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NOVEMBER 1982
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Breadboard '82
10-14 November
The Royal Horticultural Halls
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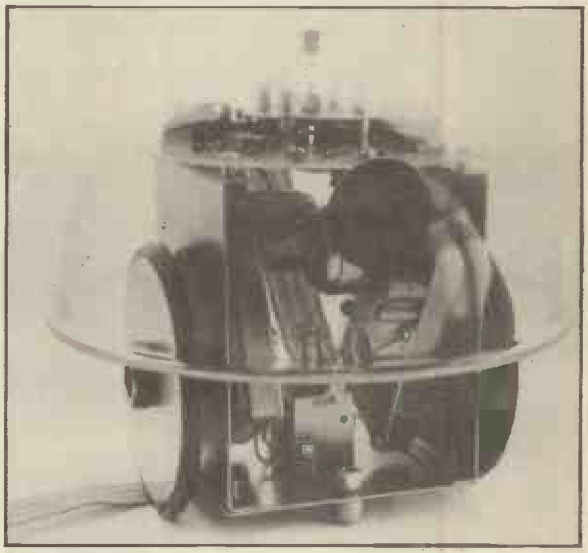

BREAD BOARD

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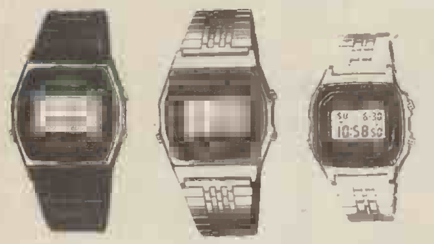

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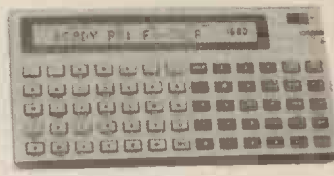

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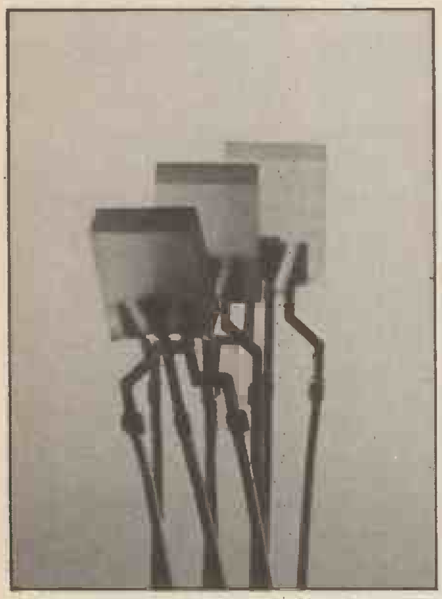
Three From Two

New to the wide range of opto-components from **Zaerix Electronics**, is a tri-colour rectangular LED **(below)**. Complementing their existing 5mm diameter tri-colour LEDs, the L119HGW rectangular LED measures 2mm x 5mm and can emit red, green or yellow light. This is achieved (inside the package) by using two LEDs, red and green, either separately or both on together. In the latter case the light passing through the diffused white lens appears as yellow.

The LED is supported on a common cathode 3-way lead frame with wire-wrappable legs having 0.1" spacing. Luminosity is about 3 mcd at 20 mA. For further details write to **Zaerix Electronics**, Electron House, St. Mary Cray, Orpington, Kent BR5 3QJ.



Adapted From AC

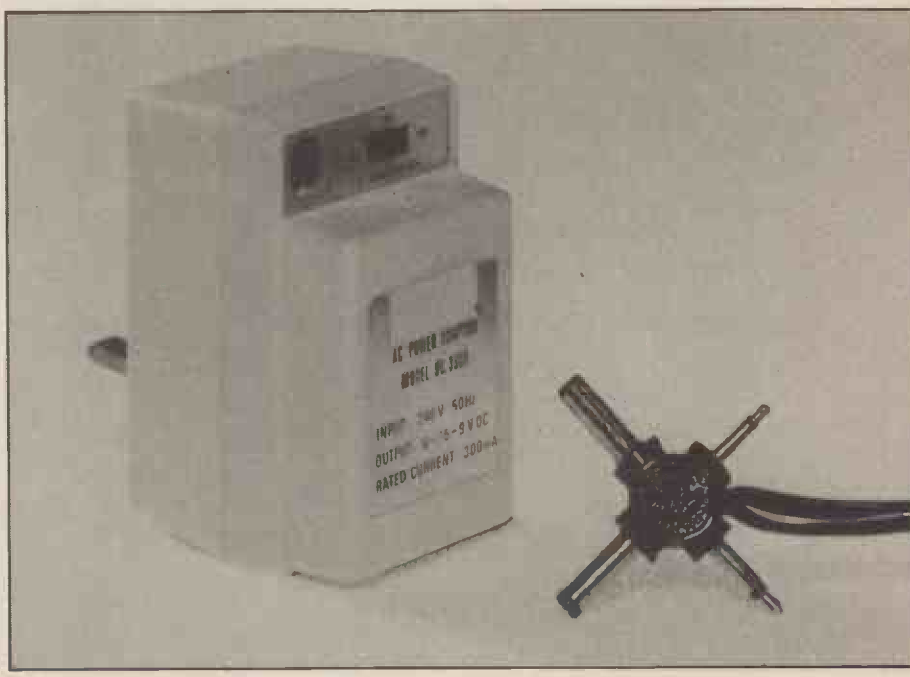
A new low cost AC adaptor **(below)** is now available from **Stotron Ltd**. For use with low voltage battery equipment, such as calculators, tape recorders etc, the unit takes a mains (240 V) input and produces three switched outputs of 6, 7.5 and 9 volts DC at 300 mA.

Supplied complete with a four-way universal adaptor plug, the device costs £5.12 all inclusive. Orders and enquiries to **Stotron Ltd**, 72 Blackheath Road, Greenwich, London SE10 8DA.

Thandar Starts Gigging

Introduced primarily to extend the upper range of their TF200 LCD frequency meter, **Thandar** have started selling the **TP1000 prescaler (right)**. This compact unit allows counting up to 1 gigahertz via a 50 ohms BNC input connector. Power is taken from a separate adaptor (supplied) and the complete unit is priced at £74.75 including VAT.

