Up/Ramp Down operation for high speeds and high inertia loads.

A third control allows the ramp time to be adjusted to match the load. The low and high speed controls can be used together to give instant starting to low speed followed by ramped acceleration and deceleration to and from a higher speed.

A separate power supply is required; 12V at 1A is sufficient for most small motors but up to 35 volts and 1.5A can be handled by the output driver i.c. which has built in thermal protection. An on-board voltage regulator provides a 5 volt supply from the main motor supply for the low power section of the circuit.

The main driver i.c.'s inputs are all accessible via a single-in-line eight way plug on the board which allows direct computer control without having to change any links or switches.

STEPPING MOTOR PRINCIPLES

The operation of stepping motors is best explained by means of Fig. 1 which shows a diagram of an elementary motor with a single permanent magnet for a rotor and two pairs of electromagnetic poles for the stator. This motor would have only four steps per revolution, but operates on exactly the same principle as one with 48 or 200 steps. The main difference is that both the rotor and stator have several pairs of magnetic poles instead of the few shown so that they can align in 48 or 200 different positions.

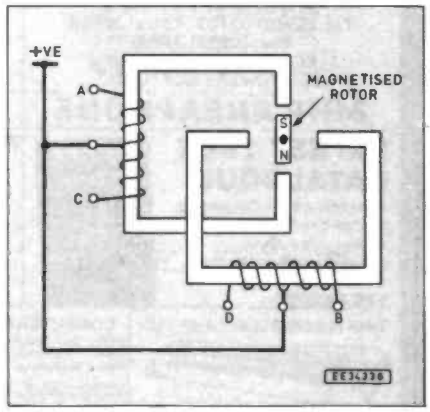
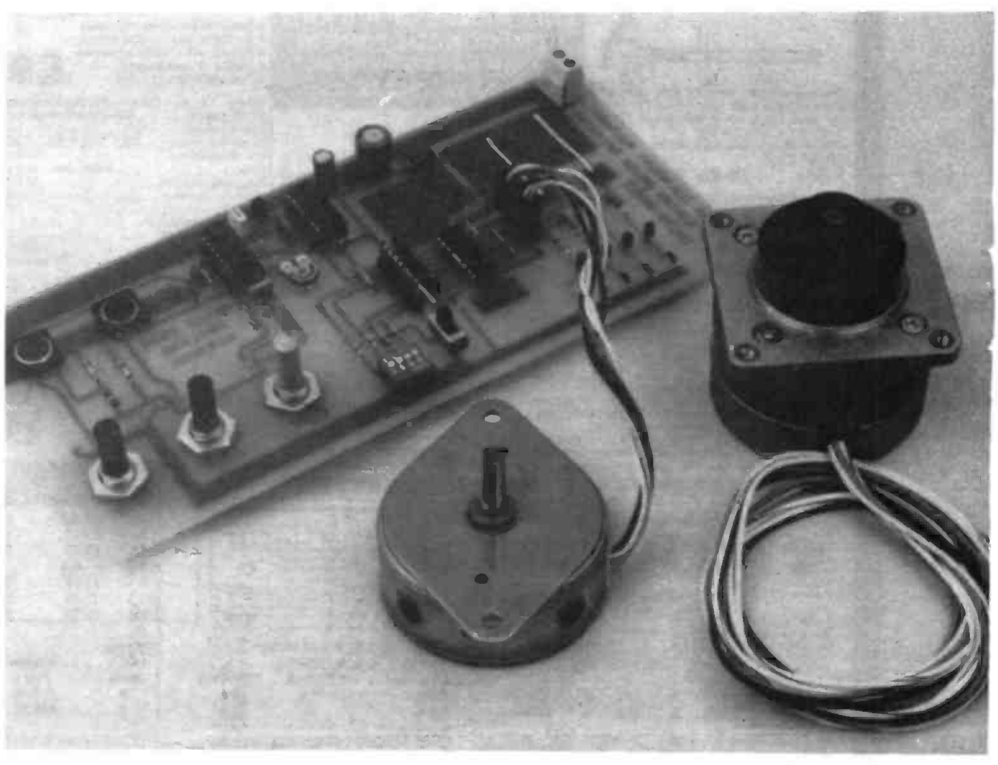


Fig. 1. Principle of operation of a stepping motor.

If the rotor of the simple motor were rotated by hand, it would tend to "notch" into one of four preferred positions with the magnet aligned either way round with each pair of poles. This effect is shown by ordinary stepping motors which have a very "notchy" feel when rotated. Counting the notches gives the number of steps per revolution in Full Step mode.



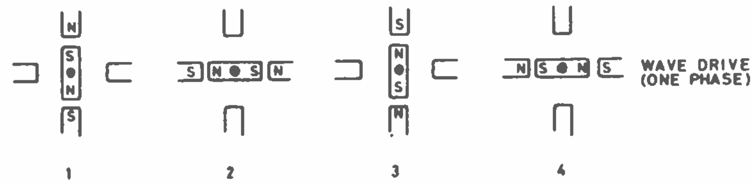


Fig. 2. Wave Drive magnetising sequence.

Table 1: Wave-Drive Sequence

↓ DIRECTION = L — DIRECTION = H ↑

Half Step = L, One Phase = H				
Step	**A**	**B**	**C**	**D**
PRO	ON	OFF	OFF	OFF
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	OFF	OFF	ON	OFF
4	OFF	OFF	OFF	ON

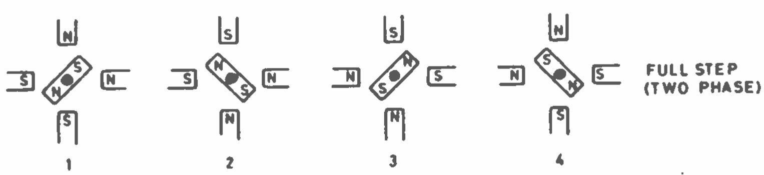


Fig. 3. Full Step or Two Phase drive sequence.

Table 2: Two-Phase Drive Sequence

↓ DIRECTION = L — DIRECTION = H ↑

Half Step = L, One Phase = L				
Step	**A**	**B**	**C**	**D**
PRO	ON	OFF	OFF	ON
1	ON	OFF	OFF	ON
2	ON	ON	OFF	OFF
3	OFF	ON	ON	OFF
4	OFF	OFF	ON	ON

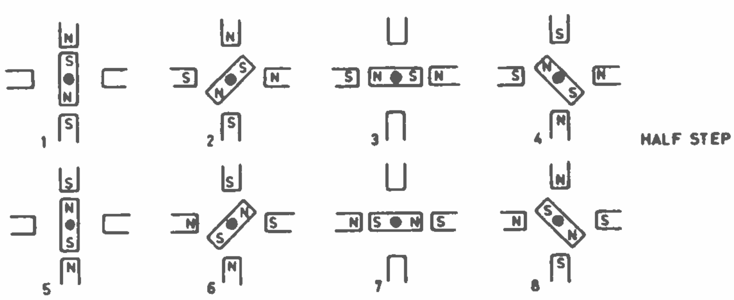


Fig. 4. Half Step mode magnetising sequence.

Table 3: Half Step Drive Sequence

↓ DIRECTION = L — DIRECTION = H ↑

Half Step = H, One Phase = L				
Step	**A**	**B**	**C**	**D**
PRO	ON	OFF	OFF	OFF
1	ON	OFF	OFF	OFF
2	ON	ON	OFF	OFF
3	OFF	ON	OFF	OFF
4	OFF	ON	ON	OFF
5	OFF	OFF	ON	OFF
6	OFF	OFF	ON	ON
7	OFF	OFF	OFF	ON
8	ON	OFF	OFF	ON

To energise the simple motor, terminals A, C, D, and B are connected individually or in combinations to the negative terminal of the motor power supply. If terminal A is connected, then current flowing from the motor supply through the winding magnetises the associated iron core in one direction. Connecting terminal C instead of A magnetises the core in the opposite direction.

If terminals A and C are connected to negative together, then the two currents' magnetising effects oppose one another and the core is not magnetised at all. The same effects apply when connecting points B and/or D to negative, the magnetisation of the associated core follows a similar pattern. Note that the two cores, with their windings, operate entirely separately from one another.

WAVE DRIVE

The simplest way to drive the motor is called Wave Drive. Fig. 2 shows the stator magnetising sequence and the corresponding rotor positions, and Table 1 shows which terminals are connected to negative for each step. Ignore for now the other information in the tables which refer to other connections of the driver i.e. The relevant information is in the columns marked A to D and rows 1 to 4.

In Wave Drive, as each winding is energised, the magnetic rotor moves to align with the electromagnetised poles. By switching in the correct sequence the magnetic rotor moves to each position in turn, rotating fully after four steps. By energising the windings in the reverse sequence, the rotor can be made to revolve in the opposite direction.

Wave Drive is the simplest method to describe but is not a very efficient way to run a stepping motor. This is because only one winding is used at a time and so only half of the winding wire and space, and the stator core material is utilised. To improve upon this Two Phase or Full Step drive is used.

FULL STEP

Full Step (or Two Phase) drive involves a similar four step sequence to Wave Drive but two windings are energised at each step. Fig. 3 and Table 2 show the rotor positions and the winding energisation patterns.

Note that the rotor aligns with the stronger magnetic field between the two sets of poles. The torque is increased substantially over Wave Drive as two windings now provide the magnetic field instead of one.

HALF STEP

A third method of operation is Half Step mode. This is a combination of the two previous ones and takes advantage of the rotor's ability to align alternately with the stator poles and between them, to double the number of steps available from the motor. Fig. 4 and Table 3 show the rotor positions and winding energisation patterns.

In this mode the torque varies up and down with each half step as the motor moves alternately between Wave Drive and Full Step modes. This would seem to be a disadvantage, but it is not a serious one. As the motor does not have to move so far with each step the varying torque does not reduce performance significantly, and the increased smoothness of running due to twice the number of steps being used gives big reductions in noise and vibration levels.

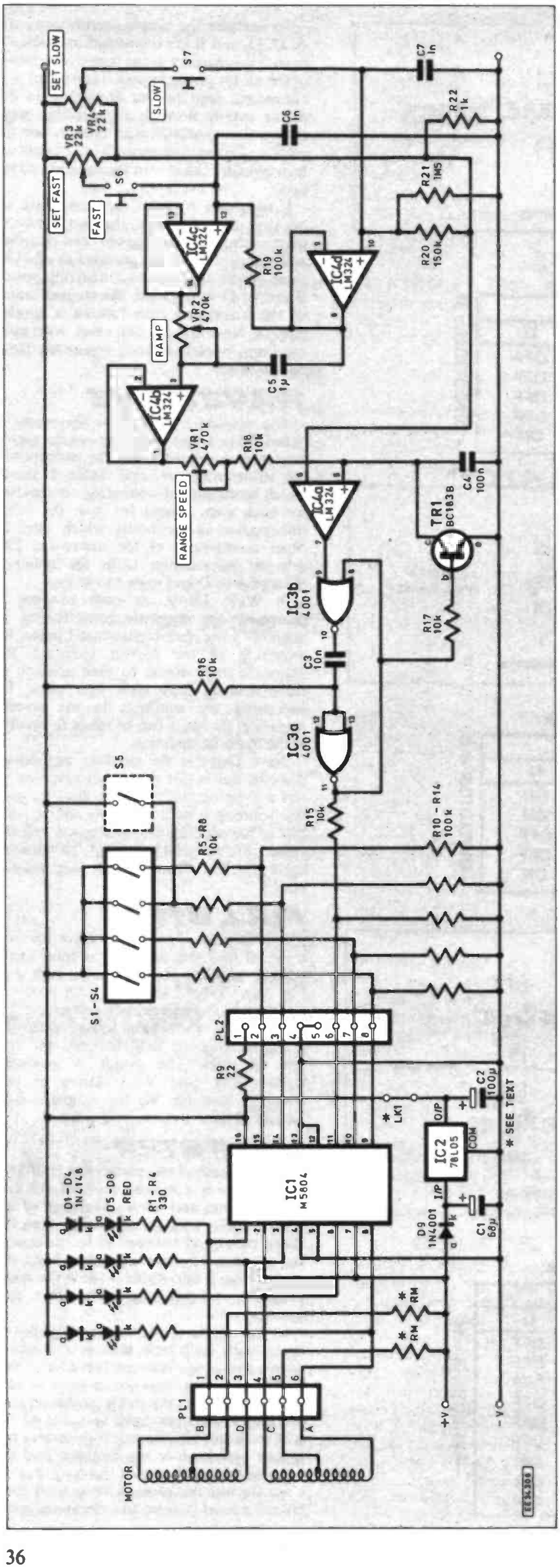


Fig. 5. Complete circuit diagram of the Stepping Motor Driver/Interface. LK1 is referred to under "Motor Connections".

In most practical stepping motor applications Full Step or Half Step operation are used. Wave Drive is inefficient and often a smaller (and cheaper) motor can be used driven in Full Step mode than would be possible with Wave Drive. Other more sophisticated methods of drive are used in industry.

One such method is Microstepping, where the current in each winding is not just switched on and off, but increased and decreased in a series of steps so that the rotor can take up many intermediate positions between the poles. With the necessarily complicated circuits this method gives very high accuracy smooth movement.

SPEED

There is no lower speed limit to stepping motor operation. One step every week is quite acceptable. At the opposite end of the spectrum however the maximum speed is limited by many things.

The main limit is determined by the inductance of the windings which reduces the rate at which the winding current can rise. Above a certain speed the winding current reduces until the torque becomes too small to be any use. This limit can be pushed up effectively by increasing the motor drive voltage at high speeds, but there is still a limit, and stepping motors can only be considered as low speed drives.

Switching of the windings is normally carried out electronically by power transistors. To use mechanical switches such as relays is impractical because of the operating speed required. In this design a special i.c. is used which contains four Darlington power transistors and all of the logic to switch them in the correct sequence to give all three modes of operation described.

The i.c. is driven by various logic inputs which select the stepping mode, direction etc. In addition a variable frequency pulse train is provided to drive the "Step" input of the i.c. For each pulse received the i.c. outputs advance one step in the selected sequence. The faster the pulse rate, the faster the motor rotates.

CIRCUIT

The full circuit diagram of the controller is shown in Fig. 5. The motor driver and interface i.c. (IC1) is the M5804. The inputs to IC1 are pins 9, 10, 11, 14, and 15. These are driven with logic levels provided by S1 to S4 and the output of IC3a which provides a pulse train for the Step input.

The four i.c. outputs are Darlington transistors connected to pins 1, 3, 6, and 8. The internal block schematic of IC1 is shown in Fig. 6 and the output Darlington transistors are shown individually in more detail in Fig. 7. Each output device is fitted with a parallel reverse protection (ground clamping) diode and a flyback (supply clamping) diode. These prevent any high voltages from appearing across the transistors as the inductive motor windings are switched on and off.

Though the transistors are each rated at 35 volts and 1.5 amps, the total output that can be provided by the i.c. is limited in practice by the package temperature rise. To allow the maximum dissipation the i.c. has a thick copper lead frame which allows heat to pass down the pins to the circuit board tracks. The printed circuit board layout has been designed to allow plenty of track area around the ground pins (4, 5, 12, and 13) to act as a heatsink.

The flyback diodes are connected to pins 2 and 7 of the i.c. These are normally connected to the highest (positive) voltage point in the circuit. In this application these connections have been made via wire links to the motor supply positive rail. Alternative connections are possible (for example via Zener diodes) but for most applications direct links to the motor positive supply are preferred.

Plenty of space has been allowed on the board for current limiting resistors. These (marked RM) are used when the application demands especially quick response time and improved torque at high speeds. How this works is explained later. For most applications these resistors can be omitted and replaced with short circuiting links.

On the input side the i.c. is almost a standard CMOS device. The only difference being that the logic supply must not exceed 7 volts. There are five input pins which function as follows:

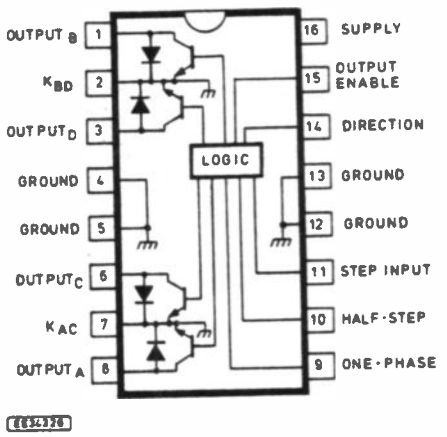


Fig. 6. Internal schematic of IC1.

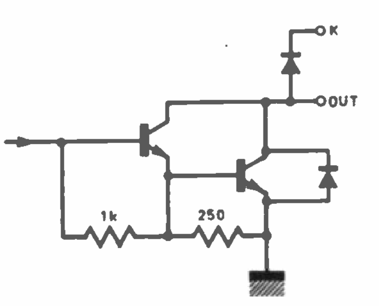


Fig. 7. IC1 output circuit.

IC1 PINS 9 & 10 TRUTH TABLE

	PIN 9	PIN 10
TWO-PHASE	L	L
ONE-PHASE	H	L
HALF-STEP	L	H
STEP-INHIBIT	H	H

Pin 9 – One Phase
This pin sets the i.c. in One Phase stepping mode when it is set to logic 1.
Pin 10 – Half Step
This pin sets the i.c. in Half Step mode when it is set to logic 1.

Note that when pins 9 and 10 are both at logic 0 the i.c. is in Full Step mode, and when they are both set to logic 1 the i.c. ignores incoming Step pulses (Step Inhibit mode). This latter function can be useful under computer control as it allows the motor to be stopped without interfering with the Step pulse input. Table 1 shows this more clearly.

Pin 11 – Step Input
When this pin changes from logic 1 to 0 (negative transition) the motor executes one step. The actual winding energisation sequence depends on which step mode is selected.

Pin 14 – Direction Input
This sets the direction of rotation of the motor by reversing the stepping sequence. The selected sequence progresses down the table when the pin is set to logic 0, and up the table when set to logic 1. To ensure correct sequences are followed, this pin, and pins 9 and 10, should only be switched when Pin 11 (Step Input) is at logic 0.

Pin 15 – Output Enable
All outputs are turned off when this pin is held at logic 1. This is useful for power saving in advanced applications by allowing the outputs to be pulsed on and off (Chopped). For most applications it is tied to logic 0. This pin does not affect the stepping sequences in any way.

The rest of the circuit is concerned with providing IC1 with input pulses and logic levels to determine the mode of operation, and indicators to monitor the output. Four input control pins to IC1 (pins 2, 3, 7, and 8 on PL2) are normally held at 0V by means of 100k resistors R10 to R14. To set these pins to 5V (logic 1) they are pulled up through resistors R5 to R8 via the four-way s.p.s.t. switch S1 to S4. As the direction control switch is likely to get a great deal more use than the others an additional switch (S5) is also fitted. this is a more robust p.c.b. mounted switch that will save wear and tear on S3.

The main input to IC1 is the STEP input which is at pin 6. This is driven with positive pulses from a voltage controlled oscillator made up from IC3a, and b, and IC4a. The frequency of this oscillator is controlled by d.c. voltages supplied via IC4b from IC4c and d. These in turn are fed from the two speed control potentiometers VR3 and VR4 via push to make switches S6 and S7.

OSCILLATOR

The oscillator is best explained if it is first assumed that C4 is fully discharged and therefore has no voltage across it. If a slow speed has been set by VR4, and S7 is being pressed, a d.c. voltage will be present at the output of IC4, C4 begins to charge from this voltage via R18 and VR1. IC4 compares the voltage across C4 with a reference voltage (approximately 0.5V) which is generated by a potential divider consisting of VR3 and VR4 in parallel in its upper section, and R22 in its lower section.

At first the voltage on C4 is small and well below the 0.5 volts across R22 and so the output of IC4a stays close to 0V. As soon as the voltage on C4 rises above the reference voltage, the output of IC4 rises swiftly to nearly 5V, and triggers the monostable formed by IC3a, and b. The output from IC3a is a positive pulse which drives the STEP input of IC1 via R15 and turns on TR1 via R17. As TR1 turns on it immediately discharges C4 which begins to charge again via R18 and VR1 at the end of the monostable pulse, and so the cycle continues.

The higher the voltage on the output of IC4b, the higher the charge current and so the quicker the voltage across C4 rises. In this way the frequency of the output pulses is proportional to the applied voltage.

The use of a voltage controlled oscillator is necessary because stepping motors cannot be driven at full speed from a standing start. The two push switches allow this to be demonstrated because the SLOW speed switch (S7) applies the control voltage instantaneously whilst the FAST speed switch (S6) allows the control voltage to ramp gently up to the set speed at a rate determined by C5 and VR2.

FAST SETTING

The Fast speed setting voltage is buffered by IC4c which has a voltage gain of 1. It has a very high input resistance and so does not load VR3 which provides it with a d.c. voltage input corresponding to the required speed. The voltage from IC4c is applied to the input of another buffer amplifier (IC4b) via the ramp control VR2 and shunt capacitor C5. The other end of C5 is held at constant voltage by IC4d which is set to the reference voltage via R20 when S7 is open, or to the Slow speed select voltage from VR4 when S7 is closed.

As S6 is closed the voltage from VR3 slider immediately appears on the output of IC4c. C5 then charges via VR2 so that the voltage at the input to IC4b slowly changes to match that at the output of IC4c. In this way the voltage controlling the pulse frequency ramps slowly up (and down) to the required level. The setting of VR2 and the value of C5 set the ramp rate which can be adjusted so that the final speed is reached in a time between a few milliseconds and several seconds.