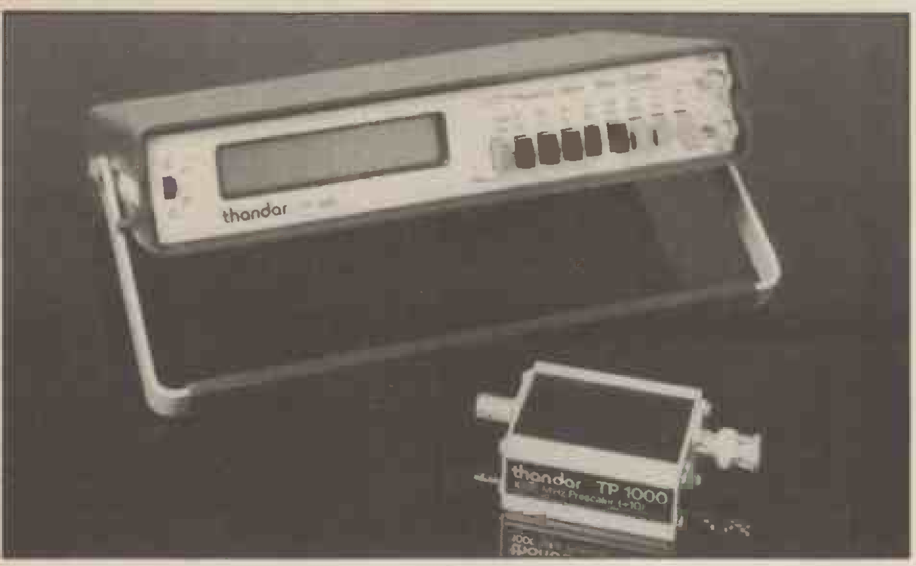
Contact **Thandar Electronics**, London Road, St. Ives Huntingdon, Cambs. PE17 4HJ for more information.



Oric Aims At Spectrum

Shortly to be released onto the micro market is the Oric I **(right)**, marketed by **Oric Products** and designed by Tangerine Computer Systems. Aimed to compete directly with the ZX Spectrum, this micro computer is to be produced in two versions; one with 16K RAM and the other with 48K. Both models will have 16 colours and run the popular Microsoft Basic. There is also planned to be a range of software compiled by a large software house.

The Oric I has 57 keys on the keyboard, upper and lower case and no more than two functions on any key. It has teletext/viewdata compatibility and a display resolution of 24 rows x 40 characters. Oric say they will be bringing out a range of peripherals (including modem, printer and discs) shortly after the launch. Costs for the 16K version will be £99 including VAT, and for the 48K an extra £70. Further details may be obtained from **Oric Products International Ltd.**, Coworth Mansion, Coworth Park, London Road, Sunninghill, Ascot, Berks SL5 7SE.

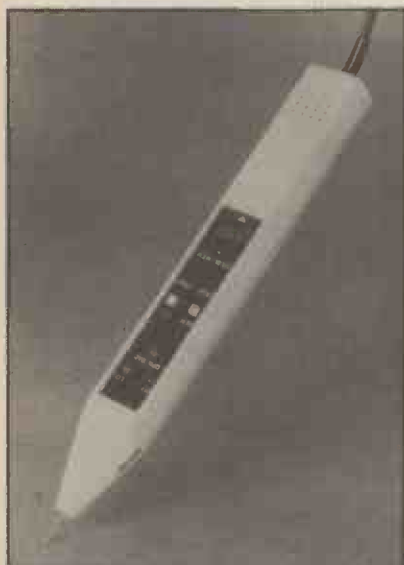


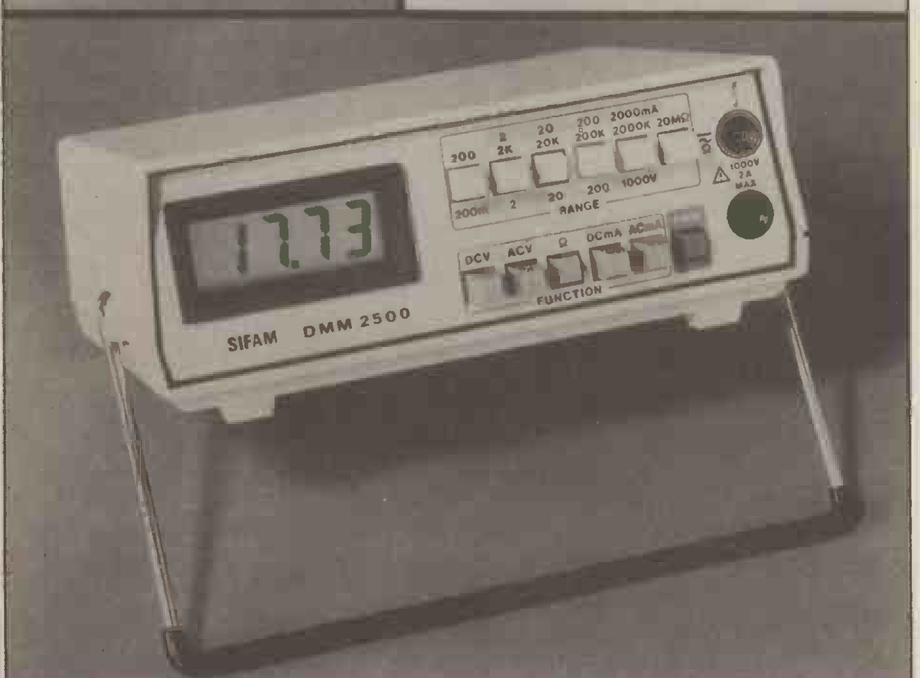
Synthesizers For Sinclair

The Namal Super Talker is a low cost speech synthesizer form Namal Electronics of Cambridge. It has a standard vocabulary of 600 words and will con nect directly to the ZX-81 or Spectrum. Later units will suit any machine with an RS232 interface.

The Super Talker is easy to program requiring a simple two word instruction to produce spoken words. It is based on a phonetic speech synthesizer made by Votrax, of Detroit. The unit comes in a plastic case, measuring 15 x 18 x 35 centimetres, complete with integral loudspeaker, volume control and ribbon cable. A users manual is also supplied. Prices vary according to the machine it is to be used with, but the cheapest (for the ZX-81) is £57.44 including VAT.

Namal Electronics are at 25 Gwydir Street, Cambridge CB1 2LG. Telephone Cambridge (0223) 355404.





And Now . . . Test Gear

That well known purveyor of control knobs and panel meters, **Sifam**, have now entered the test equipment market. They are starting off with a modest selection; bench and hand-held multimeters and a digital logic probe. All the instruments are competitively priced and backed by a one year guarantee.

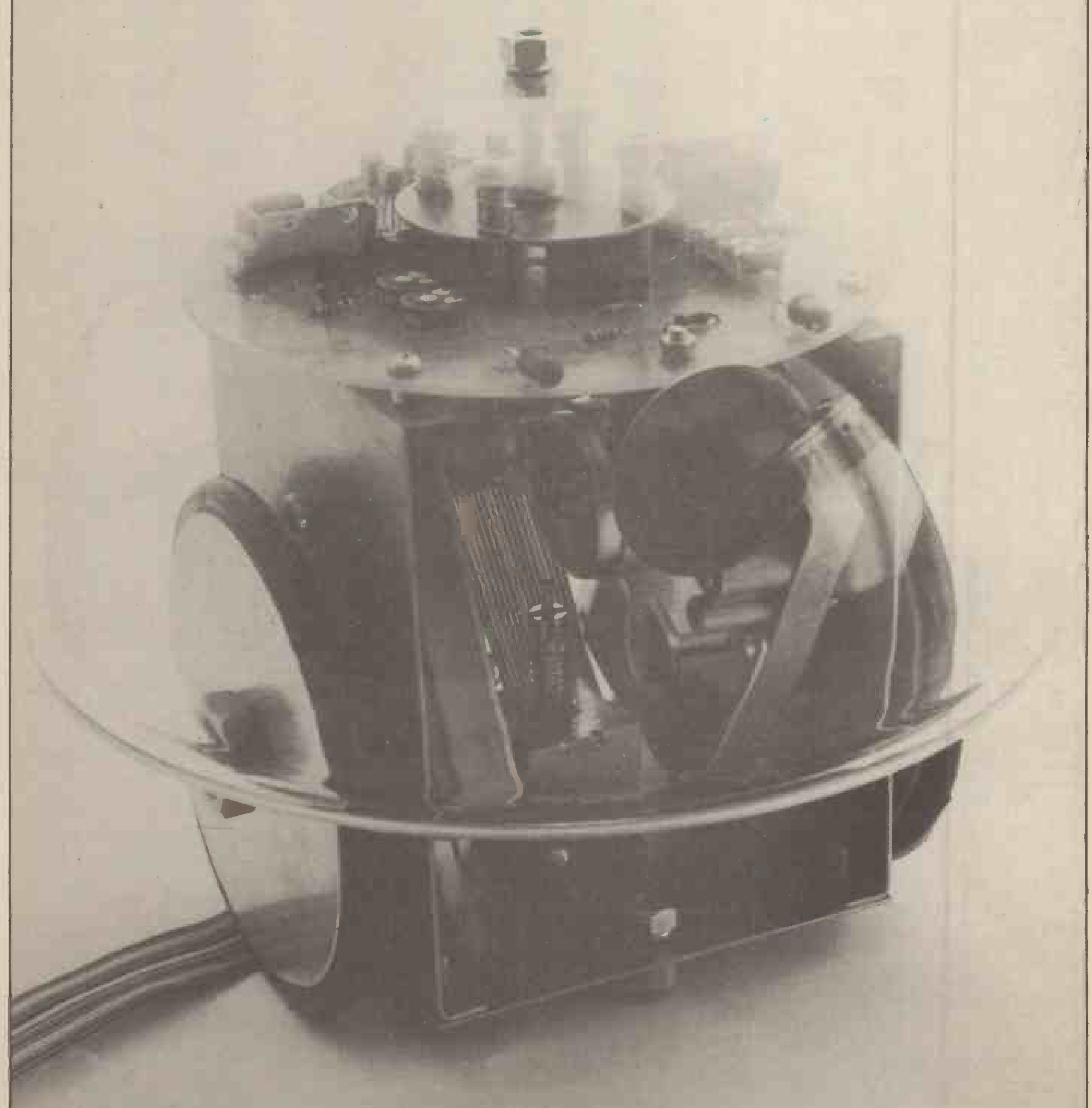
The logic probe **(left)** will operate with CMOS, TTL and DTL circuitry and has a frequency range from DC up to 50 MHz. There are three colour signals, indicating high, low and open circuit/bad level states. An alarm sounds if the input voltage exceeds that of the device under test.

The probe comes complete with carrying case, clips and manual for £44.95 including VAT.

Both the multimeters are 3½ digit LCD, with a basic accuracy of 0.3% DC volts. Model DMM2200B **(centre)** is a hand-held unit with 21 ranges covering resistance and AC/DC voltage and current. A PP3 **battery** supplies the power — over 1000 hours continuous use — and the meter is protected against voltage and current overloads. It is sent with test leads, spare fuse, battery and manual and costs £49.95.

The other model (DMM2500 **left**) is a bench standing unit with an additional 3 ranges and longer battery life (in fact, twice as long). Basic accuracy is the same as the DMM2200B, but the construction and layout are geared more for the professional person who needs something robust and reliable. The price is also higher at £75.95. For further information contact **Sifam Ltd.**, Woodland Road, Torquay, Devon TQ2 7AY.

HEBOT II



Most people have hobby horses —
now here's the Hobby Robot!

THE IDEA of a mechanical man, or ''robot'', is an ancient one, dating back to the time of the Egyptian Pharaohs. The word itself was coined by the writer Karel Kapek; it comes from the word *robota* in his native Czech, meaning ''labourer'' or ''worker''. Kapek's fictional invention undoubtedly owed a debt to the legend of the Golem, a walking figure formed from the clay of the earth by occult powers; the story of Frankenstein, although written by an English gentlewoman, is also derived from the legends of Bohemia and Transylvannia and offers another point of departure for the invention of the robot. Perhaps these shadowy origins account for some, at least, of the fear and loathing with which the robot is sometimes regarded!

This was not always so; in the past, clockwork mechanisms delighted the crowds at fairs and carnivals, while more elaborate toys and models were built for the pleasure of the well-to-do.

Apart from these, however, the robot has been a total figment of science fiction, particularly in the works of Issac Asimov, who created a virtual science of Robotics in his many novels on the theme. Another writer, whose fictional approach came closer to the modern realisation of the robot, was Robert Heinlein. His ''Waldoes'' were giant manipulators with the strength of an hydraulic forge, linked to special controls in the form of arm-length gauntlets; the Waldo mechanisms simply duplicated the movements of the operator, transmitted via the gauntlets.

Like most good science fiction, the works of Asimov and Heinlein were soundly based on real science. At about the time the authors were formulating their ideas, Norbert Weiner was defining the science of Cybernetics as ''The field of control and communications, whether in the machine or in the animal'', and the British mathemetician Turing was laying down the standards for assessing artificial intelligence, ie computer or robot intelligence. Then, too, a man named Thomas Ross built the first ''robot mouse'', the prototype of all maze-solving turtle-type robots.