The Slow speed setting control does not have a ramp facility and the pulse frequency changes immediately to the required setting. This is achieved by applying the voltage from VR4 to the lower end of C5 via IC4d and to the upper end via IC4c. This means that C5 does not have to charge or discharge as the voltage ACROSS it does not change, and so the pulse frequency changes instantly.

This method is known as bootstrapping, and is used in many other types of circuit, especially to reduce the effect of undesired capacitances. Its application here is less common but it does an admirable job as it allows both fast and slow controls to work independently and together without any unwanted interaction.

The power supply for the logic section of IC1 and the pulse generating circuits is derived from the motor supply via D9 and IC2 with decoupling capacitors C1 and C2.

INDICATORS

Four l.e.d.s (D5 to D8) are provided to monitor the states of the output drivers, these are protected from reverse voltages by D1 to D4 and have their supply current limited by R1 to R4. These are useful for demonstrating the various operating modes, and light with or without a motor being connected.

Spaces are allowed on the board for series limiting resistors "RM" which are used with lower voltage motors or higher supply voltages. For most applications these should be replaced with wire links and the motor supply voltage should match the motor rating.

It is advantageous to use series resistors and to increase the supply voltage above the motor rating when very high performance is required . The resistor values are chosen to limit the motor current to the maximum allowed for the motor. This has the effect of increasing the rate of rise of motor current and allows faster stepping rates and higher acceleration to be achieved without overheating.

CONSTRUCTION

Construction is relatively simple as the entire circuit is built on a single printed circuit board (available from the *EE PCB Service* code EE782), and there isn't any wiring to off-board components. Fig. 8 shows the component layout and the copper track pattern.

Before fitting any components check that the three potentiometers fit correctly into the large holes in the board and that all of the other holes are clear of solder.

Fit the resistors and diodes first and solder them in. Resistors R10 to R14 are in a single-in-line network which has its common pin at one end marked with a dot. The board has been drilled to accept 8 or 9 pin networks. Some of the pins are unused but do not need to be cut off as they only connect harmlessly to the negative supply. Preset VR1 should be fitted with care as it is an open type and prone to damage.

COMPONENTS

Resistors

R1 to R4	330 (4 off)
R5 to R8	10k (4 off)
R9	22
R10 to R14	100k 8 or 9 pin single in-line network
R15	10k
R16 to R18	10k (3 off)
R19	100k
R20	150k
R21	1M5
R22	1k
RM	To suit motor and supply (see text)

All 0.25W 5% carbon film except R10 to R14

See SHOP TALK Page

Potentiometers

VR1	470k preset, lin.
VR2	470k rotary carbon, lin.
VR3, VR4	22k rotary carbon, lin. (2 off)

Capacitors

C1	68μ radial elect., 35V
C2	100μ radial elect., 10V
C3	10n ceramic, 50V (5mm)
C4	100n polyester, 100V (5mm)
C5	1μ multilayer ceramic, 50V (5mm)
C6, C7	1n ceramic plate 50V (2 off)

Semiconductors

D1 to D4	1N4148 signal diode (4 off)
D5 to D8	Red 3mm l.e.d. (4 off)
D9	1N4001 1A 50V rec. diode
IC1	M5804 stepping motor driver
IC2	78L05 +5V 100mA voltage reg.
IC3	4001 quad CMOS NOR gate
IC4	LM324 quad op.amp.
TR1	BC183B *npn* transistor

Miscellaneous

S1 to S4	4-way s.p.s.t d.i.l. switch
S5	p.c.b. slide switch (optional)
S6, S7	p.c.b. mounting s.p.s.t. push-to-make switch (2 off)

Printed circuit board available from *EE PCB Service*, code EE782; PL1 6-pin 0.1in matrix p.c.b. header; PL2 8-pin 0.1in matrix p.c.b. header; motor to suit, see text; 2-way p.c.b. terminal block; connecting wire; solder, etc.

Approx cost guidance only **£30**

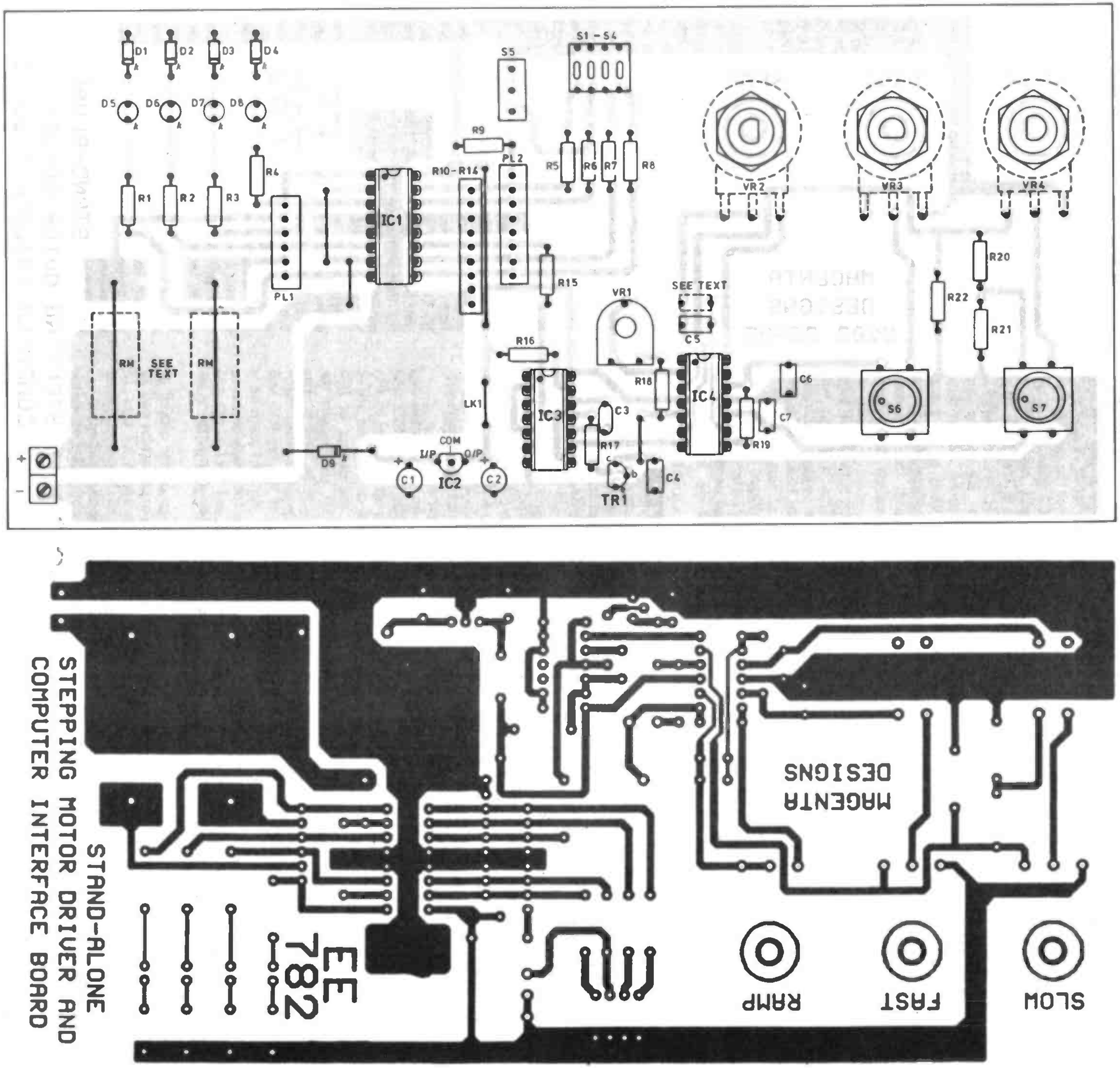


Fig. 8. P.C.B. layout and wiring, the text refers to LK1.

Next fit IC1 directly into the board. As explained earlier this i.c. uses its pins to conduct heat away to the printed circuit board tracks, a socket is not recommended as it seriously reduces the flow of heat to the board and would reduce the i.c. current rating. The M5804 has proved to be very reliable and so it is unlikely ever to need unsoldering. IC3 and IC4 can be fitted in sockets as this will help with fault-finding should any be required. IC2 should be soldered directly into the board.

Apart from C1 and C2 the capacitors can be fitted either way round. Two spaces have been provided for C5 so that its value can be doubled by adding another capacitor in parallell to give a prolonged ramp time.

Switches S1 to S4 are in an 8-pin d.i.l. package and could be fitted into a socket if preferred. If heavy use is expected it is better not to use a socket, as the constant movement could cause intermittent contact. S5 must be soldered straight into the board. In order to keep the switch upright it is helpful first to solder just one pin. The switch position can then be adjusted by melting the solder, and the other pins can be soldered when the correct position has been obtained. This process is also useful when fitting PL1 and PL2 and the l.e.d.s all of which need to be fitted upright on the board.

A number of wire links are required. These can be made from insulated or bare tinned copper wire and should be bent neatly before insertion into the board. Fit two more wire links in the positions marked RM unless resistors are to be used.

The two push-to-make switches have small plastic pips on their undersides which must be removed so that the switches fit flat on the board.

When everything else has been done the potentiometers should be fitted. Bend the tags forward so that they fit into the holes from the track side of the board with their spindles passing through to the component side. Fit the nuts first and tighten them before soldering the tags.

Once assembly is complete, carefully check the soldering for dry joints and bridges, and ensure that all components are correctly placed and the right way round where necessary. Time spent at this stage can save a great deal of time later finding simple faults.

TESTING

The entire circuit should be tested before connecting a motor. D5 to D8 indicate the state of the outputs from IC1.

Apply a current limited supply of between 8 and 15 volts to the Motor Supply terminals. A convenient type of current limit is a small bulb, such as a 12V 2.2 Watt type wired in series with the positive supply. Alternatively a resistor of 10 ohms or so could be used. A bulb is preferable, as it lights to indicate excessive current drain.

As S6 and S7 are open circuit there should not be any drive pulses to IC1 and a static pattern of one or two l.e.d.s should be present provided S1 is set to the OFF state. Set S2, S3, and S4 to OFF as well so that IC1 is set into the Full Step or Two Phase mode.

Now set VR1 to mid position, and VR2, VR3, and VR4 fully anticlockwise, and press S7. Whilst holding S7 rotate VR4 clockwise and check that the pattern of l.e.d.s begins to change and speeds up as VR4 is rotated further. Release S7 and check that the l.e.d.s stop. Repeat the process this time using S6 and VR3 and note the effect of VR2 on the speeding up and slowing down of the pattern. If all is well so far adjust VR1 and check that this has an overall effect on the speed range of both controls. Note also that the speed range is the same for VR3 and VR4, the only difference being that the ramp affects only S6 and VR3.

If any of the l.e.d.s will not light check the polarity and the associated resistor and diode.

If the oscillator section is not operating properly check that the voltage from IC2 is 5V and that the voltage across R22 is approximately 0.5V. Measure the voltage on the sliders of VR3 and VR4 and check that it can be adjusted from 0.5V to 5V. IC3c, and d are buffer amplifiers and so their outputs should follow their inputs over most of the range between 0.5V to 4V. Similarly the output of IC4b should also follow its input.

The output of IC4a should be low most of the time, pulsing positive only very briefly. Without an oscilloscope this will be impossible to see and so a multimeter will simply read 0V. It should be possible to get this section of the circuit working by simple checks and careful inspection as there are not many components involved.

The correct operation of switches S1 to S5 can be checked by a multimeter on the pins of IC1 or PL2. Setting a switch to ON will raise the voltage from zero to 4.5V. Note that as S3 and S5 are in parallel closing either of them will have the same effect, and both must be open to get 0V.

The various operating modes of IC1 can be inspected by operating the switches and setting the lowest possible speed with VR3 or VR4. With the correct setting it is possible to single-step the circuit so that the motor drive sequences can be followed. The truth table and motor drive sequence tables should be referred to and each combination checked.

MOTOR CONNECTIONS

Once it is established that the circuit is working correctly, a motor can be connected to PL1. The Magenta MD35 has a connector attached already that matches these connections and can be plugged in either way round. All Four phase unipolar motors have two separate centre-tapped windings which are interchangeable. As long as the two centre taps are correctly identified, and the corresponding winding ends are connected either side, the motor will run. Reversing either of the windings will change the direction of rotation, but will not have any other effect.

Whichever motor is used it is essential to have a power supply that can deliver enough current to supply two windings together without dropping below 8V. If the supply falls further the voltage regulator IC2 will run out of headroom and its output will drop, causing no damage, but with unpredictable results to the rest of the circuit.

It is possible to operate lower voltage motors by having a separate 5 volt supply for the logic circuits and removing link LK1. Motors can then be driven from as low as 3 volts, but the l.e.d. indicators will not function properly. PL2 allows a separate 5V supply to be connected for this purpose, and it can be conveniently derived from a computer supply as only 30mA or so is required. Resistor R9 protects the computer in case of short circuits.

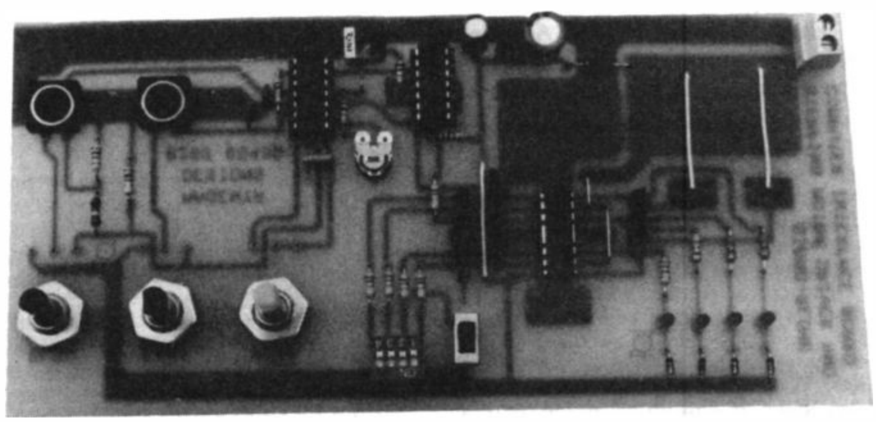
COMPUTER OPERATION

All inputs to IC1 are available at PL2 for connection to a computer output port. For many applications it will only be required to connect the Negative, Step, and Direction pins. The rest can be pre-set by the switches. Most computer ports will easily override the switch settings which are fed to IC1 via Resistors R5 to R8. These resistors should prevent any conflict and give the computer automatic priority.

Programming is simply a matter of setting the output port line connected to the Step input High and Low alternately each time a step is required. More advanced programming will allow the motor to be accelerated and run at different speeds. Up to four boards and motors can be operated from a single port if sufficient programming skill is available, and only Step and Direction commands are required to be under program control.

IN USE

As a demonstration tool this board is excellent. The three modes of motor drive can be run and their characteristics observed. The effect of inertial loads on the acceleration and motor stability can also be investigated. For practical applications the motor can be run from the board and any mechanical problems sorted out before embarking on computer control. Two boards and motors provide the basis of a computer controlled X – Y positioning system which could be operated from just four lines of a computer port. All in all the board is an effective and inexpensive way to put stepping motors to work. □



The prototype p.c.b., the final version has been modified slightly.

SHOP TALK

with David Barrington

TRANSISTOR CHECKER

Running through the list of components required to build the *Transistor Checker*, we were not expecting any supply problems to be encountered when ordering parts. We were surprised to find that the two major components, namely the rotary switch mechanism/wafers and the meter, are not so widely stocked as first anticipated.

The 0-500μA moving coil meter used in the model is an Altai T23 type and has an internal resistance of 360 ohm. This meter is currently listed by **Greenweld** (code Y200, some with mirrored scale), **Henry's Audio Electronics** (code Y200) and **Electrovalue** (code T23).

Other meters can be used of course provided they have identical electrical characteristics. The size of case may need to be changed to accommodate the meter used. One such meter is available from Greenweld (Code Y183) at about half the price.

The miniature rotary wafer switch assembly is usually listed in catalogues under such sub-headings, within switch sections, as "Maka-Switch" types and consists of the mechanical mechanism and various combinations of wafers. The spindle rotation limit stop of the mechanical assembly is adjusted to stop at position five. A number of 2-pole 5-way (**Electrovalue** – **RA series**) or the more common 2-pole 6-way wafers (**Maplin** FH46A-mech, FH48C-wafer), (**Cricklewood Electronics** WSM1-mech, WS26-wafer) are mounted on the mechanical assembly to form suitable switches for this application.

The single-sided printed circuit board is available from the *EE PCB Service*, code EE781 (see page 66).

STEPPING MOTOR DRIVER/INTERFACE

The M5804 stepping motor driver i.c. specified in the "comp list" for the *Stepping Motor Driver/Interface* is only available from **Magenta Electronics**. They also list a range of suitable stepping motors for use with this stand-alone or computer linked circuit.

A complete kit of parts (£29.95), including p.c.b. and their MD35-¼ motor, is available from **Magenta Electronics, Dept EE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST** (☎ *0283 65435*). Add £2 for post and packing.

The printed circuit board is available from the *EE PCB Service*, code EE782.

MIND MACHINE PROGRAMMER

Some of the semiconductor devices called up for the *Mind Machine Programmer*, an add-on board for last month's project, will certainly cause local sourcing problems and take some finding.

The only source we have been able to locate for the LP2951CN micropower voltage regulator is from **Electromail** (☎ *0536 204555*), code 648-578.

Double checking current catalogues and advertisement listings for the DAC0832LCN D/A converter chip, the only source of supply appears to be from **Viewcom Electronics** (☎ *081 471 9338*). They are also able to supply the Analogue to Digital i.c. ADC0804LCN and the static RAM.

The rest of the semiconductors seem to be generally available and should not cause concern. Most of them are listed in the latest components catalogue from **Cricklewood**.

However when placing your order for parts, make sure your supplier understands that you want the **BC184** transistor and NOT one with the letter *L* (BC184L). Although it is the same transistor, it has differing leadout arrangements according to letter code. If you are stuck with a BC184L, the leads can be carefully bent to fit on the circuit board.

The printed circuit board for the Programmer is available from the *EE PCB Service*, code EE780. Finally, it is very important that ALL constructors and possible users of the unit pay special attention to the warning at the start of the article.

BISHOP ROCK LIGHTHOUSE – SIMPLE MODEL SERIES

The miniature solder terminals shown in use on the "circuit boards" for the *Bishop Rock Lighthouse*, this month's *Simple Model Series* project, are the p.c.b. eyelet type. These consist of a looped wire with the resulting two end leads separated by a coloured ceramic bead and are usually used to establish test points on circuit boards.

The eyelet terminals should be readily available from advertisers and are normally sold in packs of ten, each of different colour, for about £1 per pack. The rest of the components are standard items, but the lighthouse "rocks" or base must be able to accommodate the loudspeaker.

The speaker must be rated at 64 ohms but physical size will depend on the final model. The one used in our "cut out" lighthouse is a miniature 38mm diameter type.

The model and electronic circuit is built on *printed* white card which can be obtained from the EE Editorial Offices for the sum of £1.50 (including postage). The wiring up of the circuit card is accomplished by the use of the Vero Easiwire "no soldering" wire-wrapping system.

To help with assembly special arrangements have been made with **Greenweld Electronic Components** (☎ *0703 236363*) and **Bull Electrical** (☎ *0273 203500*) to supply a complete kit, including cards, for the sum of £5.95 plus £1 postage. They are also making a special offer on Easiwire wirewrap kits – see "Special Offer" page 54.

MICRO-SENSE ALARM

We do not expect any component purchasing problems to be encountered when buying parts for the *Micro Sense Alarm*. The piezoelectric sounders used in the model are, in fact, the elements only.

Because of the dangers of possible damage during soldering, it might be wise to purchase elements which have leads already attached to them. These leads can be cut short and the specified two-core screened cable soldered to the shortened leads.

If you are going to use tilt switches for additional security, the miniature *metal* encapsulated mercury types should be purchased. These are fairly widely stocked and should not be a problem.

You could use the miniature, mercury loaded, metal cased vibration switch or the miniature glass encapsulated tilt switch. The glass type are fairly fragile and would certainly need to be *well protected* as mercury is a poisonous substance.

The 6V battery used in the unit should be a rechargeable sealed lead-acid type. These appear to be available from the larger components stockist. On special offer at the moment is a 6V 10AH version from Marco Trading which, although slightly more expensive, will give a much longer "standby life". This will mean a larger case. The printed circuit board is obtainable from the *EE PCB Service*, code EE783 (see page 66).

EVERYDAY NEWS

UK IC DESIGN

The Integrated Circuit & Application Centre at Southampton, the first of its kind to be established within Philips Semiconductors, was formally opened by Kevin Kennedy, Chairman and Managing Director, Philips Electronics (UK), on Tuesday 22 October 1991.

Employing some 360 staff, the majority of whom are graduate engineers or equivalent, it represents an investment by Philips of some £6.8m and is one of the largest single concentrations of electronic engineering expertise in the UK.

The centre combines on one site the design, marketing and logistics operations for microchips used in all types of consumer electronics equipment – television sets, VCRs, compact disc players etc. It also looks at how new developments in chip technology will improve the performance of such equipment.