All this took place in the 1930s, but subsequently robotics developed at a very slow pace until the late 70s, when useful industrial robots became a practical proposition. In the past ten years, of course, robots have become an exceedingly hot topic in the national press, to the point where they are proclaimed the keystone of the Second Industrial Revolution and Britain's economic revival.

It was at the start of the revival of interest in robotics that HEBOT, Hobby Electronics' first robot, appeared. The ''Amiable Automaton'' was, by today's standards, a simple device, entirely controlled by the on-board 'hardware'. In fact HEBOT represented no great *operational* improvement on Ross' original micro-mouse, though of course the control system was both simpler and more versatile due to the use of integrated circuit technology not available to Ross in 1938!

Son of HEBOT

Three years on and HEBOT II, while in many ways a very similar beastie, is considerably improved both in its control system and in operation, because it is designed to be used in conjunction with a microcomputer. Specifically, it is designed to be run by a ZX81, but the control system is quite simple and any microcomputer

How It Works

HEBOT II is controlled by eight data lines derived from the ZX81 computer's data bus via an interface board.

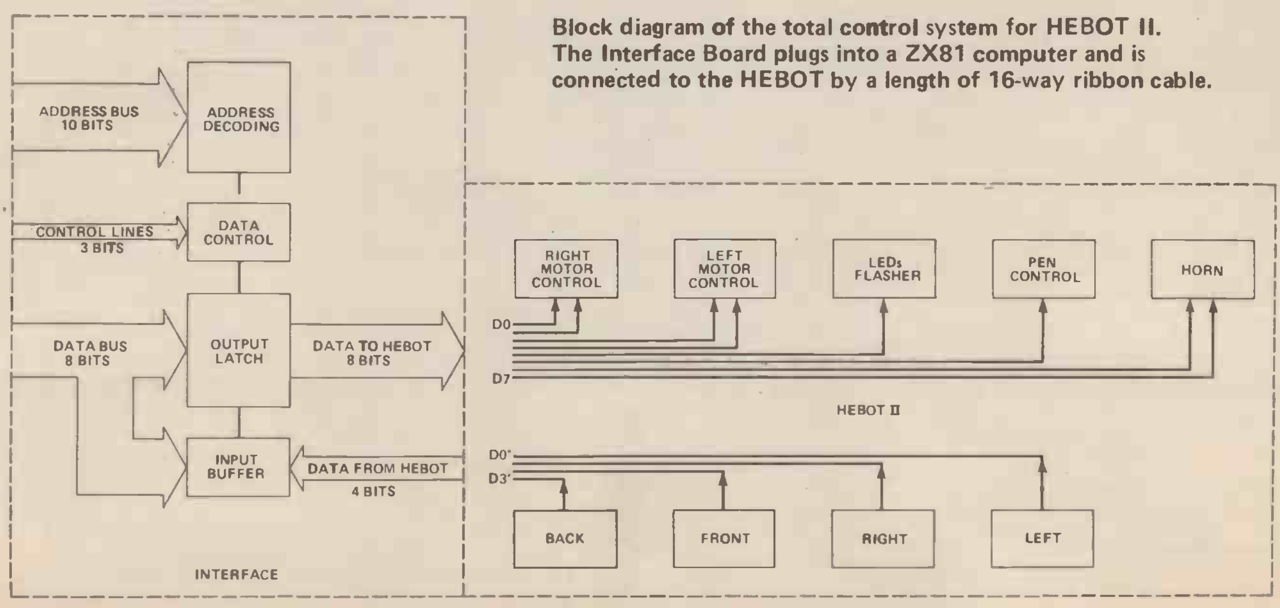
Bits 0 and 1 control the right motor drive circuits. When bit 0 is high and bit 1 is low, the motor will drive in the forward direction; when the bit pattern is reversed (D0 low, D1 high), the motor drives in reverse. When both bits are low OR both are high, the motor is stopped. The left motor is controlled by bits 2 and 3, in identical fashion, so that by turning on, or off, different combinations of bits 0-4, HEBOT can execute quite a variety of movements.

The LEDs on the robot are switched on when bit 4 goes high, and bit 5 turns on the solenoid, forcing down the centrally-mounted pen. Finally, bits 6 and 7 control HEBOT's horn; a low tone sounds when bit 6 is high, increasing in pitch when bit 7 is taken high.

The action of the control bits, especially movement controls, is summarised in Table 1.

Four microswitches are mounted on the robot's PCB, mechanically connected to the 'shell' so that they operate as collision detectors. They are directly linked to four output data lines, D0'-D3', and thence to the computer data bus via the interface board.

The interface board itself consists of four circuit blocks; the address decoder operates on the top ten address lines to produce an output only for a certain bit-pattern, corresponding to a particular address — the address of HEBOT II. The control circuitry determines, in conjunction with the output from the address decoder, whether the computer is writing data to HEBOT or reading data from it. The output latch accepts data from the computer at specific times and stores it until the next time data is sent to the machine. The input buffer transmits data from the robot when the computer is ready to accept it.



Block diagram of the total control system for HEBOT II. The Interface Board plugs into a ZX81 computer and is connected to the HEBOT by a length of 16-way ribbon cable.

Table 1. HEBOT II data input bus.

RM1 = Right motor forward
RM2 = Right motor reverse
LM1 = Left motor forward
LM2 = Left motor reverse

L = Lights on
P = Pen down
H = Horn on
T = High tone

D7	D6	D5	D4	D3	D2	D1	D0	DATA BITS
T	H	P	L	LM2	LM1	RM2	RM1	HEBOT CONTROL
128	64	32	16	8	4	2	1	DECIMAL VALUE

LM2	LM1	RM2	RM1	DECIMAL	LM	RM	MOVEMENT
0	0	0	0	0	off	off	stop
0	0	0	1	1	off	fwd	turn left about left side
0	0	1	0	2	off	rev	turn right about left side
0	0	1	1	3	off	off	stop
0	1	0	0	4	fwd	off	turn right about right side
0	1	0	1	5	fwd	fwd	forward
0	1	1	0	6	fwd	rev	turn right about centre
0	1	1	1	7	fwd	off	turn right about right side
1	0	0	0	8	rev	off	turn left about right side
1	0	0	1	9	rev	fwd	turn left about centre
1	0	1	0	10	rev	rev	backward
1	0	1	1	11	rev	off	turn left about right side
1	1	0	0	12	off	off	stop
1	1	0	1	13	off	fwd	turn left about left side
1	1	1	0	14	off	rev	turn right about left side
1	1	1	1	15	off	off	stop

Table 1 (above) shows the data control lines to HEBOT II. Data bits D0 – D3 control the direction of movement, and various bit-patterns permit a great variety of movements, particularly in turning motions. The remaining bits, D4 – D7, control the lights (LEDs), the horn and its pitch, and the position of the solenoid (up or down). In practice, HEBOT is controlled by POKEing the decimal value corresponding to the required action or combination of actions; eg, POKE (address), 5+64 commands forward movement, with the horn sounding. See Tables 3 and 4 for further examples.
Table 2 (below) shows the sensor data from HEBOT. PEEKing the robot's address will return a decimal value corresponding to a specific sensor, if a single-point collision has occurred. A 'touch' activating two sensors will return a decimal value corresponding to the combination of sensors.

Table 2. HEBOT II data output bus.

D7'	D6'	D5'	D4'	D3'	D2'	D1'	D0'
–	–	–	–	Back	Front	Right	Left
				Touch	Touch	Touch	Touch

TOUCH SENSORS ACTIVATED	BINARY	DECIMAL
None	00000000	0
Left only	00000001	1
Left and front	00000101	5
Left and back	00001001	9
Right only	00000010	2
Right and front	00000110	6
Right and back	00001010	10
Front only	00000100	4
Back only	00001000	8

capable of input/output operations, whether via a dedicated I/O port or via an expansion port (as used by the ZX) can be used to control the machine. A memory-mapped interface board for the ZX81 computer is presented as part of this project, and further issues of Hobby Electronics will explore the possibilities of other interface boards and computers. *(We would welcome readers' submissions on this subject! — Ed.)*

The significance of computer control is that, whereas the opriginal HEBOT had only a small 'library' of hard-wired routines, HEBOT II has almost unlimited capabilities within the restraints of available memory and computer speed.

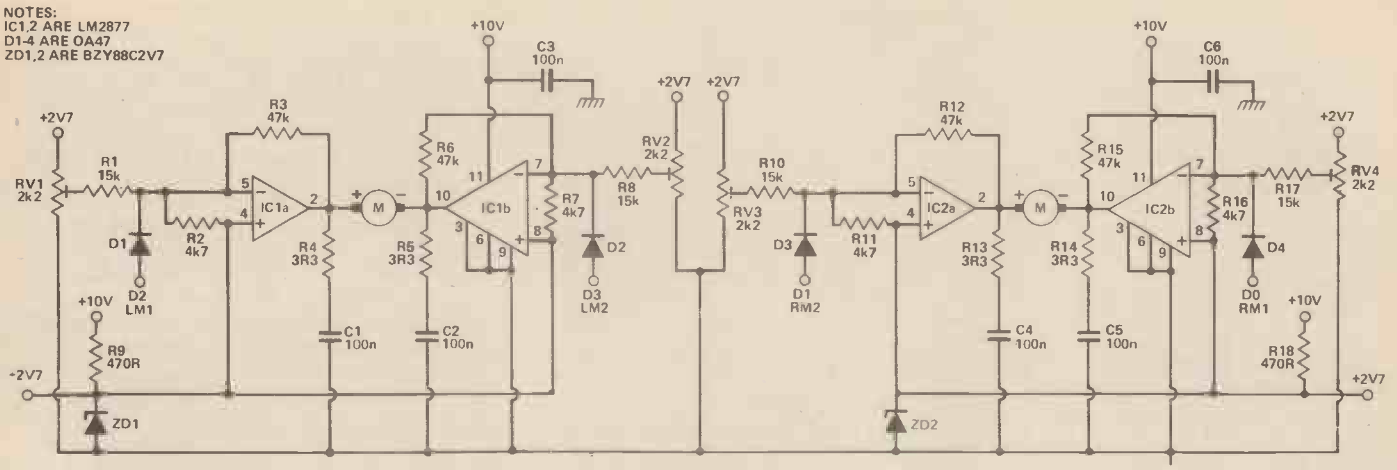
Programming In The Real World

Not only does the use of computer-control greatly increase the capabilities of HEBOT II but the machine itself takes programming out of the two dimensional world of the VDU into the real, three-dimensional world. It can perform a bewildering number of moves under program control — forward, backward, left and right — with each wheel independantly controlled. Programs can be developed so that HEBOT can sense its environment via the obstacle sensing switches coupled to its 'shell', allowing the most devious "aviodance routines" to be devised to solve a maze or map the shape of a room. It can even report directly on its environment, via the blinking LEDs and the two tone horn,and one of the most interesting possibilities is the use of the built-in pen, which can be forced down onto a sheet of paper or artboard, to draw graphs or outline sketches.

Two simple programs are listed, later, to illustrate the tremendous potential of this machine. Both routines are given as 'starting points', because they are very, very basic; this will quickly become obvious and at this point, it is left to the reader to develop more useful routines! However, HEBOT II will be fully functioning on improved programs at this year's Breadboard Exhibition, at the Royal Horticultural Society's New Hall, Greycoat Street, Westminster, London SW1, so come along and see it for yourself!

The first program is a simple 'walk and avoid' routine; when it is LOADed and RUN, HEBOT II will "proceed in a forward direction" (m'lud), flashing its 'eyes' until it encounters an obstacle. Then it will back off, sounding a note, turn left and continue forward until the next obstacle is encountered.

The second routine is a basic "learning" program which will allow up to five movement commands to be stored and repeated indefinitely. This program could form the basis of a routine for drawing patterns or graphs on a large piece of paper or board,