Startext

At Southampton engineers are developing the chips for the products of the future. Just reaching the retail shops are VCR's with Startext or PDC (Programme Delivery Control), this is the best system of programming a VCR we have so far seen.

The user simply calls up the Teletext programme schedule page, selects the required programme with a cursor and the rest is automatic. If the programme is delayed (or broken with a news bulletin) the VCR will still record it and not the interruptions. It will record every episode of a series or mini series but it will not record films designated 18 without a security code. In addition to this it puts a title and time on the start of the recording so your tape is easily identified. The system is not "local time" dependent thus eliminating the problem associated with a 24 hour clock, summertime changes, different time zones (on satellite broadcasts) etc.

Channel 4 are already transmitting the necessary Startext codes and others are likely to follow soon. Philips say that the systems is so simple even an adult can program the video.

Other developments at Southampton include Teletext for Far Eastern countries where ideographic systems of writing are used i.e. in Chinese; closed captioning for hearing impaired on US television, as required to be fitted to most TVs sold in the USA by 1993; Digital Compact Cassette chip sets; continuing development of chips for NICAM stereo and compact disc, plus HDTV developments with D2-MAC chips etc.

2 x 220 watt MOSFET AMPLIFIER

A top-of-the-range performer that will satisfy the most demanding audio enthusiast. If you're looking for an amplifier to power your subwoofer, the **SPARKOMATIC** is all you'll need! Highly sophisticated MOS-FET technology dramatically extends frequency response, separate input sensitivity controls, built-in protection circuitry for overheat and short circuit with l.e.d. indication, output power: 2 x 220 watt maximum and 2 x 110 watt at 0.1% THD, Bridged 440 watt mono maximum and 220 watt mono at 0.5% THD.

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Delivers 4 x 100 watt into 4 woofers or with the aid of its built in active cross over delivers 200 watt of Bass via sub-woofer output and 2 x 100 watt, full range into 2 speakers; thus giving you all the power you require to make even traffic jams a positive pleasure. SPECIFICATION 4 x 100W (4Ω), 2 X 200w Bridged, THD .08%, S/N RATIO: 7 90db, RESPONSE 10Hz-50KHz, LOW PASS FILTER SWITCHED 75Hz 150Hz, INPUT 4 x PHONO 100-3 Volts, INPUT x 4 HIGH LEVEL 20KΩ, SIZE 240mm x 50mm x 400mm.

£118.50 postage £4.50

75 watt x 2 CLASS A AMPLIFIER FOR CARS

Small but powerful, high efficiency amplifier, suitable for a number of hidden mounting locations. Easy connection through phono and high level input capability. SPECIFICATION 2 x 75 watts 4Ω, 1 x 150 watt Bridged, THD 0.190, S/N RATIO: 7 85 dB, RESPONSE 20Hz-30KHz. INPUTS; 2 X PHONO 100mV-3 VOLT 2 X HIGH LEVEL 2 X 20kΩ. SIZE 240mm X 50mm X 140mm.

£48.50 postage £3.50

11 BAND COMPONENT GRAPHIC EQUALIZER FOR CARS

This neat unit connects between the line output of your car stereo and your power amplifiers so you are able to adjust the sound as in a studio compensating for soft furnishing and sound reflections from glass, also it has a sub-woofer output to drive a separate amplifier for that extra deep bass sound. FEATURES: 2 channel inputs 4 channel outputs via phono sockets, CD input via 3.5mm jack 11 band graphic. SPECIFICATION RANGE 20Hz-60KHz THD 0.05%, S/N RATIO 85dB. EQ FREQUENCIES 60HZ, 120Hz, 250Hz, 380 Hz, 500 Hz, 750 Hz, 1 KHz, 2KHz, 4KHz, 8KHz, 16KHz (Boost cut of ±12 dB) SIZE 178mm x 25mm x 140mm.

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All units are fitted with big magnets "Nomex" Voice coils NOT ALUMINIUM, "Nomex" is very light and can stand extremely high temperatures, this mixture makes for high efficiency and long lasting quality of sound.

V6 6 ½" 200W Max	Range 50Hz-3KHz £34.40
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These state of the art advanced technology, high performance 10 mm dome tweeters are Ferrofluid coded and are active horn-loaded for high dispersion of sound with very low distortions. Ideal for tuning up your dull sounding in-car system. SPECIFICATION IMP4Ω 40 watts at 5KHz, 100 watt at 10KHz, MAGNET, SIZE 5mm x 30mm, VOICE COIL SIZE 10.5mm EIFFICIENCY 92.8 dB. SIZE 51mm x 51mm x 16.5mm. RECOMMENDED. 5k. 1st ORDER CROSSOVER, VALUE 1.5uf-2.2uf supplied. **£7.50pair plus 90p post.**

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BP019	20	20 ceramic trimmers
BP020	4	Tuning capacitors, 2 gang dielectric a.m. type
BP021	10	3 position, 8 tag slide switch 3 amp rated 125V a.c. *made in USA*
BP022	5	Push-button switches, push on push off, 2 pole changeover. PC mount *JAPAN made*
BP023	6	2 pole 2 way rotary switch
BP024	2	2 Right angle, PCB mounting rotary switch, 4 pole, 3 way rotary switch *UK made by LORLIN*
BP025	4	3 pole, 3 way miniature rotary switch with one extra position off (open frame YAXLEY type)
BP026	4	4 pole, 2 way rotary switch *UK made by LORLIN*
BP027	30	Mixed control knobs
BP029	6	Stereo rotary potentiometers
BP030	2	10k wire wound double precision potentiometers *UK made*
BP032	4	UHF varicap tuner heads, unboxed and untested *UK made by PHILIPS*
BP033	2	FM stereo decoder modules with diagram *UK made by PHILIPS*
BP033A	4	6"x⅜" High grade Ferrite rod. *UK made*
BP034	3	AM IF modules with diagram *PHILIPS UK MADE*
BP034A	2	AM-FM tuner head modules. *UK made by Mullard*
BP034B	1	Hi-Fi stereo pre-amp module inputs for CD, tuner, tape, magnetic cartridge with diagram. *UK made by MULLARD*
BP035	6	All metal co-axial aerial plugs
BP036	6	Fuse holders, panel mounting 20mm type
BP038	20	5 pin din, 180° chassis socket
BP039	6	Double phono sockets, Paxolin mounted
BP041	3	2.8m lenghts of 3 core 5 amp mains flex
BP042	2	Large VU meters *JAPAN made*
BP043	30	4V miniature bulbs, wire ended, new untested
BP044	2	Sonotone stereo crystal cartridge with 78 and LP styli *JAPAN made*
BP045A	2	Mono Cassette Record and play heads
BP046A	2	606 Mains transformers, PCB mounting. Size 42x33x35
BP047A	1	25V DC 150mA mains adaptor in black plastic case with flying input and output leads new units made for famous sound mixer manufacturer. Size 80x55x47
BP049	10	OC44 transistors. Remove paint from top and it becomes a photo-electric cell (ORP 12). *UK made by MULLARD*
BP050	30	Low signal transistors n.p.n., p.n.p. types
BP051	6	14 watt output transistors, 3 complimentary pairs in TO66 case *(Ideal replacement for AD161 and 162s)*
BP052A	1	Tape deck pre-amp IC with record/replay switching No LM1818 with diagram
BP053	5	5 watt audio ICs. No TBA800 *(ATEZ)*
BP054	10	Motor speed control ICs, as used with most cassette and record player motors
BP055	1	Digital DVM meter I.C. *made by PLESSEY* as used by *THANDAR* with diagram
BP056	4	7 segment 0.3 LED display (red)
BP057	8	Bridge rectifiers, 1 amp, 24V
BP058	200	Assorted carbon resistors
BP059	1	Power supply PCB with 30V 4V/A transformer. MC7818CT IC & bridge rectifier. Size 4" x 2¾"
BP061	5	6.35mm Mono jack plugs
BP063	5	6.35mm stereo switched jack sockets
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- Separate treble and bass.
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Size (H.W.D.) 74 x 400 x 195mm.
Kit enclosed: case, PCB, all components, scale and knobs **£40.00** + £3.50 pp.
(Featured project in *Everyday Electronics*, April 1989 issue). Reprint Free with kit.

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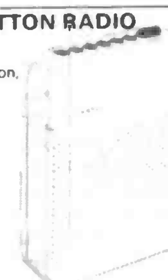

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Transmitters listed on this page are not licensable in the UK.

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Suitable for remote control of telephone answering machines, videos, appliances etc. requiring DTMF signals over telephone lines.

£8.95

Please add 75p p&p when ordering

Please add 2.2% to all our prices due to the increase of the VAT rate to 17.5%

Constructional Project

MIND MACHINE

Part 2: PROGRAMMER BOARD

ANDY FLIND

Learn to relax with this sophisticated programmable Entrainment unit.

CONSTRUCTORS of last month's *Mind Machine* will probably have found that the best way to use it is to start at a fairly high frequency, reduce it gradually, then, when the session is drawing to a close, slowly bring it back up. The snag with doing this manually is that it requires concentration which, however small, prevents the user really "letting go" and enjoying the deep relaxation the instrument can induce.

A fixed frequency could be used, but the brain appears to adapt to steady stimulation, reducing the effect. A programmable controller for the Mind Machine is therefore a highly desirable addition to this project.

PROGRAMMING

When the programming part of the design was first tackled it seemed simple, which just proves how wrong one can be! The idea at least is uncomplicated. The existing "Frequency" control is used to program the desired frequency pattern over about thirty seconds, then this is replayed over fifteen, thirty or forty-five minutes. The circuit has only to store the control sequence and reproduce it at the slower speed.

It soon became clear that the best method would be conversion of the control voltage to a stream of 8-bit digital words for storage in a RAM. These would then be read back at the slower rate and restored to the voltage.

The block diagram of Fig. 1. shows that the system consists of an analogue-to-digital (A/D) converter, the RAM, and a digital-to-analogue (D/A) converter for the output. A "clock" oscillator motivates it, an "address generator" tells the RAM where to store the bits, some switching and timing controls it all and a counter halts it when the sequence is complete. For anyone who hasn't actually designed this sort of circuit however, life is full of exciting surprises!

STORAGE

The 6264 CMOS RAM was chosen for storage. With a capacity of just over eight thousand 8-bit words and a micropower standby mode, it seemed ideal. The first pitfall was that when "enabled" for data transfer, it proved quite thirsty.

It must be given a valid address, "selected" briefly and written to or read from, then returned to the standby state to conserve power. The current eight bits of data must therefore be copied into an eight-bit latch before conversion to analogue.

The A/D and D/A converters, chosen for their low operating current, are both intended for use with microprocessors and have connections that must be tied high or low to achieve the desired operation. Like the RAM they must be told when to perform their functions, and their inputs must be valid before this happens, leading to some fairly complex timing circuitry.

Finally, the analogue output from the D/A chip is a current, not a voltage, which should flow into negative supply potential. To convert this to the original voltage requires an op-amp able to operate below negative supply, so an extra, lower voltage negative supply rail is needed.

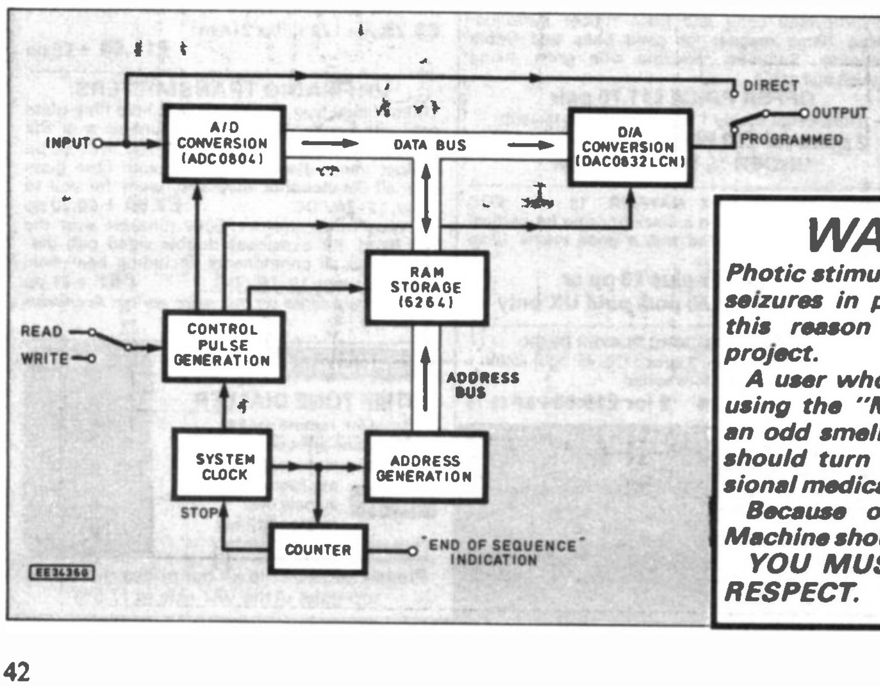
CIRCUIT DESCRIPTION

The full circuit of the Mind Machine Programmer appears in Fig. 2. Starting with the "clock", this is constructed from internal oscillator gates in IC4, a CMOS 4060B. Switches S1a and S1b determine the final output frequency by selecting the appropriate oscillator speed and division ratio.

This is further divided by four in the 4024B divider IC6, the final "clock" appearing at pin 11 of this chip. The frequencies here are approximately 270Hz for the 30-second programming sequence; 9.1Hz for a fifteen minute session; 4.6Hz for thirty minutes, and 3Hz for forty-five minutes.

Moving to the address generator, the RAM address bus has thirteen bits, the first of these being taken from the next stage of IC6 at pin 9. This is also applied to the input of the twelve-stage divider IC7, a 4040B, which generates the remaining twelve address bits.

Fig. 1. Block diagram of the programming system for the Mind Machine.



WARNING NOTICE

Photic stimulation at Alpha frequencies can cause seizures in persons suffering from Epilepsy. For this reason such people MUST NOT try this project.

A user who is not a known epileptic, but when using the "Mind Machine" begins to experience an odd smell, sound or other unexplained effect, should turn it off immediately and seek professional medical advice.

Because of the above possibility the Mind Machine should not be used while on your own.

YOU MUST TREAT THIS UNIT WITH DUE RESPECT.

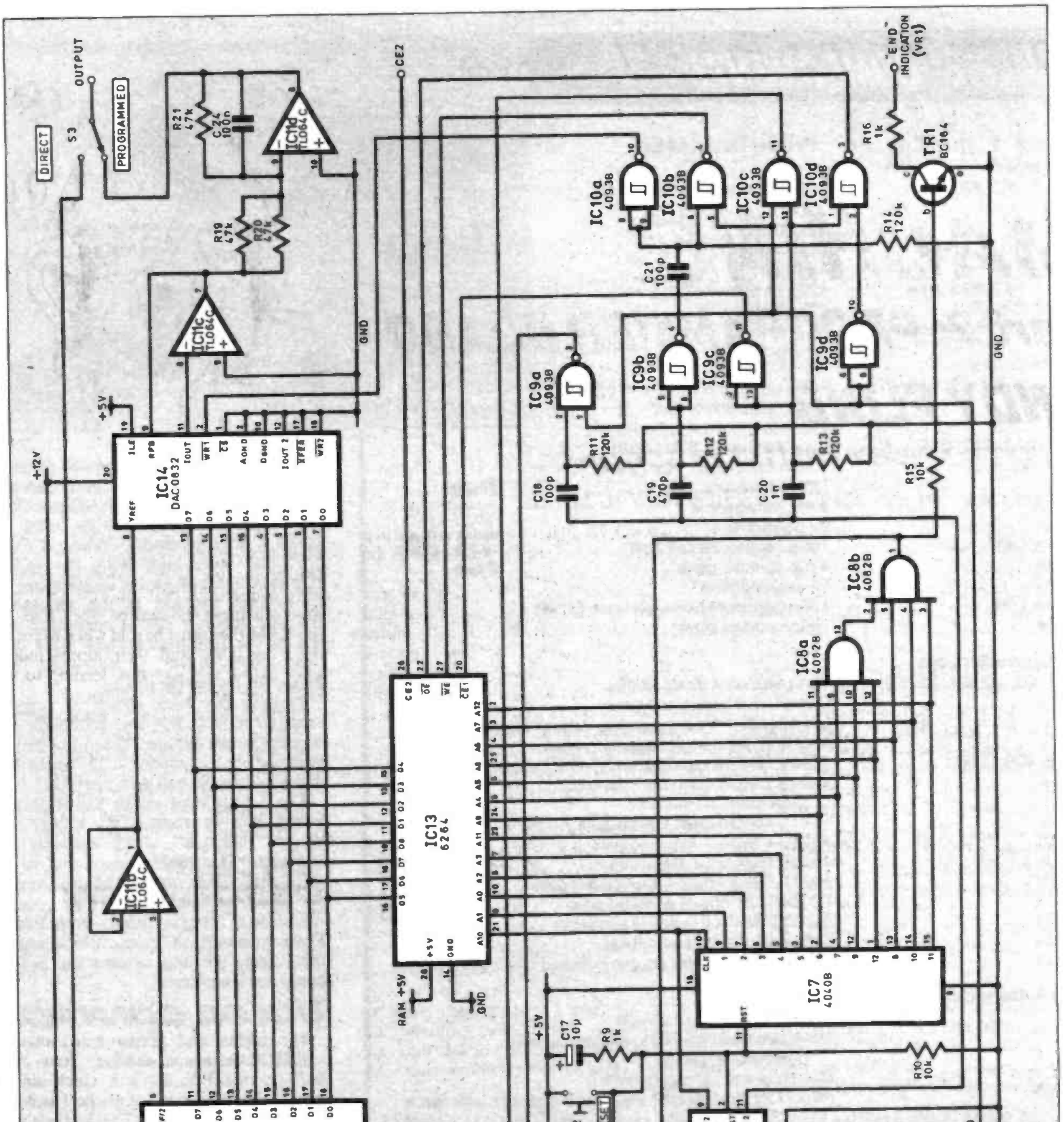
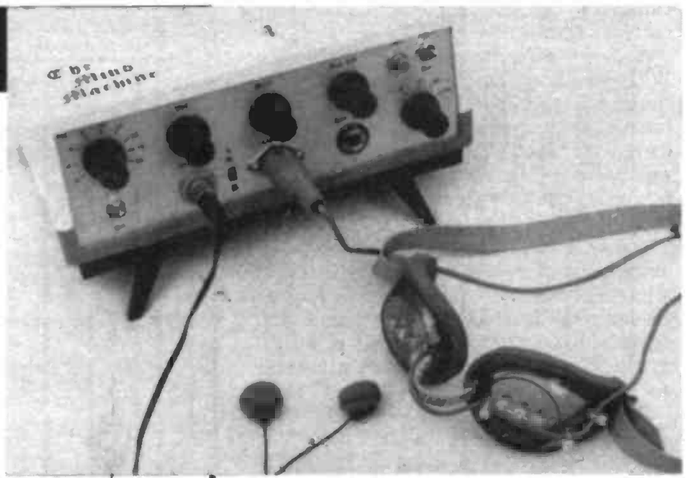


Fig. 2. Complete circuit diagram for the Mind Machine Programmer section. The power supply voltage regulation circuit is shown in Fig. 4.

COMPONENTS



PROGRAMMER

Resistors

R, R2, R7, R8, R17	100k (5 off)
R3	220k
R4, R5	22k (2 off)
R6, R10, R15, R18	10k (4 off)
R9, R16	1k (2 off)
R11, R12, R13, R14	120k (4 off)
R19, R20, R21	47k (3 off)

All 0.6W 1% metal film

Capacitors

C1, C4, C7, C9, C15, C16	100n ceramic disc, 50V (6 off)
C2	100µ radial elect., 25V
C3	10n miniature polyester layer
C5, C11, C12, C17	10µ radial elect. 50V (4 off)
C6, C8,	100µ radial elect., 10V (2 off)
C10	2µ2 radial elect., 50V
C13	470p polystyrene
C14	1n polystyrene
C18, C21	100p ceramic plate (2 off)
C19	470p ceramic plate
C20	1n ceramic plate
C22, C24	100n miniature polyester layer (2 off)
C23	150p ceramic plate

See SHOP TALK Page

Semiconductors

D1, D2, D3, D4, D5, D6	1N4148 signal diode (6 off)
TR1	BC184 *npn* silicon transistor
IC1	LP2951CN +5V micropower voltage regulator
IC2	ICL7660 negative voltage converter
IC3, IC9, IC10	4093B, CMOS quad Schmitt NAND gate (3 off)
IC4	4060B CMOS 14-stage counter, with internal oscillator
IC5	4011B CMOS quad NAND gate
IC6	4024B CMOS 7-stage counter
IC7	4040B CMOS 12-stage counter
IC8	4082B CMOS dual 4-input AND gate
IC11	TL064C low power quad op-amp
IC12	ADC0804LCN 8-bit A/D converter
IC13	6264 64K CMOS static RAM
IC14	DAC0832LCN 8-bit double buffered D/A converter

Miscellaneous

S1	3-pole 4-way rotary switch
S2	Miniature push-to-make, release-to-break, pushbutton switch
S3	Miniature s.p.d.t. toggle switch
WD1	PBN2720 piezoelectric transducer element, with leads

Printed circuit board, available from *EE PCB Service*, code EE780; 8-pin d.i.l. socket (2 off); 14-pin d.i.l. socket (7 off); 16-pin d.i.l. socket (2 off); 20-pin d.i.l. socket (2 off); 28-pin d.i.l. socket; AAA alkaline cells (3 off); ribbon cable, connecting wire; solder etc.

CHARGER

Resistors

R1	12
R2	10k

Both 0.6W 1% metal film

Capacitors

C1	470µ radial elect., 25V

Semiconductors

D1, D2, D3	1N4007 1A 1000V rect. diode (3 off)
TR1	BC214L *pnp* silicon transistor
TR2	BFX30 *pnp* silicon transistor

Miscellaneous

T1	Mains transformer, 240V primary; 15V-0V-15V 100mA secondary

Stripboard 0.1in. matrix, size 10 strips x 20 holes; miniature 240V mains chassis mounting plug and "free" socket; plastic bracket for mounting stripboard; mains rated wire; connecting wire etc.

Approx cost guidance only **£44.50**

These thirteen bits are applied directly to the RAM, IC13. The last seven also go to IC8, a 4082B dual 4-input AND gate. When the output of this goes high, after 8128 cycles, it stops the clock by taking IC4's (pin 12) "reset" input high. When the output of IC8 goes high it also turns on transistor TR1 to indicate the end of the sequence to the user. Resistor R16 is connected to the top of the Brilliance control, VR1 of the "sound/light board", so that when TR1 is biased on, it dims the glasses.

Pressing the Reset switch S2 takes the "resets" of IC4, IC6 and IC7 high, resetting the whole counter. When the circuit is switched on, capacitor C17 resets it as though switch S2 had been operated.

The output from switch S1c is normally pulled low by resistor R6 except when set to "Program", which connects it to +5 volts. This enables the circuit to read a sequence into the RAM and activate the circuit around IC5, which generates one-second "bleeps" during programming. There are exactly thirty-one bleeps, counting them helps the user to time the program pattern as it is entered.

PULSE CONTROL

The timers and gating built with IC9 and IC10 determine whether data is "written" or "read" to IC13, by providing the appropriate sequence of control pulses to IC12, IC13 and IC14. The address increments each time IC6 pin 11 goes low, whilst control pulses are produced as it goes high, so there is always a valid address when control pulses appear.

Each time the clock goes high, the RAM is activated by a 100µS pulse from IC9c to it's "chip enable" input, pin 20. If switch S1c is in the "Program" position, a 10µS pulse from IC9a causes A/D converter IC12 to start a conversion. At the same time IC12's outputs are enabled by a 100µS pulse from IC10c, so the data resulting from the conversion appears at them.

Note that IC9a and IC10c are both enabled by the positive signal from switch S1c. In "replay" positions this signal is "low" so input conversion does not take place and IC12's outputs are effectively open circuit.

The analogue input at resistor R17 is buffered by IC11a before going to IC12. Manual or "Direct" operation is possible through switch S3, which transfers this buffered input directly to the output, bypassing the digital process.

A delay of about 45µS is produced by IC9b, following which IC10b, also enabled by switch S1c, sends a 10µS pulse to the "write enable" (pin 27) of RAM IC13. This causes it to read the data from IC12 into the current address.

A similar pulse from IC10a is sent to the $\overline{WR1}$ pin (2) of the D/A converter IC14, causing it to copy data at it's input to internal latches, where it is converted to a current at "Iout", pin 11. IC9d inverts the signal from S1c and so inhibits IC10d, preventing an "output enable" signal going to the RAM.

The D/A converter IC14 contains an internal chain of switchable resistors, fed from a reference voltage, with a feedback resistor for use in an inverting op-amp circuit. The designer has to supply the op-amp, in this case IC11c, and the output of this is inverted and restored to the original value by IC11d.

The reference for the resistor chain is 2.5V in this design. Conveniently, this appears at pin 9 of IC12, derived from the 5volt supply rail. Not so conveniently, the input to IC14 has a low impedance, so it is buffered by IC11b.

During "replay", the signal from S1c is low, disabling IC9a and IC10c, so IC12 does nothing. IC10d is now enabled, however. As the clock goes positive and the RAM is activated, IC10d tells it to output data from the current address.

As before, a delayed 10µS pulse from IC10a initiates copying of data to the internal latches of IC14 for analogue conversion. When the RAM enabling pulses end and it's outputs go open-circuit, the data remains in IC14's latches and the analogue output remains valid. The timing for all this is shown in the diagram of Fig. 3.

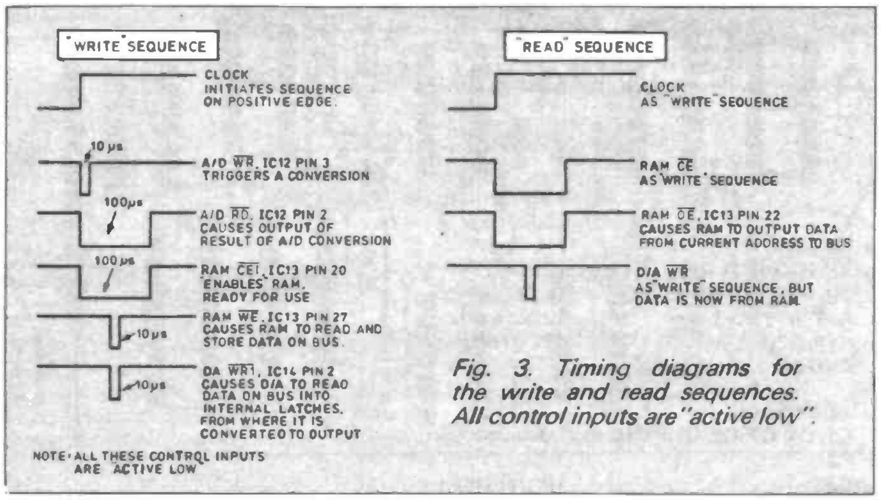


Fig. 3. Timing diagrams for the write and read sequences. All control inputs are "active low".

VOLTAGE REGULATION

Voltage regulation for the circuit, shown in Fig. 4, is on the same board. Raw battery +12V is decoupled by capacitors C1 and C2, and supplied to IC11 and IC14. IC1 provides regulated +5V through diode D1 for everything else except the RAM, which is powered through diode D2.

Placing diode D1 between the output pin 1 and sense pin 2 of IC1 causes automatic compensation for the drop across this diode and D2. When the power is off, the +4.5V backup battery supplies the RAM through diode D3 to retain the program, with diode D2 isolating it from the rest of the circuit.

The error output, at IC1 pin 5, is normally high but goes low if the output falls by five per cent. It needs a pull-up resistor, in this case R1.

When the circuit is switched on and this output indicates a healthy supply, resistor R2 and capacitor C10 introduce a brief delay before the RAM can be activated. When it is switched off, the RAM is disabled immediately.

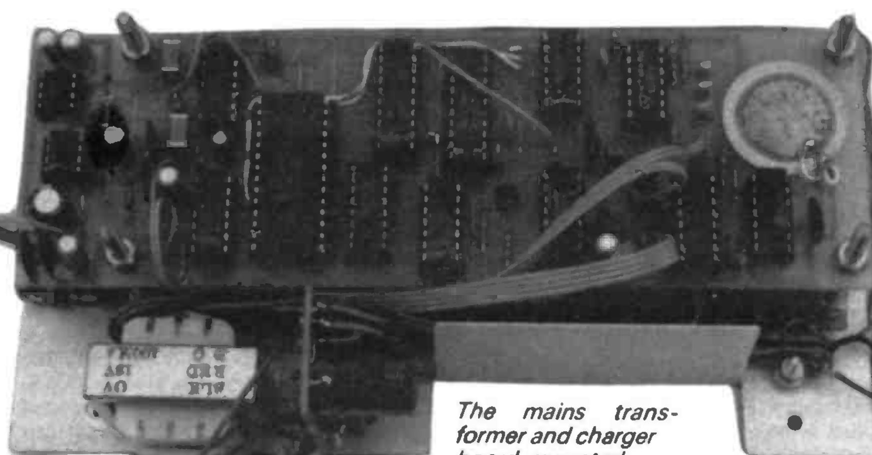
This arrangement prevents it being enabled and connected to other parts of the circuit whilst they are in "non-valid" states.

Finally, as IC11c's output must be able to swing below negative rail, an auxiliary −5V supply for IC11 is generated by the converter IC2.

CONSTRUCTION

The Programmer and Supply Regulator circuits are both built up on the same printed circuit board (p.c.b.). This board is available from the *EE PCB Service*, code EE780.

The printed circuit board component lay-


The mains transformer and charger board mounted on the chassis plate. The "common earth" point can be seen on the right.

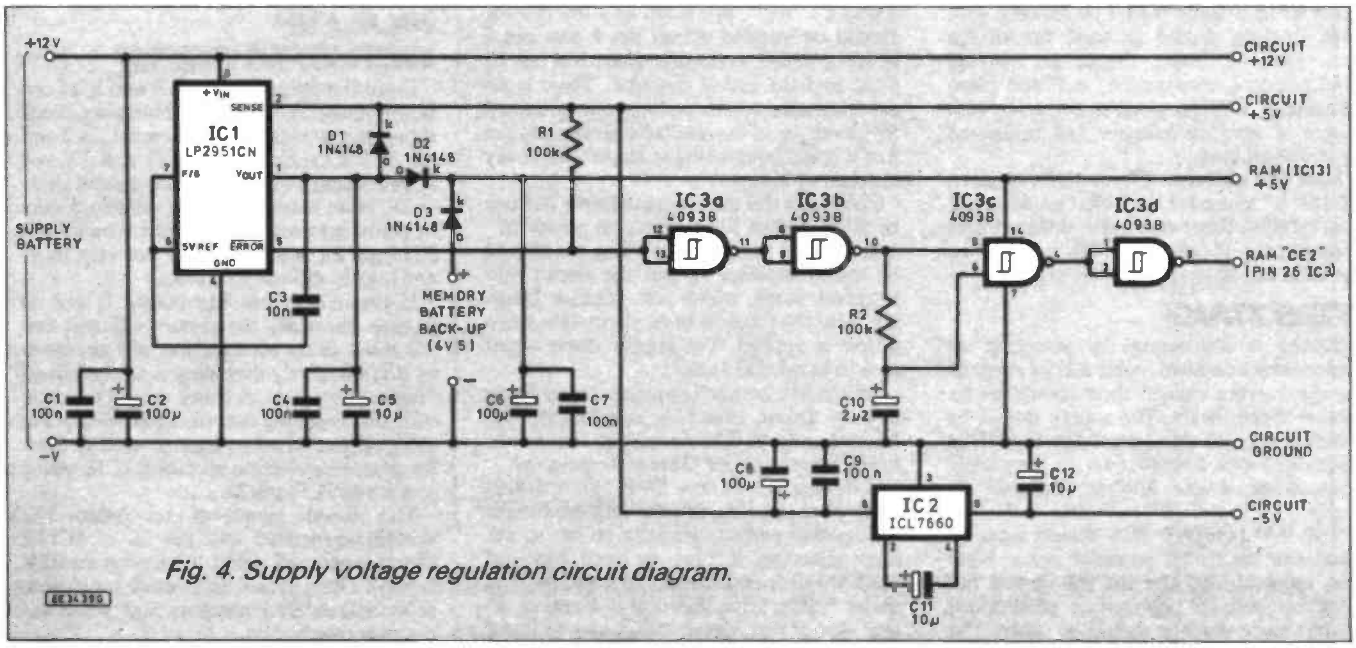


Fig. 4. Supply voltage regulation circuit diagram.

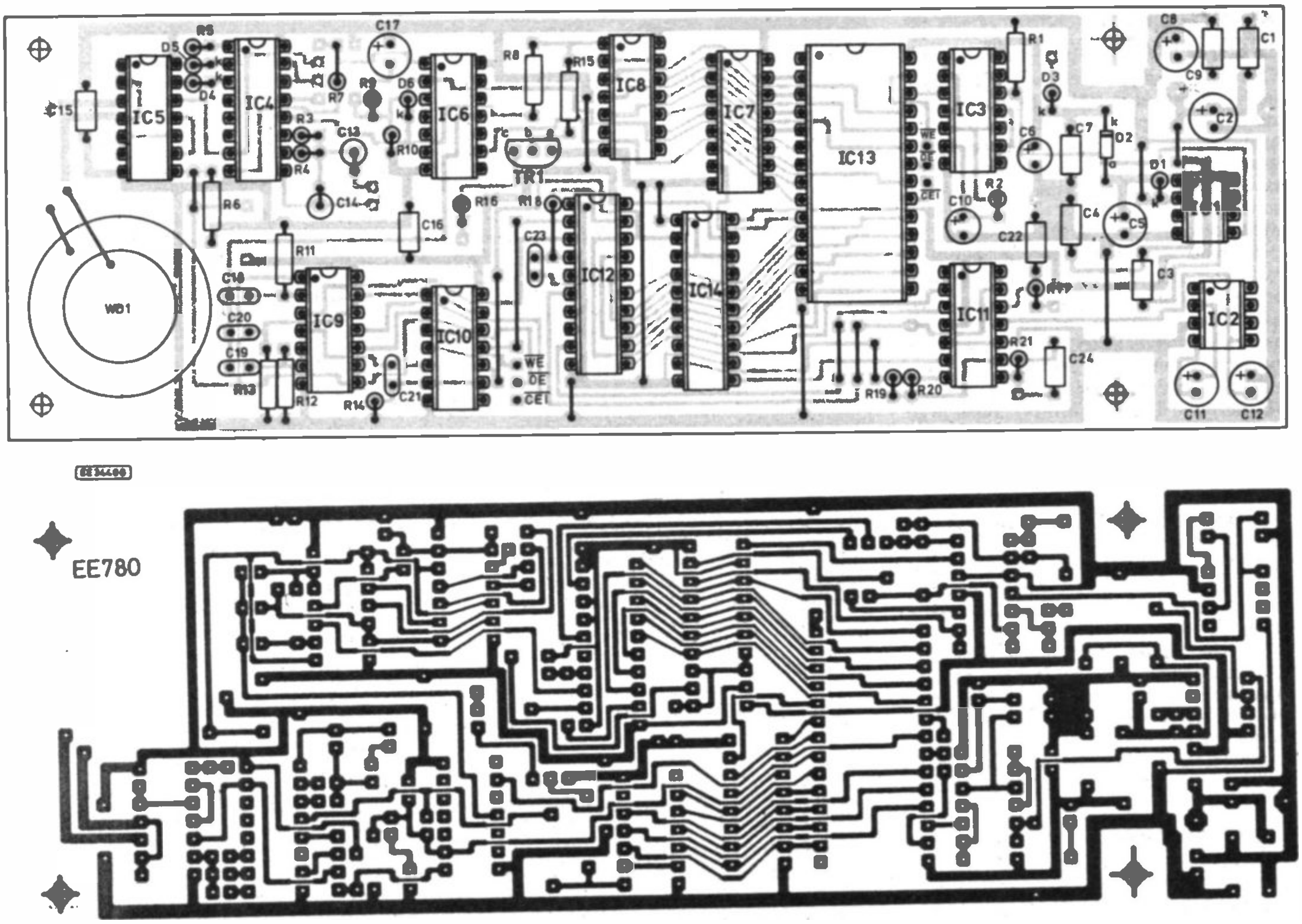


Fig. 5. Printed circuit board component layout and full size copper foil master pattern.

out and full-size copper foil master pattern is shown in Fig. 5. Construction of the board should follow the usual procedure of fitting components in height order, the lowest first for greatest ease.

To reduce cost a single-sided p.c.b. is used, a drawback to this being that thirteen links are necessary. Additionally the six points marked in pairs as $\overline{WE}$, $\overline{OE}$ and $\overline{CEI}$ must be linked together with insulated wire. The route of these three wires can be seen from the photographs.

The small ceramic capacitors tend to crack easily so their leads should be handled with care. Sockets should be used for all the i.c.s, none of which should be inserted until testing is commenced. A 27mm piezo transducer, WD1, is glued to the p.c.b. with a spot of Araldite adhesive and connected by two short leads.

Note that transistor TR1 is a BC184, not a BC184"L" as used in the Light/Sound board (last month). Same transistor, different lead arrangement. If only a BC184L is available, the leads can be bent to allow it's use.

TESTING

Testing is commenced by powering up *without* any i.c.s fitted. After a brief surge as the electrolytics charge, there should be no further supply drain. The supply should be switched off and the electrolytics should be discharged with a resistor across the supply connections, a one kilohm (1k) will do nicely.

The +V regulator IC1 should now be fitted and the circuit powered again. Note that most of the i.c.s on this board are CMOS types, so appropriate precautions against static damage should be taken. The supply current should now be about 140µA, and the regulated +5V should be present across decoupling capacitors C8 and C6.

Next, the −5V converter IC2 can be fitted, and when powered the presence of −5V across capacitor C12 checked. The drain current should now be around 200µA. If this is OK, the regulation is operational and testing of the rest of the circuit can proceed.

CLOCK

Starting with the clock IC4, this won't run unless it's "reset" line is low so a 10k resistor should be inserted across pin 1 and pin 7 of IC8's socket to do this. Then IC4 can be fitted and the circuit powered. There is no need to make connections to any of switch S1 points yet. If the oscillator is running, pin 3 of IC4 will be clocking at about 1Hz, easily checked with a meter.

Following this the bleep generator IC5 can be fitted. Switch S1c connection points "*C*" and "*D*" on the p.c.b. (see Fig. 6.) should be linked together to put the circuit into Program mode, which will produce bleeping from the transducer at about 1Hz when power is applied. The supply drain ought now to be around 1mA.

Switch S1b connection points *E* and *G* can now be linked, effectively selecting the 30-Minute position. The circuit will continue to bleep, because *C* and *D* are still connected.

If divider IC6 is now fitted, pin 6 should clock at about 1Hz, in time with the bleeps. This proves correct operation so far, so address generator IC7 can be fitted. Pin 9 of this should clock at about 1Hz, and pin 7 at about 0.5Hz. If so, this too is working, so the "end of run" detector IC8 can be fitted, following removal of the 10k resistor from it's socket.

At the connections for S1b, points *E* and *F* should now be linked to select a Thirty-Second run time. On power-up, an automatic "reset" should be effected by capacitor C17, so the circuit should bleep thirty-one times and then stop.

Momentarily shorting S2 connection points *I* and *J* should cause the sequence to repeat. If so, the clock and address generator sections are working correctly.

PULSE GENERATORS

Control pulse generators IC9 and IC10 can now be fitted. With the circuit bleeping, check the apparent voltage at IC12 socket pin 2 and pin 3, IC13 socket pins 20, 22 and 27, and IC14 socket pin 2. All of these should show +5V. If an oscilloscope is available it may be possible to see negative pulses on all but IC13 pin 22, although these are very short and may be difficult to resolve.

If the link across S1c points *C* and *D* is now removed, the circuit will still run for about thirty seconds, but will not bleep as it is effectively executing a thirty-second "replay" sequence. A check should be made whilst it is running that the above points are still positive. A 'scope may be used to look for negative pulses on all except IC12 pins 2 and 3, and IC13 pin 27.

The RAM power-up controller IC3 should be inserted and pin 26 of IC13's socket monitored whilst turning on the 12V supply. There should be a small but visible delay before this point goes high when the circuit is switched on.

A/D-D/A CONVERTERS

With power supplies, clock, address generator and control pulses all running, at last the interesting part has been reached! The A/D converter IC12 can be inserted. Pin 19 is an internal "clock" output and should have an average d.c. level of about 2.5V. It may be checked with a 'scope, it runs at about 350kHz.

Reference output pin 9 should be at 2.5V d.c. The supply current should by now be 2.5mA to 3.0mA.

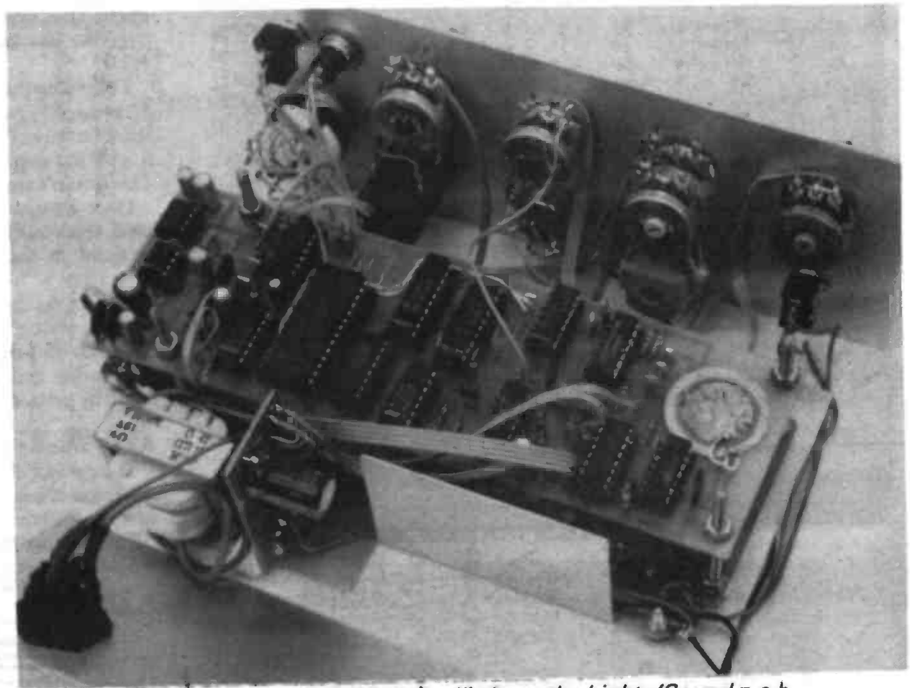
Next, IC11, the TL064 quad op. amp, should be fitted. The circuit input, point *Q*, should be connected to "ground" (negative rail). This ought to result in 0V at IC11 pin 14, the input buffer. Pin one should be at 2.5V, and the total supply current should be about 4.1mA.