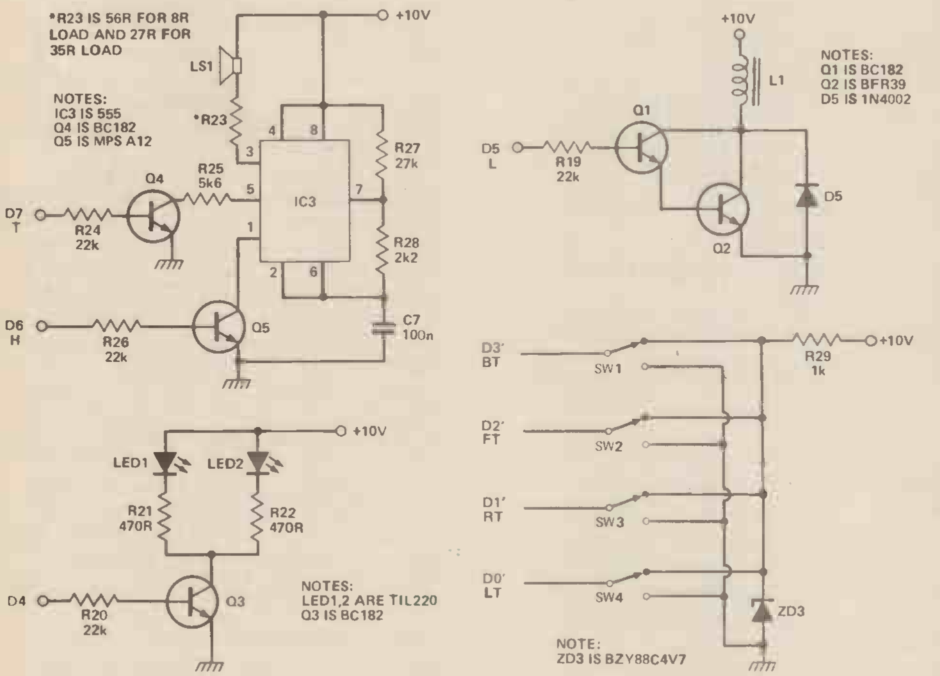


Figure 1. Circuits of the HEBOT II Control Board: (top) both motor control circuits — they are identical except that each is controlled by two different data bits and each has a separate +2V7 bias voltage; (middle left) the circuit of the tone generator (horn) is based on a single 555 IC. Bit D6 turns it on by connecting pin 1 to ground via Q5, while bit D7 increases the pitch; (middle right) the solenoid control. Bit D5 turns on Q1 and Q2, activating solenoid L1; (bottom left) the LED flasher circuit ; (bottom right) the collision detectors are simply microswitches connected accross a +4V7 Zener diode. The diagram shows all four switches closed — ie, a collision on all sides!

using the pen control. The scope of this routine is severely limited by available memory — five commands are the most that can be squeezed into what's left of the 1k of a basic ZX81!

HEBOT — The Circuit

The circular PCB mounted atop HEBOT contains all the circuitry for the motor drives, the LED drivers and the tone generator, plus the collision detectors — which are simply microswitches mechanically coupled to the shell. All circuits are shown in **Figure 1**.

Each motor is driven by a pair of high gain operational amplifiers contained in a single package. The ICs chosen for the design are LM2877s, dual four watt devices with internal current limiting, short circuit and thermal shutdown protection. The amplifiers are internally compensated to maintain stability for gains greater than ten however, because a gain of about three is all that is required, input shunt resistors are used to provide stability with the gain at this level.

The drive circuits are identical for each motor. Considering IC2a, the gain is set by R10, R12; R11, which is connected across the inputs, limits the gain at high frequencies to give improved stability.

The voltage on the non-inverting input, pin 4, is set precisely at 2V7 by R18 and the Zener diode, ZD2. This stabilised voltage is also fed to the inverting input at pin 5, via the trim-pot RV3, and when data input D1 is low (0V), this voltage is amplified to about 6-7V by the op-amp and applied to the motor. If, at the same time, the D0 input is taken high, pin 7 of IC2b is taken above the voltage set by RV4, to about +5V, and the output at pin 10 goes hard towards 0V (actually about 1V6), allowing the motor to drive.

Similarly, if D1 is taken high and D0 low, pin 10 of IC2b goes to about 6V and pin 2 of IC2a goes to nearly 0V — and the motor drives in the opposite direction. However, if both data inputs are the same (both high or both low), then the op-amp outputs will be the same and the motor will not turn.

Thus these simple op-amp circuits convert logic levels into reversible and independently asjustable voltages; further, since the motor drive voltages are derived from a Zener stabilised supply, they will remain independent of variations in the supply line voltage. The RC networks on the outputs of the op-amps are 'Zobel networks', to further ensure high frequency stability.

The remaining circuits are very simple; data bit four (D4) turns on Q3 when high, thus turning on LEDs 1 and 2. The solenoid is controlled by D5; Q2 is a high current transistor which receives its basic drive from Q1 when D5 is high. The two-tone horn consists of a 555 IC operating as an astable and driving a loudspeaker. Transistor Q5 will switch on whenever D6 is high, thus connecting pin 1 to ground allowing it to oscillate at about 500 Hz; the frequency is increased to 1000 Hz by taking D7 high under program control.

On the output side, the microswitches simply switch from 0V to +4V7 whenever a collision occurs.

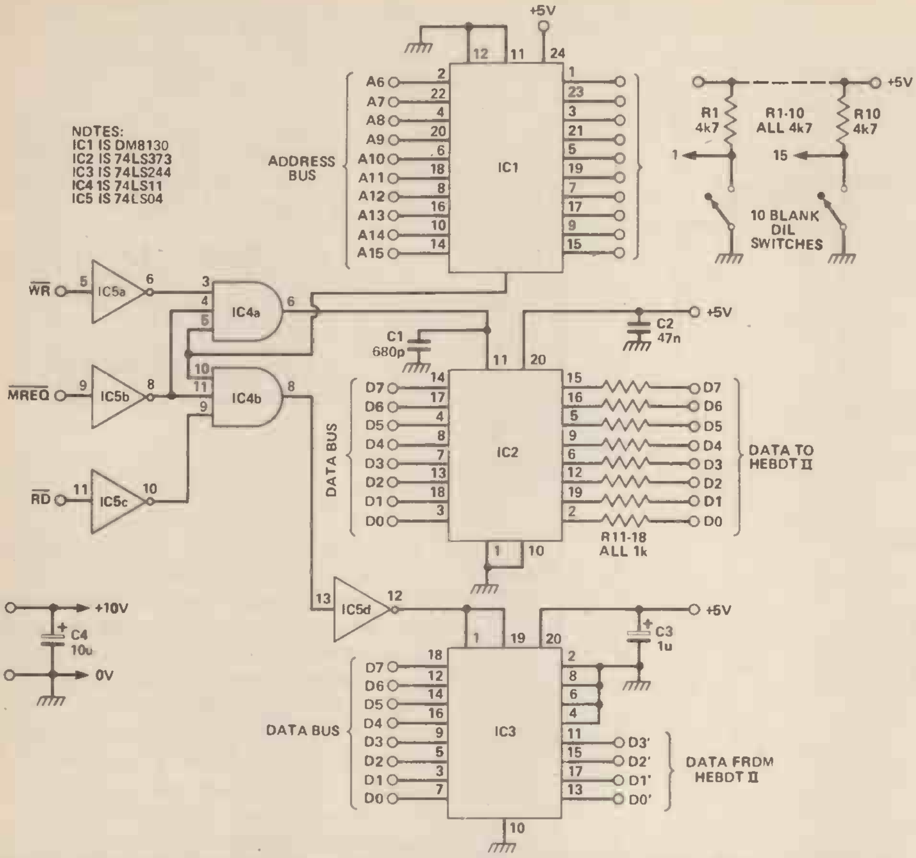


Figure 2. The circuit of the ZX81 Interface Board. Resistors R2 — R9 are contained in a nine-pin SIL (Single-In-Line) package.