The D/A converter IC14 can be inserted next, and S1c points *C* and *D* shorted again to put the circuit into Program mode. Whilst the circuit is running (and bleeping), the output, from point *R*, should equal the input, since data conversion and transfer between the A/D and D/A chips should be taking place.

If a ten kilohm linear potentiometer is connected across the 5V supply (across capacitor C8) and the wiper (centre tag) taken to the input, a meter will show the output tracking the input during the programming period. When the sequence ends, the output should remain at it's final value.

RAM CHECK

Finally, the RAM chip IC13 can be fitted. A programming sequence should be executed with a varying voltage applied to the input, then the short across S1c connections removed, and the sequence triggered again by linking S2's connections briefly.



The programmer board "stacked" above the Lights/Sound p.c.b.

This should result in a replay of the voltage pattern just entered, this time obtained from the RAM. It will run for only thirty seconds of course, since for testing this period is still selected at S1b's connections.

This completes the board checks, so it can now be fitted to the Mind Machine project for fully automated operation. The total supply current taken by this board when running should be about 5.0mA.

ASSEMBLY

The Programmer board fits above the existing Mind Machine Lights/Sound board, on the four screws projecting from the chassis plate. It faces the opposite way to the Sound/Lights board, all the i.c.s pointing away from the front panel.

The board is longer than the first board, one end projecting beyond the mounting. The back-up battery "pack" fits beneath this projection.

Connection into the Mind Machine project is straightforward. The trickiest part is the bunch of wires connecting switch S1, but with some ribbon cable to keep things neat this shouldn't cause any real difficulties. All connections are shown in Fig. 6.

The lead from the wiper of Frequency control VR4 is disconnected from the original p.c.b. and taken instead to the input, point *Q*, of the Programmer board. A s.p.d.t. S3 switch selects Programmed (point *R*) or Direct (point *N*) output from the programmer and feeds it to the original board's input. S2 is a miniature press-to-make switch for program restarting.

The +12V supply is taken from the existing on-off switch to point *S* on the board, whilst negative, point *T*, is connected to the common "Earth" on the chassis. The backup battery consists of three alkaline AAA cells, taped and soldered together to make a 4.5V pack and fastened to the chassis with cable ties. This semipermanent installation is fine since they should last virtually for their shelf life, a couple of years at least.

The "end of run" output, point *M*, is soldered to the existing lead on the top end of Brilliance control VR1. When transistor TR1 turns on it reduces the voltage across this potentiometer to about a tenth of it's normal value, causing marked dimming of the lights.

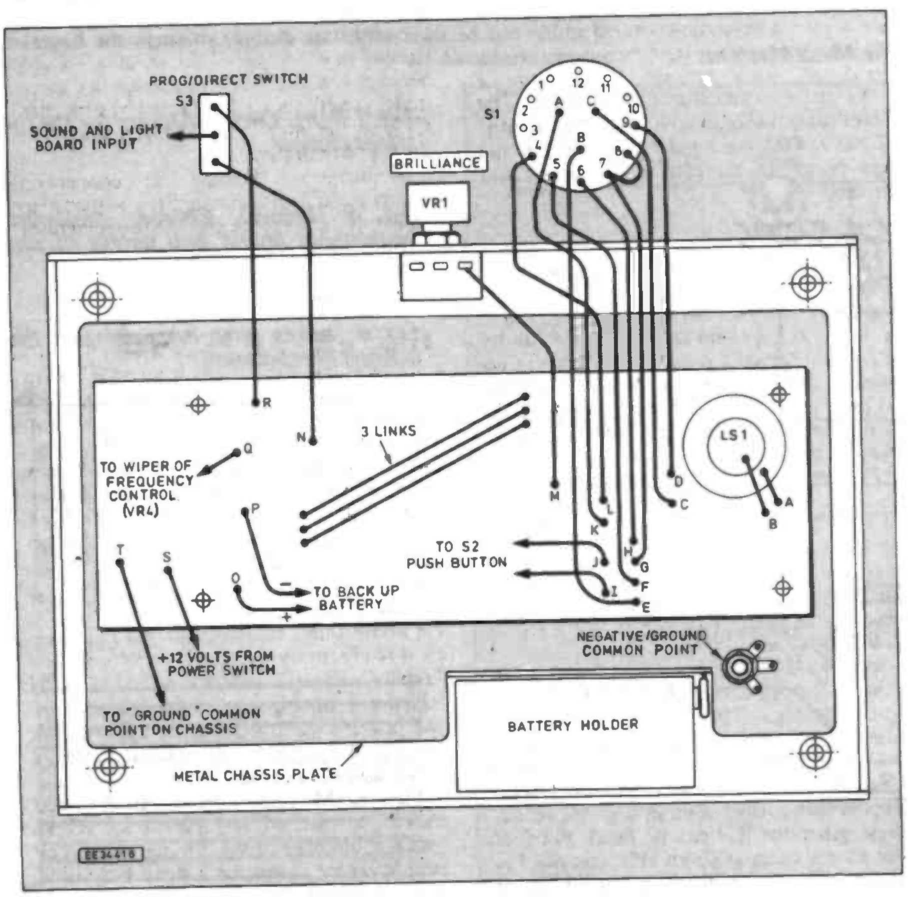
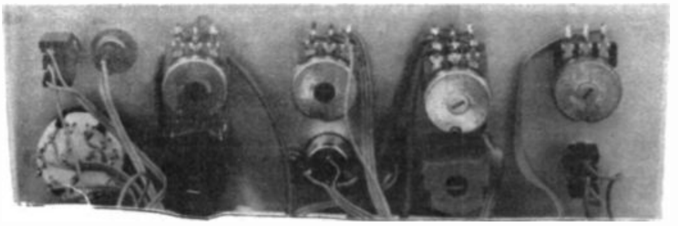


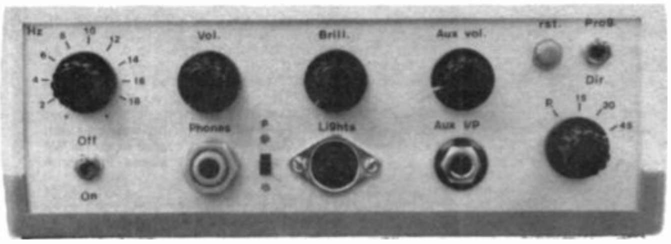
Fig. 6. Interwiring from the circuit board to off-board components.

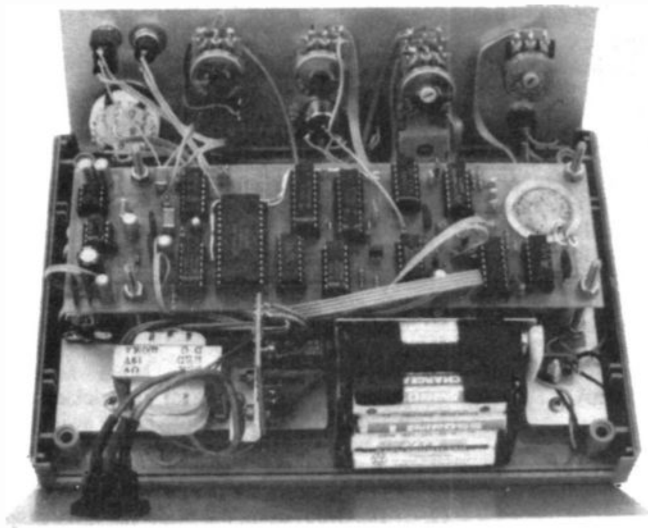
RELAX

In normal use, switch S1 is set to Program, S3 to Programmed, and the Reset button S2 pressed. Programming begins as soon as it is released, and the desired pattern is entered with the frequency control, the bleeps being counted so that the point in the program is known. The author normally starts at about 14Hz, falling to 7Hz to 8Hz over the first two or three bleeps, holding this briefly, then dropping slowly to 4Hz, then back up to



Rear view (above) of components mounted on the front panel and (below) front panel lettering on the completed unit.





General layout of components inside the Mind Machine.

about 7Hz, with some brief (one-bleep) excursions to 12Hz, then over the last two or three bleeps returning smoothly to 14Hz-16Hz.

Following program entry, S1 is set to 15, 30 or 45 minutes and S2 pressed to repeat the sequence over this period. It is possible to relax far more deeply with the automatic control sequence, in fact it is all too easy to fall asleep as *delta* frequencies are approached! This doesn't seem to detract from the beneficial effects, though.

Once a satisfactory program pattern has been found, it can be used repeatedly. There is no need to reprogram as it will be retained in the RAM when the machine is switched off. On power-up a "reset" is performed automatically, so it is only necessary to don glasses and phones and switch on to enjoy a session.

Switch S3 permits manual frequency control, though if the sequence has ended the lights will be dimmed. This is easily overcome by pressing Reset.

BUILT-IN CHARGER

The project can be powered by ordinary batteries. However, to save case dismantling for battery changes, the prototype is fitted with Ni-Cads and a built-in charger.

This is a simple transformer, rectifier and constant-current arrangement connected *permanently* to the battery pack. A miniature three-pin chassis plug mounted on the case rear panel accepts mains input to the charger.

The charger circuit diagram is shown in Fig. 7. The mains transformer T1 has a 15V-0V-15V secondary winding, with the output rectified by diodes D1 and D2 and smoothed by capacitor C1. Transistors TR1 and TR2 form a simple constant-current circuit, the output from this going to the battery pack through diode D3 to prevent any "back-feeding" when it is not operating.

This little circuit was assembled on a scrap of 0.1in. stripboard. The breaks in the underside copper strips and the topside component layout appear in Fig. 8.

Transistor TR2 may warm up a little in use so a clip-on heatsink should be fitted. Testing is simple, just check that a voltage appears across capacitor C1 when the transformer is powered and that the output into the batteries is around 50mA-60mA.

There is just room inside the case for the transformer and board behind the p.c.b.s, alongside the battery pack, as can be seen in the photographs. The board is mounted vertically on a bracket cut from a piece of plastic.

The mains Earth is connected to the chassis plate, and all connections to the rear of the plug are sleeved for safety. The wiring for this part of the project is shown in Fig. 9. The Mind Machine can be used whilst on charge, although the batteries must be connected. □

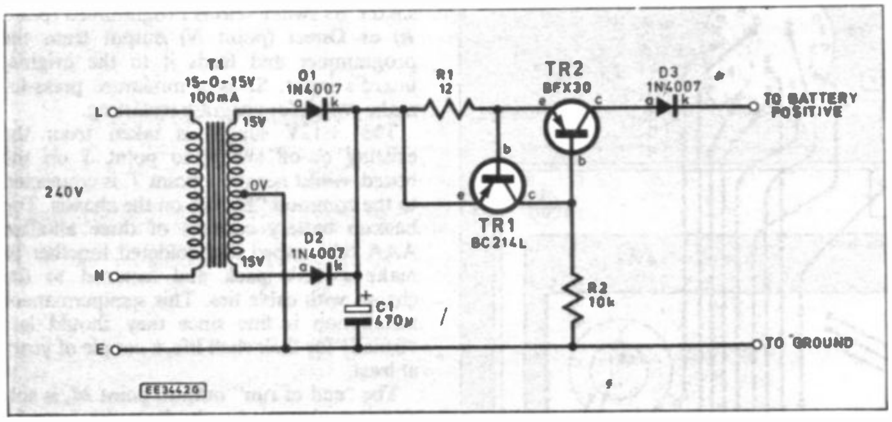


Fig. 7 (left). Circuit diagram for the internal charger.

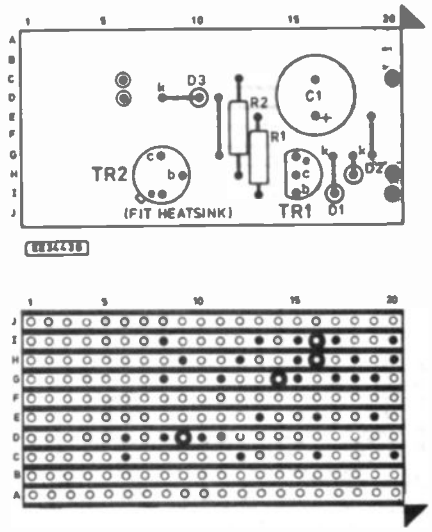


Fig. 8 (below). Charger stripboard component layout and details of underside breaks in copper strips.

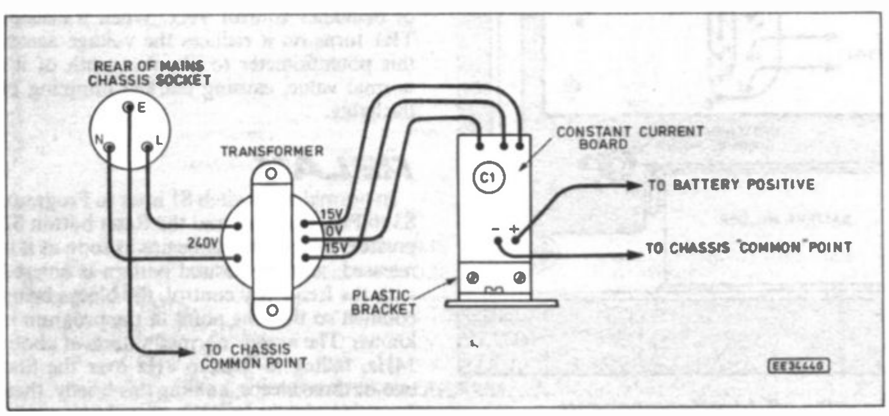


Fig. 9 (below left). Interwiring of the charger components.

INTERFACE

Robert Penfold

IN LAST month's *Interface* article a simple eight bit Analogue to Digital Converter was described, together with a simple temperature sensor. This month we continue on the same theme, with an improved temperature sensor circuit. This provides greater resolution and a wider temperature range.

SIGNAL PROCESSING

The main problem with the basic design described last month is that it provides a resolution of only one degree Centigrade. Over a temperature range of 0 to 100 or 110 degrees, it is actually possible to obtain a much more useful resolution of 0.5 degrees using an 8-bit converter.

A second problem with the original design is that it lacks accuracy at low temperatures. This is partially due to limitations of the temperature sensor, and partially due to problems in removing the slight zero offset of the converter.

The circuit diagram for the Improved Temperature Sensor is shown in Fig. 1. Like the original circuit, this is based on the LM35DZ temperature sensor (IC1), which is usable over a 0 to 100 degree Centigrade temperature range. If the more expensive LM35CZ is used, the upper end of the range is extended to 110 degrees Centigrade.

The LM35 provides an output voltage that is equal to 10 millivolts per degree Centigrade, with no d.c. offset. This matches the 10 millivolt resolution of the Analogue to Digital Converter (last month), giving the one degree resolution. Simply amplifying the output from the LM35 by a factor of two boosts the output voltage to 20 millivolts per degree, and gives 0.5 degree resolution. With a maximum temperature of 100 or 110 degrees Centigrade, this gives a maximum output potential of 2.0 or 2.2 volts, which is still within the 2.56 volt maximum of the converter.

CIRCUIT

Component IC2 is a simple non-inverting amplifier which is d.c. coupled and has a voltage gain of two times. Its gain must be set very precisely at this figure in order to obtain accurate results. The gain has therefore been made adjustable, and VR2 is used to trim it to precisely the correct figure.

Potentiometer VR1 is an offset null control. Conventionally an offset null control is used to compensate for offset voltages in the operational amplifier's biasing. It will do so in this case, but it can also be used to compensate for any slight offsets in the analogue to digital converter, or in the temperature sensor.

Note that the output of this circuit must connect directly to the analogue input terminal of the ZN448E in the converter circuit. The input attenuator and zero adjustment circuits of the converter should be omitted.

SOFTWARE

Taking readings from the interface is achieved in much the same way as for the original temperature interface. First output a dummy value to in/out address 768 in order to initiate a reading. After a delay of at least nine microseconds, the converter is read at input/output address 768. Simply divide the returned values by two in order to convert them into readings in degrees Centigrade.

I have assumed here that the converter is at the base address of the thirty two address "prototype card" block. If the unit is placed elsewhere in the input/output map, then obviously the appropriate address must be used instead of address 768.

The accompanying Listing.1 is for a program that takes readings at one second intervals. It displays the current temperature on the screen, together with maximum and minimum readings.

This program is useful for testing and calibration purposes, as well as for use when utilizing the system for temperature monitoring. It is suitable for the Quick BASIC compiler, or the QBASIC interpreter supplied with MS/DOS 5.0. It might work with other PC BASICs, but if not it should certainly be quite easy to convert it to work with other PC BASICs.

CALIBRATION

The original temperature interface circuit does not require any calibration, but it does not exactly offer the ultimate in accuracy. This version can provide much better accuracy, but only if it is calibrated accurately.

Calibration requires two accurate temperatures, and one of these can be iced water at 0 degrees Centigrade. The other

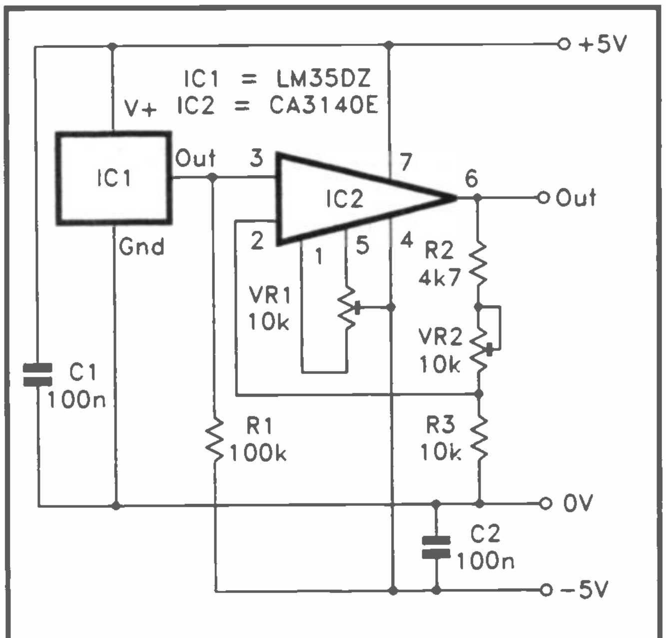


Fig. 1. Circuit diagram for the Improved Temperature Sensor Interface.

Listing One: Temperature Reading

```
SCREEN 0
WIDTH 40, 25
CLS 2

Tmax = 0
Tmin = 127
f$ = "£££.££"

LOCATE 8, 6
PRINT "Temp."
LOCATE 8, 18
PRINT "Max"
LOCATE 8, 31
PRINT "Min"
LOCATE 15, 1
PRINT "Press SPACE BAR to exit"

WHILE INKEY$ <> " "
     OUT 768, 0
     SLEEP 1
     Tnow = INP(768) / 2
     IF Tnow > Tmax THEN Tmax = Tnow
     IF Tnow < Tmin THEN Tmin = Tnow
     LOCATE 10, 5
     PRINT USING f$; Tnow
     LOCATE 10, 17
     PRINT USING f$; Tmax
     LOCATE 10, 30
     PRINT USING f$; Tmin
WEND
```

temperature must be much higher, and this could be water at about 50 degrees Centigrade or so. A good quality thermometer should be used to accurately monitor the precise temperature of the water.

The calibration process is very straightforward. Start with both VR1 and VR2 set at roughly the centres of their adjustment ranges. Place IC1 in the iced water and adjust VR1 for a reading of zero. Next place IC1 in the hot water, and adjust VR2 for the correct reading. Repeat this procedure a few times until no further adjustment is necessary. The unit should then work with good accuracy over the full temperature range.

When calibrating and using the unit, bear in mind that IC1 should not be directly immersed in liquids. It must be mounted inside a container of some kind, such as a small test-tube, so that no liquid comes into contact with its leadout wires.

It is a good idea to use some silicon grease to give a good thermal contact between the container and IC1. Even so, the response time will not be particularly fast. It will take the sensor several seconds to respond to large and rapid changes in temperature. Be careful to allow sufficient adjustment time when calibrating the unit.

NEGATIVE TEMPERATURES

The LM35CZ can handle negative temperatures down to −40 degrees Centigrade. Unfortunately, these negative temperatures provide negative output voltages which the converter can not handle. One way around this difficulty is to use VR1 to provide an offset, so that the output voltage from IC2 is always positive.

For example, suppose that the unit must measure temperatures down to −10 degrees Centigrade. With IC1 at this temperature, VR1 would be adjusted for a reading of zero. With IC1 then set at the higher calibration temperature, VR2 would be adjusted for a reading ten degrees higher than the actual calibration temperature.

In order to obtain readings in degrees Centigrade, the software would first have to divide readings by two, and then deduct ten to compensate for the deliberate offset. This would give a usable temperature range of −10 to −110 degrees Centigrade.

Some initial experiments would suggest that a 10 degree offset can be handled with no significant degradation in accuracy. This might not be the case with the full 40 degree offset needed to read down to the −40 degree minimum of the LM35CZ.

However, if you need to read down to such low temperatures it might be worthwhile experimenting along these lines. VR1 certainly seems to be able to handle a 40 millivolt input offset. Of course, if the unit is made to read right down to −40 degrees, you have to accept some loss of coverage at the other end of the range. The maximum input voltage of the converter would be reached at a temperature of 87.5 degrees.

There is plenty of scope for experimentation with a unit of this type. With suitable software you can do such things as monitoring heating systems, the outside temperature, etc. Most PCs have good graphics capability these days, and it should not be too difficult to produce software to log readings and then display them as graphs.

PC INCOMPATIBILITIES

There are hundreds of different PC expansion cards, monitors, etc. currently available, and with a few provisos, they should all work perfectly well together. In reality there seems to be the occasional problem, which I suppose is inevitable with so many products being produced by so many different companies around the world. This means that you need to be a little careful when buying PC hardware.

Possibly I have been unlucky, but I have encountered numerous PC compatibility problems over the last few years. The worst case was a 12MHz AT motherboard which only seemed to work with about one-in-two expansion cards! With some swapping around of cards between various computers I did eventually managed to produce a complete computer based on this motherboard, but why did some cards refuse to work with it while others were fine?

More recently I have had problems with non-Intel maths co-processors which worked in some computers but not in others, and a monitor which worked with some VGA cards in all modes, but refused to respond to others when used in the 800 x 600 super VGA mode.

In the case of the monitor the problem seemed to be due to differences in the scan rates of VGA cards. The super VGA modes are not properly standardised, and this clearly leaves room for incompatibility problems. Many VGA cards now have a configuration switch which enables you to select between two sets of scanning frequencies. A lower set than any super VGA monitor should be able to handle, and a higher one for "flicker-free" viewing on suitable monitors.

The expansion card problem and (possibly) the co-processor one seems to be something more fundamental. Modern motherboards and expansion cards are largely devoid of TTL chips, and instead use a variety of LSI chip technologies. This seems to result in occasional conflicts where two sets of chips do not agree about what constitutes valid logic 0 and logic 1 voltages. This usually results in the computer completely hanging up, or crashing soon after switch-on.

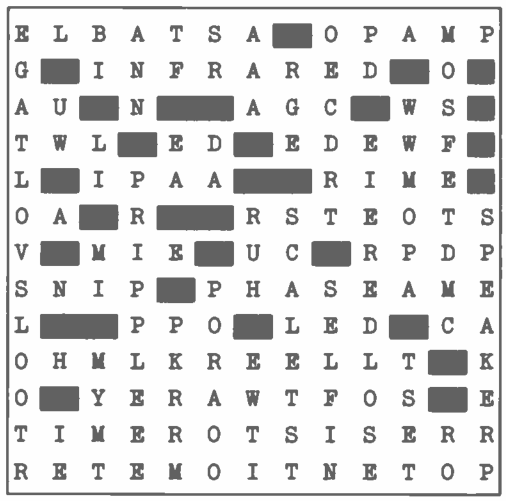
There also seems to be problems with drive currents, with some chips simply not having sufficiently powerful outputs. This factor seems to be responsible for some computers being unable to drive some printers via their parallel ports.

It would seem to be a good idea, where possible, to check that PC hardware will work properly with your system before handing over any money. Alternatively, make sure that you can return the equipment for a refund if there are any incompatibility problems.

Next month: We will continue with PC interfacing, and the subject of digital to analogue converters will be covered.

Crossword Solution

EE WORD SEARCH



SOLUTION

The familiar title is – EVERYDAY ELECTRONICS The associated name is – MIKE KENWARD

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MAGNETIC RECORDING

Part 4: HEAD DRIVE CIRCUITS

VIVIAN CAPEL

IT MAY may seem that all we need to do to make a magnetic recording on tape is to connect a recording head to an amplifier and a biasing system, and pass the tape at uniform speed across it. As may be expected, there is rather more to it than that.

Our first consideration is that of head impedance, it should be of the optimum for the required function. Just as with the magnetic characteristics we discussed last month, the electrical requirements for the recording and playback heads are quite different.

The strength of a magnetic field produced by a coil is proportional to the *current* flowing through it rather than the voltage across it. So we must be able to drive adequate signal and bias currents through the head in order to make a good recording. As *high* impedances limit the amount of current that could pass, it follows that the head winding should be of *low* impedance.

In the case of the playback head, it is necessary to generate as high a voltage as possible from the flux on the tape, in order that a large signal voltage is presented to the first stage and a high signal/noise ratio thus be obtained. This requires a large number of turns on the coil, which gives it a high impedance.

So, a *low* impedance is best for the *recording* head whereas a *high* impedance is desirable for *playback*. No problem here as long as *separate* heads are used, but with a single record/playback head, impedance must be a compromise.

SWITCHING

When a single head is used it must be switched from the record to the playback amplifier and back again, which can be done with a single-pole two-way switch. An obvious way of connecting it is having one side of the winding connected to the chassis, and the other switched either to the input of the playback amplifier or the output of the recording amplifier.

Such an arrangement though, would be prone to trouble. Remember that very high gain must follow the playback head to translate the minute signals from the tape into the high volume needed for realistic sound reproduction. So, any trace of oxide on the switch contacts would produce audible noise. Furthermore, the switch and its terminals would be liable to pick up hum and would need careful screening which could pose practical difficulties.

The alternative switching system commonly used, is both simple and ingenious. One side of the head winding is permanently connected to the recording amplifier output circuit, while the other side is permanently taken to the playback amplifier input. Connections from both are taken to a switch, while the switch common is connected to the chassis (Fig. 1).

In the play position, the switch "earths" the *A* side of the windings, but in the record position, the *B* side of the winding is earthed. As the switch is connected to chassis in both positions it cannot pick up hum, and there is no switching of "live" connections,

There is no need to switch the erase head during playback with a.c. systems, as the oscillator is switched off. With d.c. erasure, switching the head is necessary.

H.F. LOSS

Taking a further look at the impedance of the head, this results from a combination of inductance and the d.c. resistance of the coils. The formula is:

$$Z = \sqrt{R^2 + X_L^2}$$

where Z is the impedance; R is the resistance of the coils; and X_L is the reactance resulting from the coil inductance.

When recording low frequencies, the reactance X_L is low compared to the resistance, but at high frequencies the opposite is true, and the reactance becomes large in proportion to the resistance. What this means in practice is that the recording current encounters a low impedance at bass frequencies, but a continually rising one as the frequency increases. It decreases proportionally, producing a falling treble response.

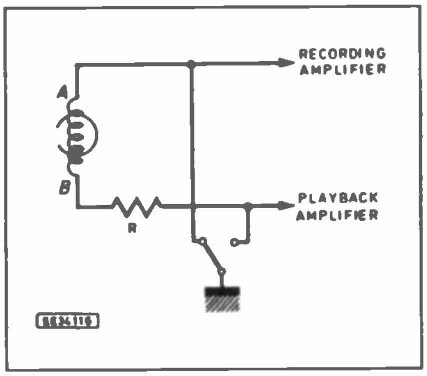

Fig. 1. Switching to a combined record/playback head. One end of the head winding goes to the recording amplifier and the other to the playback circuit. Alternate ends of the winding are earthed for each function thereby avoiding signal switching and possible hum problems.

PHASE ANGLES

There is another ill effect. Phase angles change as the relationship between reactance and resistance alters. So, high frequencies become displaced in phase relative to lower ones. As the stereo effect depends strongly on phase differences between channels it can be seen that phase errors can result in impaired stereo.

The most common solution to these problems is to increase the value of *R* by including a high value resistor in series with the head coil. This has a swamping effect by maintaining a more constant ratio between reactance and resistance over the frequency range. It ensures that the circuit is mainly resistive and so behaves in a more linear manner in its frequency as well as its phase response.

A further improvement can be achieved by connecting a capacitor across the resistor. This increases the high frequencies applied to the head and also improves the phase corelation between high and low frequencies. The values of the resistor and capacitor depend on the resistance and inductance of the head, all being chosen to give the flattest overall response with minimum phase displacement for the particular head.

This gives rise to an important practical point. Replacing a worn head on a tape recorder is quite a straightforward task. If the maker's replacement is used there is no problem, but it may not be available, or it may be decided to upgrade from a permalloy to an HPF (hot-pressed ferrite).

Whatever the replacement, it should have approximately the same resistance and inductance as the original, otherwise the series components will not produce the required compensation. Having said that, minor differences, particularly of coil resistance, have little effect and can be ignored.

RECORDING AMPLIFIER

The output stage feeding the head circuit must produce a high voltage to overcome the high series resistance, and also a high current to drive the coils. So it must provide a high power compared to what actually is needed to generate the recording flux. The output stage must therefore be of a power output type, and many recorders use the loudspeaker output stage to drive the head in the record mode.

Another factor which comes into play is the ***slew rate*** of the output stage. All power amplifiers have a limit to the rate of change that the output voltage can follow. It is obvious that the rate of change of a large signal is greater than that of a smaller one.

It is also evident that a high frequency cycle is completed much quicker than a cycle of a low frequency, so the rate of change is correspondingly greater. The rate of change is thus proportional to frequency and signal magnitude.

In a recording amplifier where high output voltages are required, the output stage slew rate may be inadequate at high frequencies. This can be another cause of falling h.f. response, and also generate the intermodulation distortion which occurs when the slew rate is exceeded. The effect is reduced by selecting output transistors having high slew ratings at the voltages and frequencies required.

There is another type of output stage which overcomes these problems by eliminating the need for the high-value series resistor. As we have seen, the recording flux is obtained as a result of current through the head windings rather than voltage. The output stage therefore is designed as a *constant-current* source,

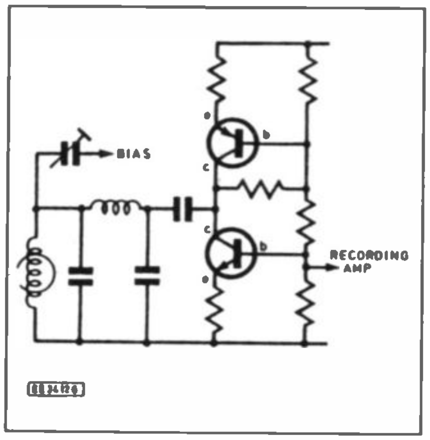

Fig. 2. Transconductance recording output stage supplies signal current that is not dependant on the impedance of the load thereby eliminating the need for a high-value series resistor *(Tanburg Actilinear).*

that is the current it supplies remains constant irrespective of the impedance of the load. So, when the impedance rises at higher frequencies, the current is not reduced.

An example of this type of circuit is the Actilinear circuit devised by Tanberg, (Fig. 2). It consists of a complementary push-pull output circuit similar to that used for many audio amplifiers, but with *negative* feedback from the transistor collectors (c) to the base circuit. An *LC* filter circuit couples the output to the head.

This type of circuit provides more than sufficient current to drive the head and because high signal voltages are not required to overcome a high series resistance there are no slew rate problems. A bonus is that the stage serves as a buffer between the bias oscillator and the recording amplifier so that feedback of the oscillator voltage to earlier stages is greatly reduced.

HEAD DRIVE ADJUSTMENT

Recording signals that are too large cause the operating point on the hysteresis loop to encroach onto the curved portions and so generate distortion. Yet those that are too small degrade the signal/noise ratio and require the playback amplifier to be turned well up, further increasing noise. So there is an optimum point beyond which peak recording levels should not rise, nor should they fall too far below.

This is the 0dB point on the recording level meter. However, due to the tolerances of components in the recording amplifier this has to be set for each particular instrument during manufacture, and a pre-set control will be found inside the machine for the purpose.

To reset it a millivoltmeter and an audio oscillator with variable output is required, also the service manual, or at least the appropriate information from it. A 10 or 100 ohm resistor is included in the "earthy" end of the record head by the makers and the meter is connected across it, see Fig. 3. To avoid false readings the bias oscillator must now be disabled, and then the fixed tone from the external audio oscillator is injected into the Auxiliary or MIC socket.

The output level of the oscillator is next adjusted to obtain 0dB on the VU meter, then the pre-set drive control is set to give the millivolt reading specified in the manual. Readings vary from model to model, but a typical one is 0.35mV over 10 ohm for Ferric tape, and 0.7mV for Chrome tape.

It can be said that this adjustment rarely needs to be done unless major components have been changed in the recording amplifier.

BIAS LEVEL ADJUSTMENT

The bias level may need resetting if a different type of tape from that recommended is used. In most cases the differences are too small to make much difference for average domestic use. Professionals set the bias for each tape recorded, as these are masters from which copies will be made and top performance is essential. Hi-fi enthusiasts may also wish to optimise the setting for a particular brand of tape.

Adjustment is usually by means of a small variable capacitor in series with the bias oscillator feed to the record head, but variable resistors or tunable coils are also used. The measurement is made in the same way as that for recording level, that is across the 10 or 100 ohm resistor in series with the recording head.

When the recorder is switched to record with no signal input, a reading is obtained. If the maker's setting is being checked, the reading should be compared with that given in the manual and any necessary adjustment made. As with the recording drive, values vary between models, but roughly, the reading should be about ten times that of the recording level at zero VU. Across 10 ohm it usually ranges from 3.0-7.5mV, while across 100 ohm, 30-75mV.

To set the level for a different make of tape, an audio oscillator that can generate a 400Hz and a 10kHz tone is required. These are recorded on the tape at −12dB on the VU meter. The tape is played back and the output levels of the two tones compared. If that of the 10kHz tone is lower, there is too much bias and the amount should be decreased, but if it is higher, bias is insufficient and it should be increased.

Adjust accordingly, then erase the tape and record the two tones again at the

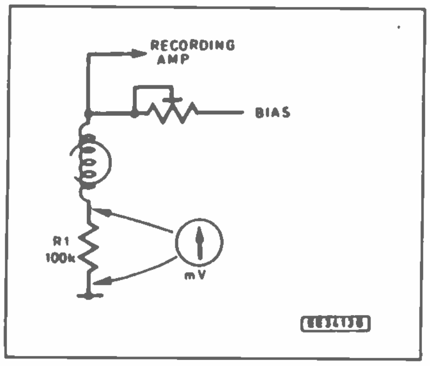

Fig. 3. Adjusting recording bias, commonly by preset resistor in series with the bias feed. Reading is taken by a millivoltmeter across 100 ohms (10 ohms in some models) in the earthy end of the head.

same level. Playback once more and check the comparative levels as before, then make further bias adjustment as required.

The process is repeated until the 10kHz tone is just 1dB down if optimum distortion level is desired. It may be remembered from a previous article, that the two do no coincide, one must adjust for either one or the other, or a compromise can be made.

AUTOMATIC LEVEL CONTROL

Automatic level control (*ALC*) is found in most portable recorders. Part of the output of the recording amplifier is rectified then used to control the gain of an earlier stage. This ensures that the recording level is not too high or too low without the necessity of manually adjusting the level. It also takes care of increases and decreases of signal level during recording.

The time constants of the circuit are chosen to give a rapid attack, but slow decay. Thus sudden loud signals produce an almost immediate reduction in gain to prevent overload, but afterwards the circuit fades up the gain gradually to avoid too obvious gain changes.

The system is useful for speech and "on location" recordings where it would be difficult to set and maintain levels manually, but it does have serious drawbacks for other work. Level changes are noticeable, as background noise drops then fades up as the signal varies.

For recording music it is hopeless, as the dynamic range is telescoped, musical climaxes are emaciated, and quiet passages that are reduced to almost inaudibility after loud fortissimos, gradually get unnaturally louder.

Early recorders had a manual/automatic switch, whereby the user could select the mode according to the use, but although gimmicks abound on modern machines, this very useful facility has disappeared. Some serious users have had their machines converted to manual operation. This involves removing the feed to the controlled stage and either fitting a manual control or in some cases it is possible to arrange for the playback volume control to serve as a level control during recording. Modification details differ considerably between models.

Having explored the heads and their drive circuits, we will return to the tape itself in our next article and see how this apparently simple commodity is far more complex than it appears, and what is involved in its manufacture.

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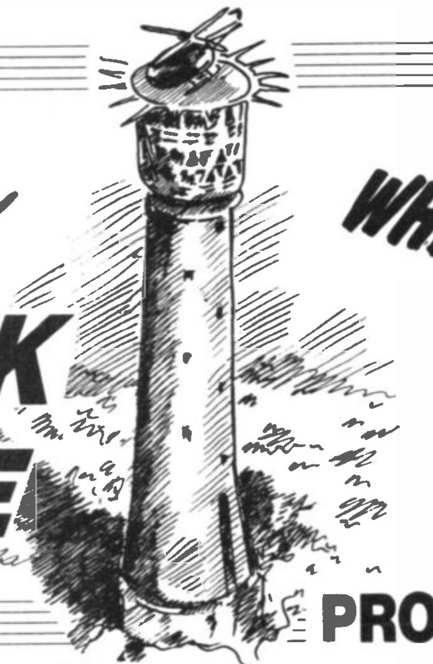

BISHOP ROCK LIGHTHOUSE

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PROJECT 7

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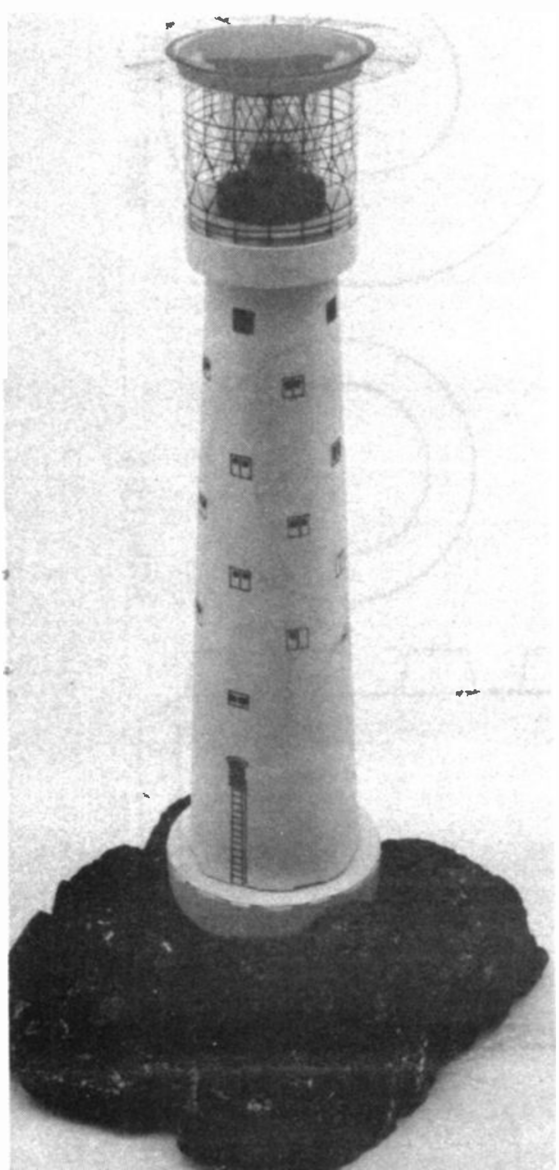


STANDING on a pinnacle of rock rising sheer out of the ocean floor in the westernmost Scilly Isles, the Bishop Rock lighthouse is said to be the most exposed in Britain. The rocks are submerged at spring tides and, given that there are an average of 30 gales in this area each year, it is small wonder that this region is a potential danger to shipping. The rock is said to be named after a sailor called Bishop who was one of only two survivors cast up on it after the wrecking of a whole merchant fleet in the Scillies in the 17th Century.

The present lighthouse is Bishop Rock III. The original Bishop Rock I was started in 1847 but was destroyed by a storm in 1850 before it ever became operational. Bishop Rock II was a sturdier and taller structure which was first lit in 1858, but suffered greatly from the storms. Eventually it was encased in further granite masonry and increased in height to its present size. Its design was by James Douglass, and it was built by his son William Tregarthen Douglass. It first came into service on 25 October 1887.

Even in these days of remote operation, Bishop Rock III continues to be a watched lighthouse, operated by Trinity House. The addition of a "helideck", well above the surges of the Atlantic breakers, makes relief operations considerably easier than they used to be, though still hazardous enough.

Bishop Rock III was originally lit by oil lamps, but now uses an electric lamp of 2,600,000 candle-power, with a range of 29 sea miles. It is white and its characteristic signal is two flashes every 15 seconds. The original fog warning was an explosive charge set off every five minutes but nowadays there is a fog-horn, giving two blasts every 90 seconds.

The model is based on the dimensions of the light-house at a scale of approximately 1/200. It reproduces the light character and fog warning of Bishop Rock III, except that we have simplified the logic circuit by sounding the fog-horn every 60 seconds.

In the real lighthouse, the flash is produced by a set of lenses rotating around the lamp; for simplicity we flash the lamp on and off electronically. However, to simulate the effect of the rotating lenses, the lamp takes an appreciable time to acquire full brightness and to turn off.

The circuit can be adapted to produce other light characters should you prefer to base your model on a lighthouse near your home. Similarly, the fog horn has variable pitch and a programmable sounding sequence.

BUILDING THE TOWER

The lower part of the tower is a cylindrical base. Use a plastic or metal cap taken from a domestic spray-can (furniture polish, oven-cleaner etc). The cap should have an external diameter of about 54mm, and an internal diameter of at least 50mm. The exact height does not matter except that, to accommodate the circuit boards and speaker, it needs to be at least 47mm high. Fig. 1 shows the details. Paint the cap a "rocky" granite colour and draw a vertical ladder down from top to bottom, about 2mm wide with rungs 2mm apart.