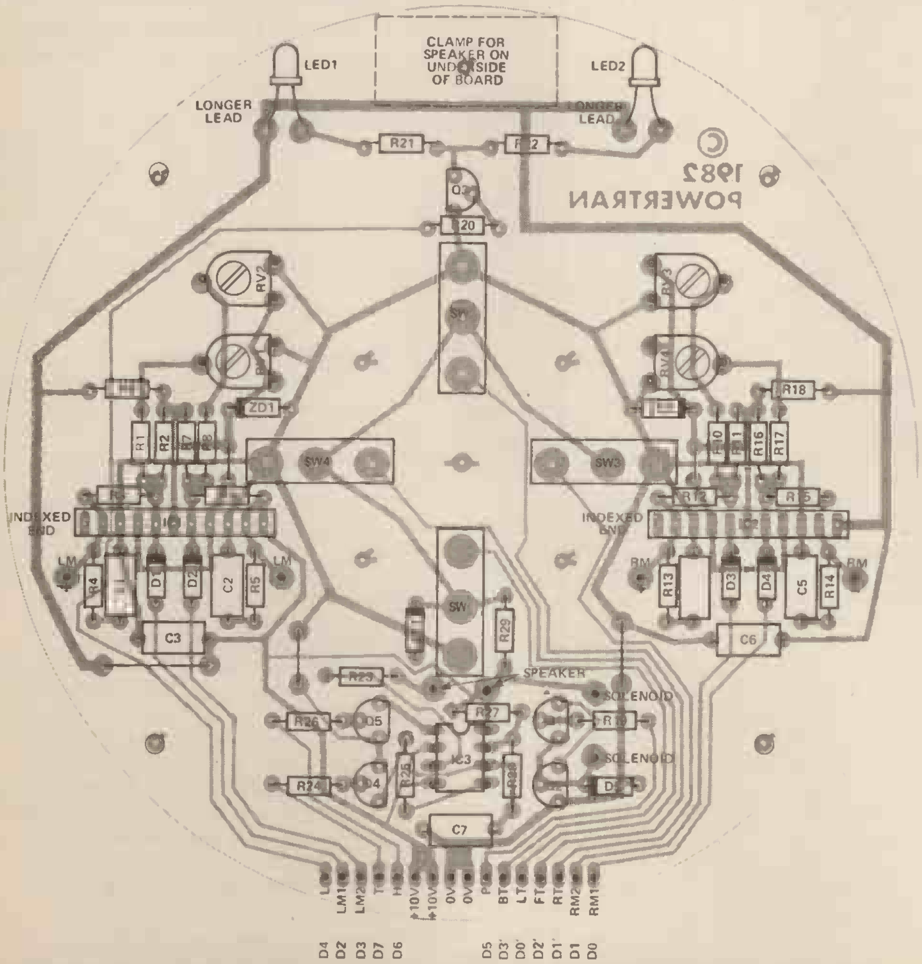


Figure 3. The component overlay board for the HEBOT Control Board; the LEDs indicate the "forward" direction.

The Interface Circuit

This circuit (Figure 2) enables HEBOT II to be treated as a memory-mapped I/O device; in other words, data can be sent to and received from the robot as if it were another memory location in RAM or ROM. It uses the computer's address and data busses, together with the control lines $\overline{WR}$ (active low WRite command), $\overline{RD}$ (ReaD) and $\overline{MREQ}$ (Memory REQuest).

As briefly explained in How It Works, the interface board consists of four circuit elements. The address decoder is a comparator, IC1, which compares the top ten address lines with a ten-bit code set up on the ten-bank DIL switch and resistor network. Thus by setting these switches, any one of 1024 64-byte wide memory sectors can be selected as HEBOT's location in memory. The most convenient address is 65535, right at the top of the memory space, corresponding to all DIL switches open (ie, all address bits high).

Whatever address is selected, IC1's output at pin 13 will go high only when the top ten address bits correspond to the code set up on the switches. When there is a match, and when both the $\overline{WR}$ and $\overline{MREQ}$ lines are low, data latch IC2 will be enabled and the bit-pattern on the computer's data base will be tranferred to HEBOT's data input lines. After this, the data will remain latched in IC2 until a new WRite instruction to HEBOT is issued by the computer.

Simillarly, IC3, which is an eight-bit buffer IC, will transfer data to the computer when both $\overline{RD}$ and $\overline{MREQ}$ are low and when there is an address match from IC1.

Construction

Start by assembling the HEBOT PCB (Figure 3); the only points to watch here are that the microswitches are fitted square and firmly mounted, and that the ICs are fitted the right way around. To help, the makers have put an index mark on the package at the pin 1 end and, in case you miss that, they have also cut the corner off the cooling fin! Next, wire in the 16-way ribbon cable which connects HEBOT to the interface band. The remaining components can then be fitted and the PCB completed.

Now for the collision detector — see Figure 4. First insert the central mounting screw, which will eventually hold the shell in place. Next assemble the mounting plate mechanism and screw it loosely to the PCB; the small ball-bearing must be slipped under the mounting plate, where it will be held between the depression in the PCB and the bottom of the central mounting screw — this is probably the trickiest part of the entire assembly! Now tighten down the four mounting screws, but then unscrew them about half a turn, to permit the plate to rock slightly. Pressing down on one side should operate one or two of the microswitches, and they should