If you cannot find a suitable cap, cut the base from thin cardboard as shown. Form this into a cylinder and secure the flap with glue. Bend the tags inward. Cut out the base top and glue this to the tags. We used buff-coloured card for the base and main

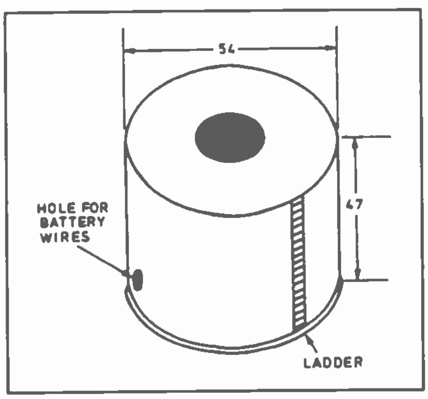
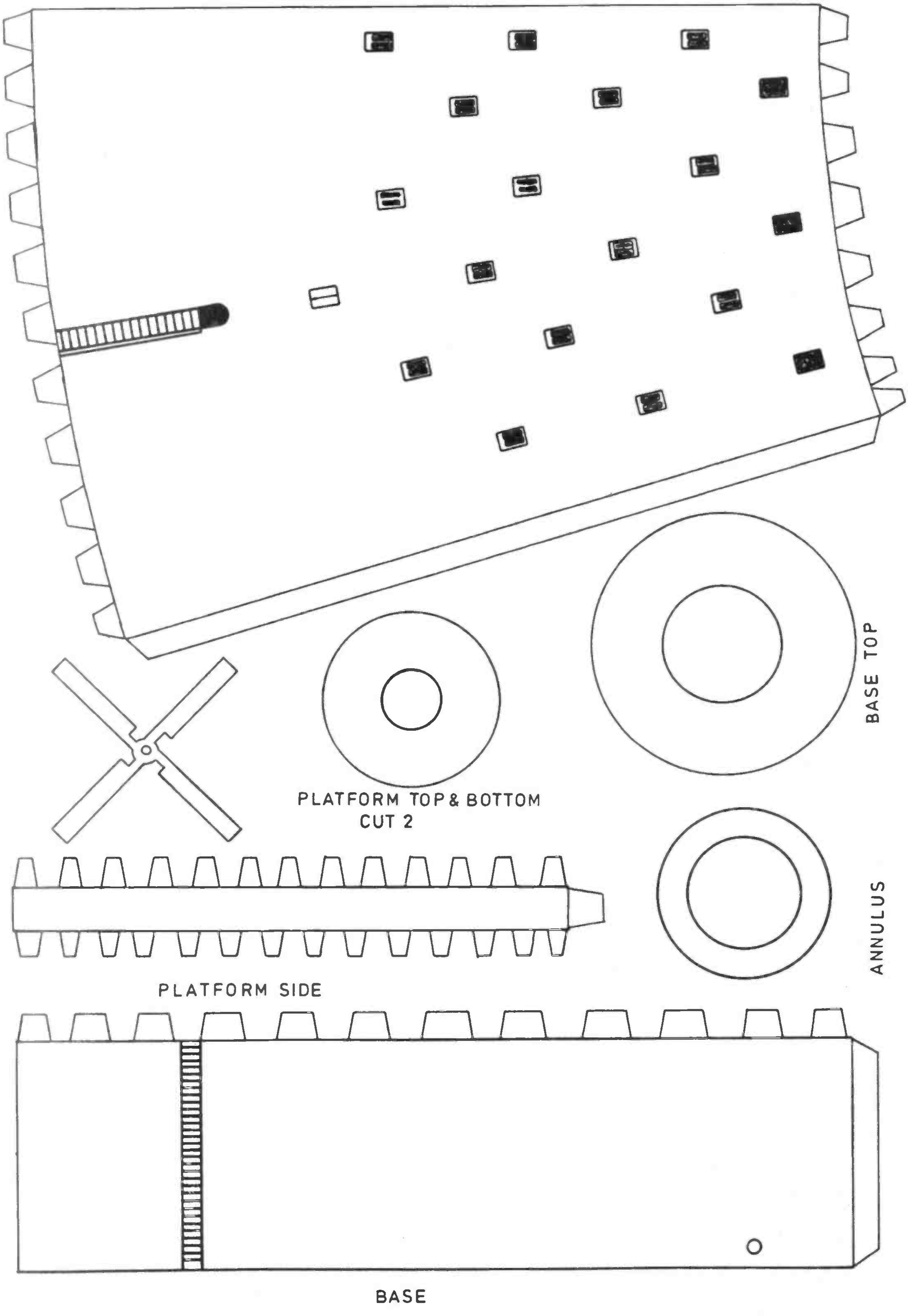


Fig. 1. The base of the Lighthouse.



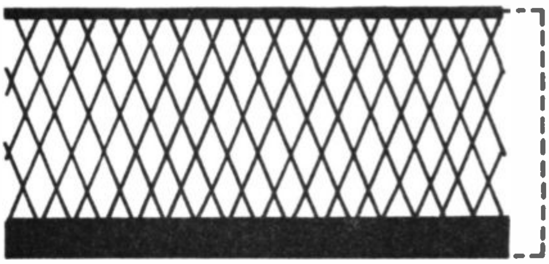
PLATFORM TOP & BOTTOM
CUT 2

BASE TOP

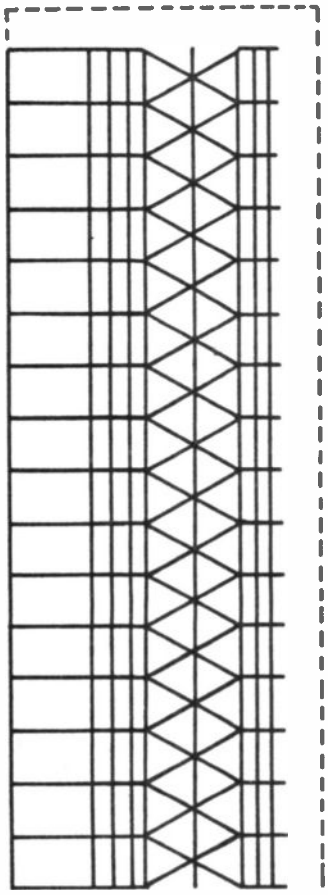
PLATFORM SIDE

ANNULUS

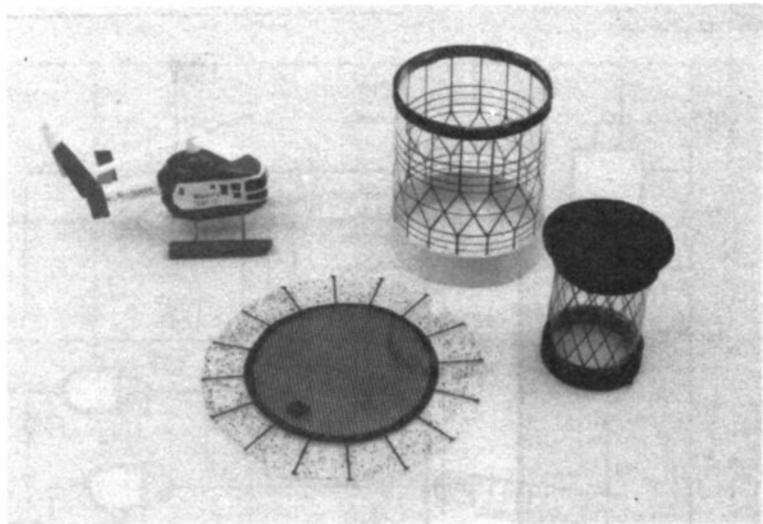
BASE

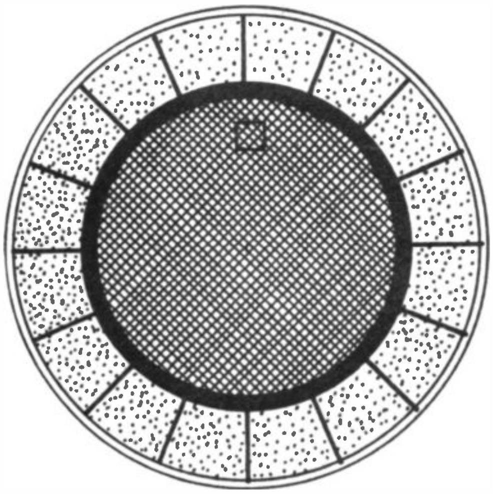


LANTERN

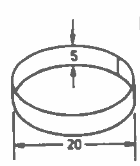


HELIDECK CAGE





HELIDECK



CUT 2

Fig. 2 (left). Card rings for the lantern

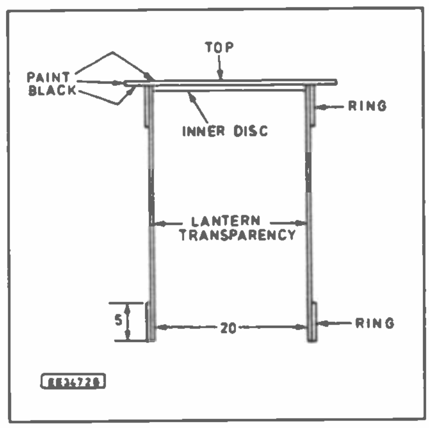


Fig. 3. Formation of the lantern housing

tower, so no painting was needed. If you are using white card, paint the base and draw the ladder on it where shown.

Readers with the equipment and skill could model the main tower by turning it in wood on a lathe. It is 162mm long and tapers from 42mm diameter at the bottom end to 27mm at the top. The tapering is more pronounced toward the bottom of the tower, and it hardly tapers at all near the top. Bore a hole centrally up the tower to take the wires from the base to the lamp.

The tower is topped by a circular platform which can be cut from 9mm plywood, with a hole bored centrally in it. Paint the tower, and draw the door and windows. A ladder leads from the door down to the bottom of the main tower.

The main tower can also be made from thin cardboard, though this inevitably lacks the graceful lines of the real thing, and of the wood-turned model. Form the cardboard into a narrow cone and secure the flap with glue. Make the platform from two card circles glued to two discs which form the top and bottom of the platform. Finally glue the tags at the top and bottom of the main tower to the platform and base respectively.

THE LANTERN

Make a photocopy of the designs for the lantern, helideck and helideck cage on transparent film, in black. Cut out the lantern design. Cut two strips of thin card 5mm wide and about 200mm long. Apply glue to one side of one strip, for half its length. Wind the strip around a cylindrical object 20mm in diameter, to form a ring of about three turns (Fig. 2). The cylinder should preferably taper slightly to make it easier to remove the ring from it when the glue has dried. A small cap from a domestic spray-can was found to be exactly the right size and shape for this. Use a large black spirit-marker pen to blacken the edges and outside surface of the ring. Prepare a second ring using the other strip and blacken this too.

Cut out a card disc 27mm diameter, for the top of the lantern; blacken the upper surface of this, its edge and the outer region of the lower surface (Fig. 3). Cut another disc 20mm in diameter. Roll the lantern transparency into a cylinder and use one ring to hold it rolled, the ring being nearer to what will eventually be the bottom of the lantern. Apply glue to the inside of the other ring and insert the eventual top of the rolled transparency into this. Press the transparency firmly against the inside of this ring to form it into a perfect cylinder.

While the glue is still wet, invert the rolled transparency on the under-side of the lantern top. Then apply glue to the inner card disc and push this down inside the lantern, gluing it to the underside of the lantern top. This helps push the transparency firmly against the inside of the ring. When the glue has dried, remove the first ring, apply glue to its inner surface and push in back on to what will eventually be the lower end of the lantern.

Cut out an annulus of medium-thick card and glue this to the top of the platform. The lantern is a push-fit into this so that it can easily be removed for changing the bulb.

Cut out the photocopied designs for the helideck and the helideck cage. The construction of the helideck cage is similar to that of the lantern, except that the rings are made from strips 2.5mm and 9mm wide. They are wound around a cylindrical object 36mm in diameter. Paint the narrow ring black inside and out. The wide ring is to be the same colour as the tower. Form the cage design into a cylinder and slip the narrow ring around it near the top. Apply glue to the inside of the wide ring and push the lower end of the cage into this so that the lower edge of the cage pattern itself

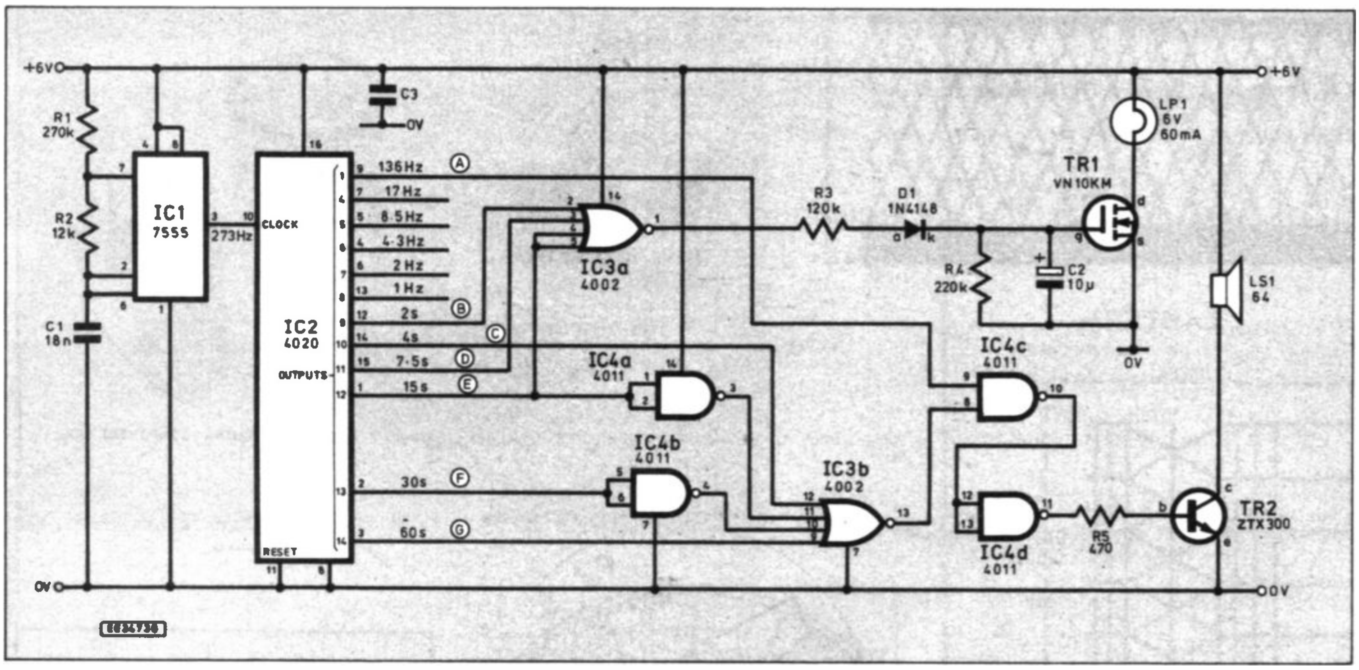


Fig. 4. Circuit diagram for the light and fog horn.

(the triple railings) are *just* visible above the ring. This ring is to be a push-fit over the platform, so that the cage may be removed for changing the bulb.

When the glue is dry, apply glue to the inside and top edge of the narrow ring and slide this into place at the top of the cage. At the same time invert the cage on to the helideck transparency (also inverted), so fixing the helideck to the top of the cage.

HOW IT WORKS

The clock (IC1 in Fig. 4) oscillates at 273Hz. This signal is repeatedly halved in frequency by the 14 stages of the counter in IC2. The outputs from stages 2 and 3 are not available. The available outputs with their frequencies or periods are shown. Any of these outputs can be used to produce the desired character. The logic is explained below in some detail so that readers will understand how to adapt the circuit for producing other characters.

The logic for flashing the lamp depends on the binary sequence of outputs from stages B, D and E, where "0" = low voltage and "1" = high voltage (Table 1). Each count in the table represents slightly less than one second, so the sequence repeats with the period of output E, which is approximately 15 seconds, as required. During this time the lamp flashes twice, each flash lasting one second.

Table 1: Truth table for lamp flashing

Count	Output E D C B	State of lamp
0	0 0 0 0	FLASH
1	0 0 0 1	
2	0 0 1 0	FLASH
3	0 0 1 1	
4	0 1 0 0	
5	0 1 0 1	
6	0 1 1 0	
7	0 1 1 1	
8	1 0 0 0	
9	1 0 0 1	
10	1 0 1 0	
11	1 0 1 1	
12	1 1 0 0	
13	1 1 0 1	
14	1 1 1 0	
15	1 1 1 1	

The table shows that the flash occurs if and only if B, D and E are all low. The state of C is immaterial. The state of B, D and E is detected by feeding the three outputs to a NOR gate. A four-input gate is used, so signal E is fed to two of the inputs.

The output of the NOR gate is normally low, but goes high when all three inputs are low. A high output from the NOR gate raises the voltage of the gate of TR1, turning the transistor on. The transistor conducts readily and the lamp lights. The switching action is modified by R4 and C2, which delays the time at which the lamp reaches full brightness. When the NOR gate goes low, the diode prevents the capacitor from discharging. The charge leaks away through R4 and the lamp dims out.

The logic for sounding the fog-horn depends on the binary sequence of outputs from stages C to G (Table 2). Each count in this table represents about four seconds, and the sequence repeats with the period of output G, which is approximately 60 seconds. During this time the fog-horn sounds twice, each blast lasting two seconds. The table shows that the flash occurs if and only if C and G are low and E and F are high. The fact that E has to be high means that there is always an appreciable gap between the horn sounding and the lamps flashing, giving a more realistic effect. The state of D is immaterial.

The state of C, E, F and G is detected by feeding the four outputs to a NOR gate, as before. However, because we are looking for *high* states of E and F, these signals must be inverted. The signals first go to NAND gates (IC4a/b) with their inputs wired together so that they act as INVERT gates, then to the NOR gate.

When C, E, F and G are in the correct state the output of the NOR gates goes high, and this output goes to a NAND gate (IC4c). This gate also receives the 136Hz audio signal A, but this passes through the gate only when the NOR gate output is high. When the NOR gate is low the output from IC4c is continuously high. The signal is inverted once again, by IC4d, so that it is low between blasts, thus leaving TR2 and the loudspeaker switched *off* during the inactive state.

CIRCUIT BOARD A

Circuit board "A" (Fig. 5) holds the timer and counter i.c.s. Like (almost) everything to do with lighthouses, the circuit boards are circular and stack inside the lighthouse base. Drill the holes in the board, then insert the two i.c. sockets and capacitor C1; glue them to the board to make the wiring more secure. Insert C2 and bend its leads and glue the body of the capacitor to the board. Next insert the p.c.b. terminals.

There are more terminals than usual in this project as this makes it easier to customise the circuit design to produce a range of light and fog-horn characters. The beads on the recommended p.c.b pins are in a

Table 2: Truth table for the fog-horn

Count	Output G F E D C	State of horn
0	0 0 0 0 0	
1	0 0 0 0 1	
2	0 0 0 1 0	
3	0 0 0 1 1	
4	0 0 1 0 0	
5	0 0 1 0 1	
6	0 0 1 1 0	
7	0 0 1 1 1	
8	0 1 0 0 0	
9	0 1 0 0 1	
10	0 1 0 1 0	
11	0 1 0 1 1	
12	0 1 1 0 0	SOUND
13	0 1 1 0 1	
14	0 1 1 1 0	SOUND
15	0 1 1 1 1	
16	1 0 0 0 0	
17	1 0 0 0 1	
18	1 0 0 1 0	
19	1 0 0 1 1	
20	1 0 1 0 0	
21	1 0 1 0 1	
22	1 0 1 1 0	
23	1 0 1 1 1	
24	1 1 0 0 0	
25	1 1 0 0 1	
26	1 1 0 1 0	
27	1 1 0 1 1	
28	1 1 1 0 0	
29	1 1 1 0 1	
30	1 1 1 1 0	
31	1 1 1 1 1	

COMPONENTS

Resistors

R1	270k	
R2	12k	
R3	120k	
R4	220k	
R5	470	

See SHOP TALK Page

Carbon film 0.25W, 5%, or metal film 0.6W 1%.

Capacitors

C1	18n polyester miniature dipped case, or metallised ceramic plate
C2	10μ tantalum, 15V
C3	220n polyester miniature layer

Semiconductors

D1	1N4148 silicon signal diode
TR1	VN10KM VMOS *n*-channel power f.e.t.
TR2	ZTX300 *npn* transistor
IC1	7555 CMOS timer
IC2	4020 CMOS 14-stage counter/divider
IC3	4002 CMOS dual 4-input NOR gate
IC4	4011 CMOS quadruple 2-input NAND gate

Miscellaneous

LP1	6V, 60mA MES filament lamp (or similar)
LS1	64Ω speaker, 38mm diam.

16-pin d.i.l. i.c. socket; 14-pin d.i.l. i.c. sockets (2 off); 8-pin d.i.l. i.c. socket; p.c.b. eyelet terminals (21 off); battery connector; insulating tape; p.c.b. lacquer; Easywire pen and tool; insulated connecting wire.

Materials

Thin card, buff or printed white card – see Shop Talk and Special Offer page, (or wood) for tower. Block of expanded polystyrene, approx. 140 x 100 x 50. Red and white enamel paint (e.g. Humbrol); black acrylic paint (e.g. Tamiya Color).

Approx cost guidance only **£6** *(components only)*

range of different colours: it is advisable to adopt a colour code for each of the lines A to G, and to use the same code on board B. For certain variations in the light and sound characters, you may need to wire the p.c.b. terminals to a different set of output pins (see later).

Test the circuit by connecting the battery. The output from IC1 pin 3 is a signal of 273Hz. You can hear this if you connect a crystal earphone to pin 3, by way of a 100n capacitor. Connect the other terminal of the earphone to the 0V rail.

On an oscilloscope, the signal can be seen to have a very high mark-space ratio. Monitor the signals from the terminals of IC2; the important ones are those labelled A to G in Fig. 4. Signal A can be heard with an earphone; a voltmeter is used to check signals B to G.

CIRCUIT BOARD B

Circuit board "B" holds the logic circuits and the transistor switches which control the lamp and loudspeaker. It may be necessary to revise the logic connections if other light and sound characters are required.

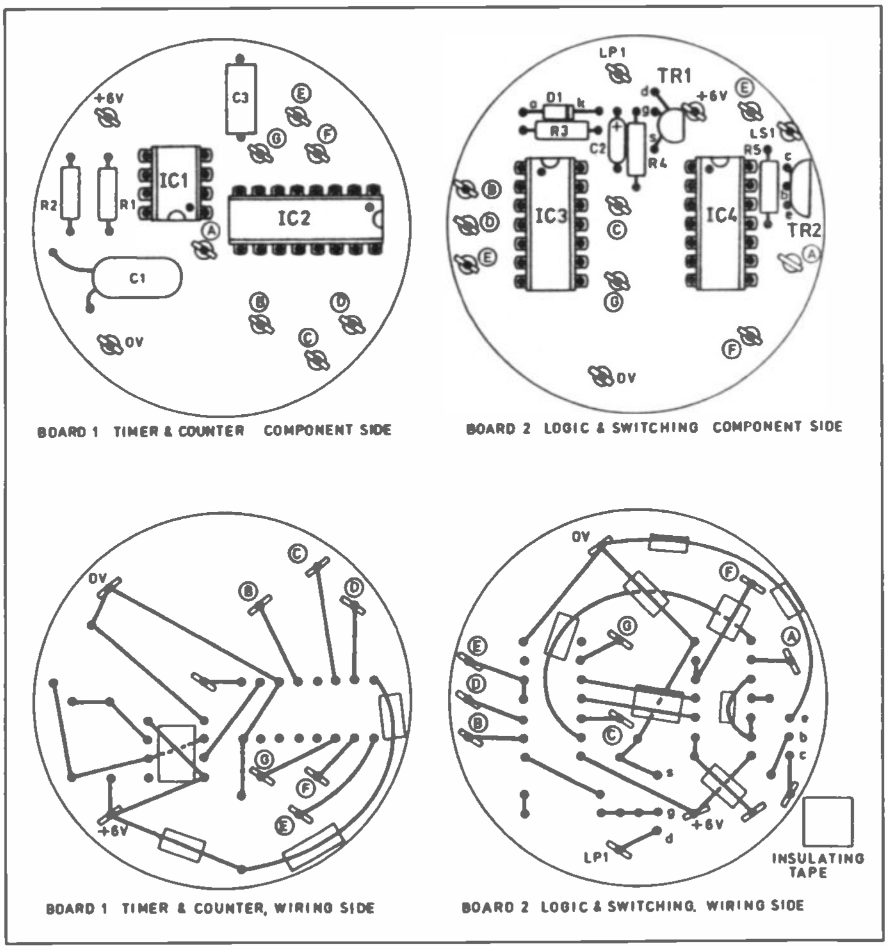


Fig. 5. The construction of the two circuit cards using the Easiwire wiring system.

Wiring up the board is straightforward. The board is tested after wiring the inter-board connections (Fig. 6). Note that there are *two* E terminals on Board B.

Use thin flexible insulated wires, each about 10cm long, except for the lamp and battery is connections. For the battery, you can use a press-stud battery connector, but you may need to extend the wires if the battery to be hidden from sight. The wires to the lamp need to be about 30cm long. If a bulb holder is used, connect the wires to the screw terminals. Otherwise, solder the wires directly to the bulb, or hold them in place with insulating tape. When the battery is connected, the lamp begins to flash and the loudspeaker sounds as described earlier.

ASSEMBLY

The final assembly is shown in Fig. 7, with the circuit boards and loudspeaker stacked inside the base with card separators (discs 50cm diameter) to prevent short circuits. The speaker rests face-down on the table.

If the lamp is in a holder, glue this to the platform. If the wires are soldered to the lamp, wrap black insulating tape around the threaded part of the bulb. Nip the tube of tape below the bulb and wedge it firmly into the hole in the top of the platform. Place the lantern over the bulb; it is held in place by the annulus. Lower the cage over the lantern and push it gently down over the platform. All that is needed now is a helicopter to bring supplies to the keeper.

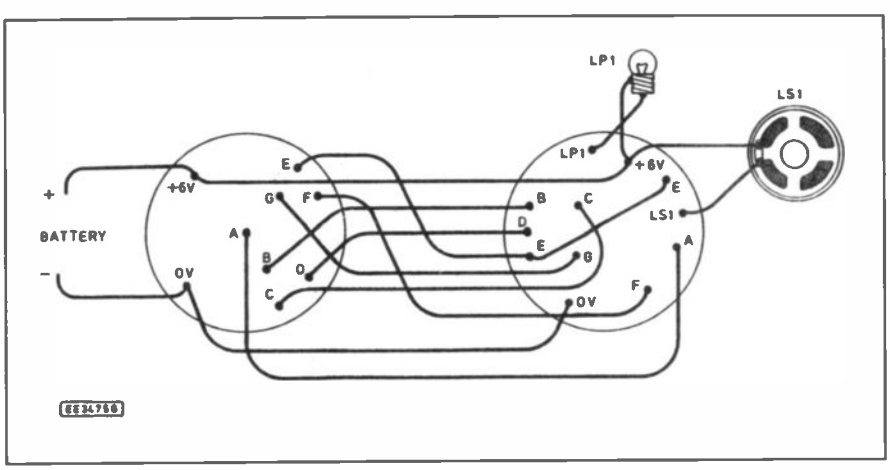
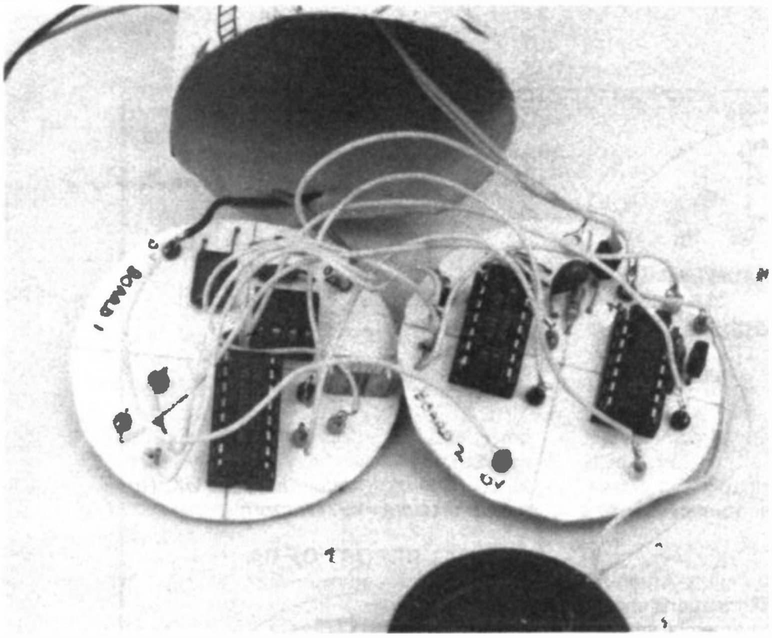


Fig. 6. Interwiring between the board, battery, lamp and loudspeaker.



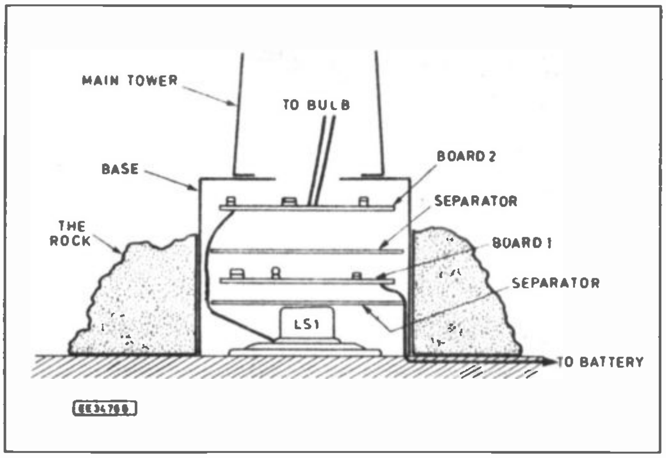


Fig. 7. Fitting the electronics in the base.

HELICOPTER

The supply helicopter used by Trinity House is the popular West German light utility helicopter, the MBB BO105. We made a simple model of this, moulding the main fuselage from Fimo, a modelling material which is fairly soft when purchased but which hardens when placed in an oven at 130°C for about half an hour. To save a certain amount of painting use either red or white Fimo.

Make the rear fuselage from 3mm diameter white plastic rod. Before hardening the main fuselage make a socket in this to accept the rear fuselage. Also push a pin in at four places to make holes ready for the undercarriage struts.

Cut the tail and rudder from thin red card and glue into slots cut in the rear fuselage (Fig. 8). Cut a propeller from thin white card and mount this on the tail-plane as shown; fill the collar with glue before inserting the pin into it. Cut the four-bladed rotor from the same white card.

Carve the floats from plastic strip; bore two holes half-way into each to take the struts. Make the struts from dressmaker's pins; you may have to experiment here, as some types of pins snap in two when you try to bend them. The pins will not be a really firm fit in the holes but, when the model is painted, the paint secures them well enough.

Paint the main fuselage white, with red top and bottom. Also paint windows in black and, if possible the logo "Trinity House" and the registration number of one of its helicopters G-BATC. Finally mount the rotor.

BISHOP ROCK

The rock itself can be carved from a block of expanded polystyrene or timber. It needs a flat bottom, sheer sides and a very rugged top. A circular opening 54mm in diameter runs from top to bottom so that the rock surrounds the base of the light-house, making it less likely to topple over. Cut a groove in the bottom of the rock for the battery wires.

Paint the rock matt black, possibly adding a touch of dark brown here and there. Before painting, test the paint on a spare scrap of expanded polystrene; the solvents of some paints cause the polystyrene to shrink away almost to nothing! A water-soluble acrylic model paint (Tamiya Color, matt black XF-1) gave a very realistic effect on white polystyrene.

OTHER CHARACTERS

Both the light and fog horn can be changed to different characteristics. The first thing to decide is the length of the longest sequence, usually the fog-horn sequence. The length of the shorter sequence (usually the light) must be a binary submultiple (half, quarter, eighth . . .) of this. The actual length of the Bishop Rock fog-horn sequence is 90s but, since the light sequence lasts 15s, it was decided to make the horn sequence 60s, i.e. *four* times the light sequence, instead of six times, which is difficult to arrange.

If the longest sequence is t seconds, and this is to be taken from ouput G, the frequency of the clock must be $f = 16384/t$. The frequency is determined by the values of R1, R2 and C1:

$$f = \frac{1.44}{(R1 + 2.R2)\,C1}$$

If this frequency proves to be suitable for the fog-horn, it can be used direct from the clock; otherwise, use A which runs at $f/2$. If a lower frequency is needed, use output F for the longest sequence, length t, and calculate $f = 8192/t$.

Next set out truth tables similar to Tables 1 and 2 and mark when the lamp is to flash or the horn to sound. Try to mark these events so that they occur when there is a majority of '0's on the line. Then decide the logic requirements. Table 1 gives a double flash, as required for Bishop Rock, but a single flash can be obtained (at count 0) by NORing together all four outputs. A single flash of double the length (counts 1 and 2) is obtained by NORing outputs C, D and E only.

The circuit has two NAND gates (IC4a/b) for inverting outputs that are to be active when they are "1". If either of these gates are not used, their inputs *must* be wired either to 0V or +6V.

This model concludes the series, we hope you have enjoyed making at least one of the models. □

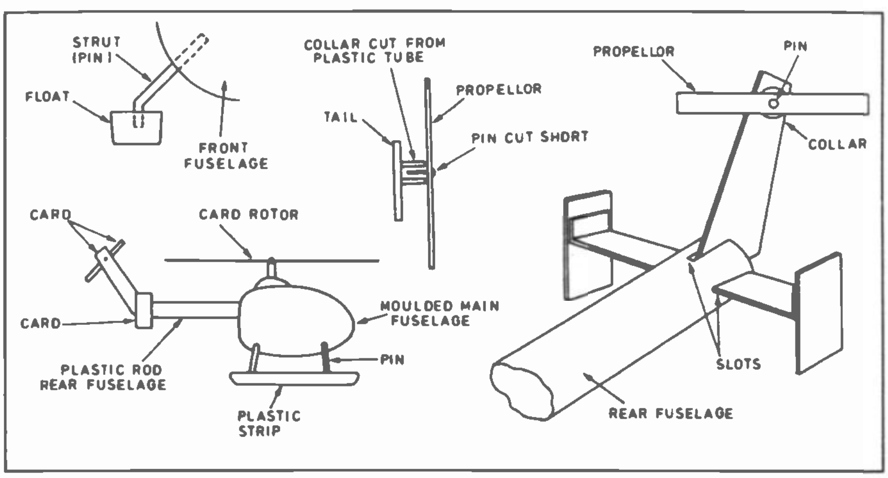


Fig. 8. Construction of the helicopter.

REPORTING AMATEUR RADIO

Tony Smith G4FAI

ALBANIA BACK

The first Albanian amateur radio station for 45 years came on-the-air on 16th September. At a grand opening ceremony at Albania's PTT headquarters, attended by high government officials, and broadcast on Tirana TV, amateur station ZA1A made a special transmission to ITU headquarters in Geneva where the ITU Secretary-General was present.

In the days that followed, the bands went wild as Dxers, award hunters, and others just wanting to welcome the Albanians back, tried to contact ZA1A. Because of the numbers involved, each contact could only be a brief exchange of reception reports, but that was enough to get a QSL card confirming contact with a new country. More stations are appearing as time goes on and just a few days before writing this, in early October, I listened with awe as a "pileup" of what must have been hundreds of stations from many countries tried to make contact with two more ZAs on 28MHz.

No one new to amateur radio could cope with such a situation unaided however, and teams of experienced operators from several countries, under the auspices of the International Amateur Radio Union and other amateur organisations, have been in Albania training a number of enthusiastic students ready to take the lead in reviving amateur radio throughout their country.

Trying to get through pileups is not my favourite type of operating, but I do have a go sometimes and get the same satisfaction as everyone else when I manage to beat the pack. In this case though, I shall probably wait till there are a few more ZAs on the air and there's time to actually have a chat with some of them!

USA BOMBSHELL

A sensational proposal by the FCC (the USA licensing authority) could change the entire concept of "amateur" radio; a change which in the long term could well affect the status of the hobby in many countries, including the UK.

Continually bombarded with letters and phone calls from amateurs who want changes in the "absolutely-no-business" rules; and subject from time to time to political lobbying and Congressional inquiries along the same lines, the FCC has suggested to the American Radio Relay League, America's national radio society, that it makes formal proposals for change. It has even suggested what those changes might be, so there seems little doubt about the eventual outcome.

It all hinges around "third party" communications, that is, the passing of messages on behalf of other persons. In the USA, and in many other countries, all amateurs can already pass simple greetings messages on behalf of others and they can also provide communications on behalf of the emergency and other services in certain defined circumstances. In the UK there are lesser third party facilities plus long-established emergency services as mentioned in this column from time to time.

The essential basis of third party communications is that no regular organizational or business communications should be provided for which commercial services are available, and that no payment should be received by amateur operators whatsoever. It has often been suggested to the FCC that the rules are too restrictive and that amateur radio could be used for non-commercial activities without affecting its amateur status.

RELAXATION OF RULES

The FCC now proposes that non-amateur communications handled by amateurs in the future, without the present limitations, could include communications for non-profit or charitable organizations, government agencies, and public safety agencies; classroom instruction in schools; selling or trading electronic apparatus amongst amateurs; providing information to the news media; club business; personal business, including placing orders on local suppliers via auto-patch into the public telephone system; and rebroadcasting transmissions from other stations such as weather stations, the Voice of America, or WWV (time signals, etc.)

The order or precedence would be *Priority* – emergency communications; *Primary* – normal amateur communications; and *Secondary* – non-amateur communications. Only when the first two traditional usages are insufficient to completely occupy the bands would the unused frequencies be available to carry non-amateur traffic.

To preserve the non-business status of amateur radio no operator would be able to sell a communication service using amateur frequencies. An exception to this would be permitted payment to control operators transmitting Morse practice and information bulletins from W1AW, ARRL's headquarters station (already permitted); and those providing classroom instruction over the air.

These proposals will inevitably provoke a mixed reception. Those who believe the amateur spectrum should be opened up to non-amateur communications will be delighted, but many will feel that the unique character of amateur radio is under threat and that the bands are full enough already without congesting them further with non-amateur traffic.

The communications industry, which stands to lose business if the proposals are implemented, may have something to say also! It will be interesting to follow this debate over the months ahead and to see the final outcome. With the DTI's current policy of liberalisation and deregulation it will also be interesting to see if similar proposals eventually reach, and receive consideration, in the UK. (Information from *W5YI Report*).

ANNUAL REPORT OF RA

The Radiocommunications Agency (previously the Radiocommunications Division) of the DTI recently published its annual report for the year 1990-1991. This covers the entire field of non-government activity in the radio spectrum, but I refer here only to that part of the report covering amateur radio.

Apart from describing the introduction of the Amateur Radio Novice licence on 1st April 1991, previously covered at length in this column, the report refers to the concern of the RA about abuse on amateur radio, in particular associated with repeater stations.

Action, the report says, has been taken to deal with this by improving the management and monitoring of the 300 or so repeaters in the UK. Each repeater is managed by a local group, while the Radio Society of Great Britain provides a number of central services and support through its Repeater Management Group.

Additionally, amateurs are encouraged to submit reports of abuse to the RSGB's Amateur Radio Observation Service (AROS). If AROS is unable to solve the problem a report may be sent to the Radio Investigation Service for further investigation, and this has resulted in a number of successful prosecutions.

During the year, some changes have been made to the amateur radio licence. The most significant involved providing clubs with special event privileges, allocating extra frequencies for unattended operation and allowing vertical polarisation and mobile operation at 50MHz.

As at 31st March 1991, the number of amateur licences class A, was 32,954 and Class B, 27,930. There were also 257 voice repeaters, 236 packet radio repeaters, and 55 beacons. During the year there were five convictions for offences under the Wireless Telegraphy Acts and two formal warnings were issued for breaches of the Act.

SANGEAN SERVICING – 2

I mentioned last month the problem a reader was having in getting his Sangean ATS 803A world band receiver repaired by Comet. I have now received a letter from Charlie Avery, PR Executive of Comet PLC, who says that his company decided to discontinue this model early in 1991, and that the manufacturer has since gone out of business.

Prior to this, Comet were able to secure a limited supply of spare parts so they can still repair some sets, depending on the problem. If they do not have the appropriate spares, however, it is unlikely that they will be able to help.

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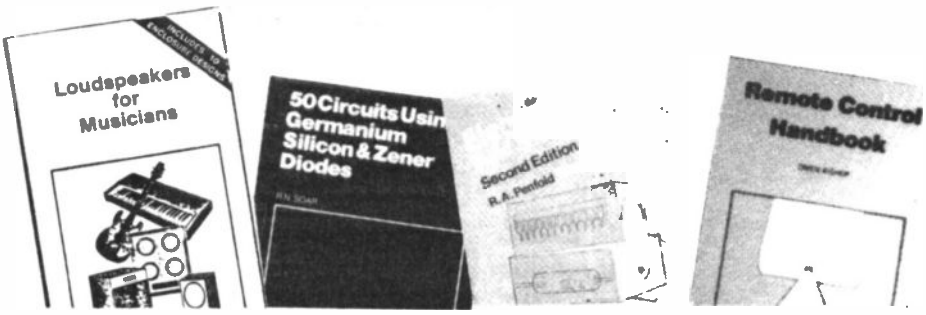

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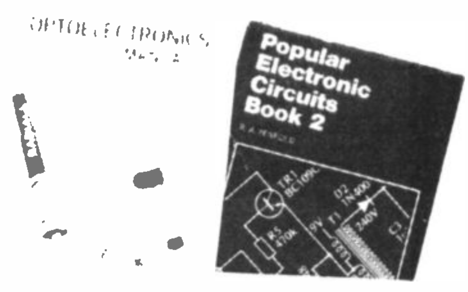

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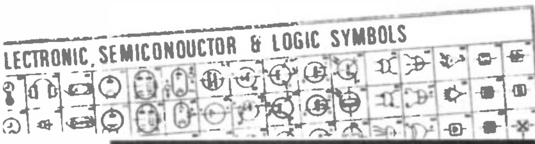

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