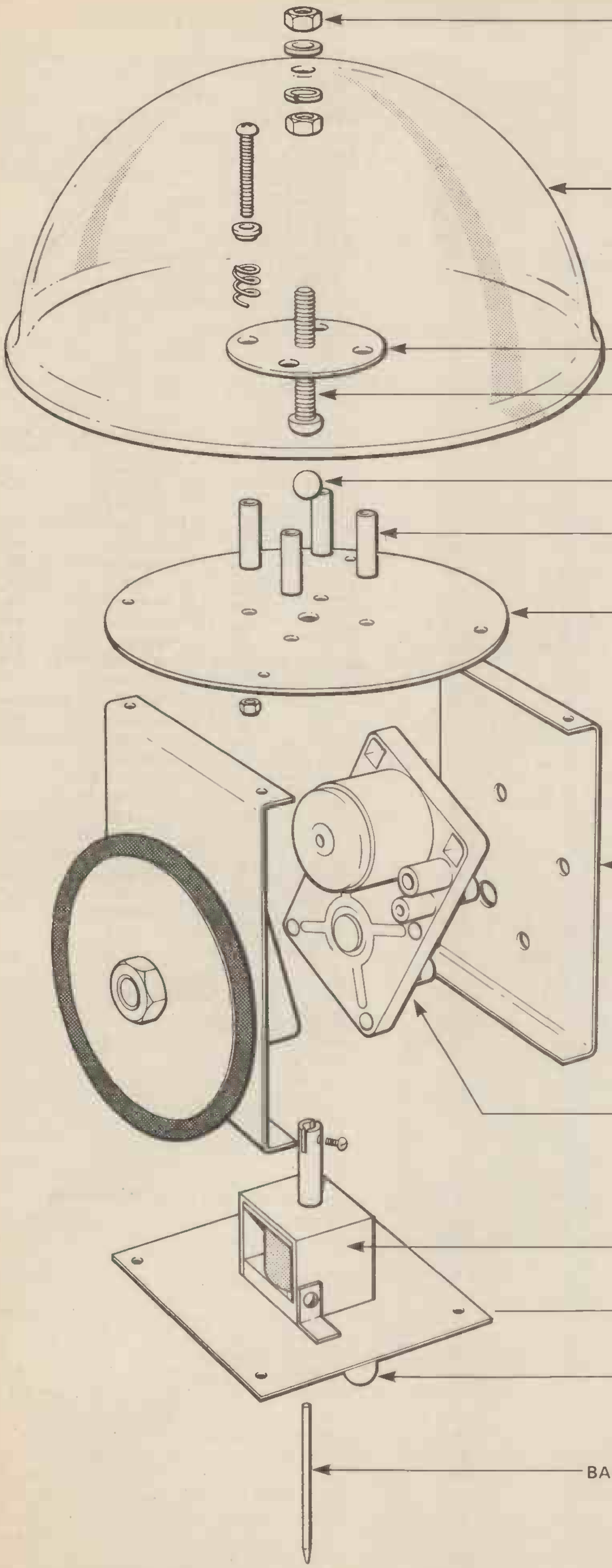


Figure 5. The HEBOT mechanical assembly diagram.

release when the pressure is removed from the plate. After this, you can fit the 'speaker to the underside of the PCB using the special clip, and wire it in.

The next stage is to fit the motors to the side plates (see **Figure 5**) and to attach these to the base plate. Mount the PCB to the side plates using stand-off spacers, and wire up the motors; the LEDs and the speaker are regarded as being the front of the robot. Secure the pen in the solenoid — **Figure 6** — and fit it to the base plate; fix the wheels to the motor shafts with a nylon washer between the wheels and the plates and then adjust the pen so

Parts

A complete kit of parts for HEBOT II, consisting of the components and hardware listed below, is available from **Powertran Cybernetics** — see **Buylines** for details. The components for the Interface Board (including the double-sided PCB), the 23-way connector and the three-way RAM pack adaptor are all available separately — see page 33.

I/O Board
RESISTORS
(all ¼ watt 5% carbon, unless stated)

R1,10	4k7
R2-8	4k7 SIL package
R11-18	1k

CAPACITORS

C1	680p ceramic disc
C2	47n ceramic disc
C3	1u 16V tantalum bead
C4	10u 16V tantalum bead

SEMICONDUCTORS

IC1	DM8130 10-bit address decoder
IC2	74LS373 octal latch
IC3	74LS244 tri-state octal buffer
IC4	74LS11 triple 3-input AND
IC5	74LS04 hex inverter

MISCELLANEOUS

SW1-10	DIL switch 10 way rocker type

PCB; cable clip; 14 pin (2 off), 20 pin (2 off), 24 pin DIL sockets; 23 + 23 way edge connector, polarising key (posn 3), PCB mounting (2 off); 16 way ribbon cable.

Main Board and Mechanics

RESISTORS
(All ¼ watt 5% carbon)

R1,8,10,17	15k

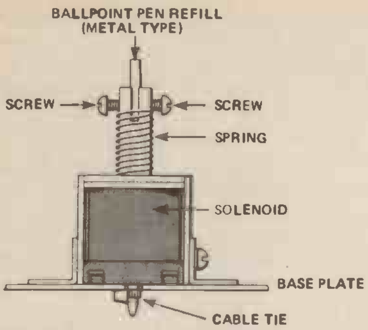


Figure 6. Mechanical detail of the solenoid. Note the cable tie, which holds the pen in place.

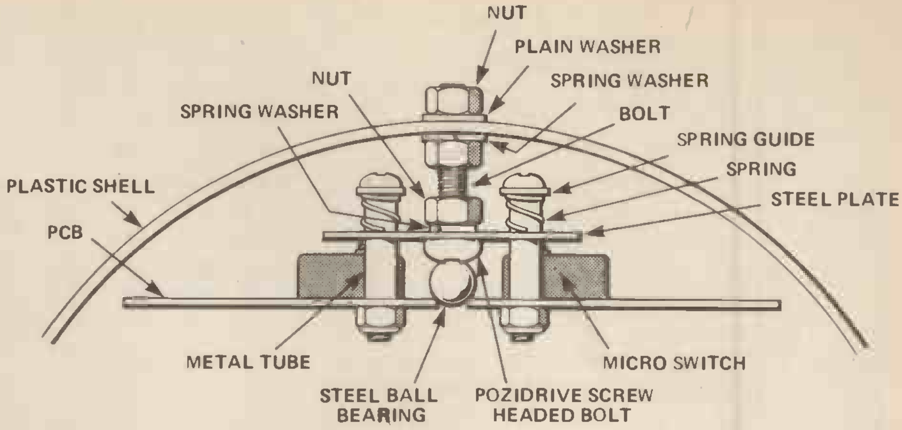


Figure 4. How to assemble the collision detector mechanism.

List

R2,7,11,16 . . . . 4k7
R3,6,12,15 . . . . 47k
R4,5,13,14 . . . . 3R3
R9,18,21,22 . . . . 470R
R19,20,24,26 . . . . 22k
R23 . . . . (see text)
R25 . . . . 5k6
R27 . . . . 27k
R28 . . . . 2k2

POTENTIOMETERS
(All miniature carbon presets)
RV1-4 . . . . 2k2

CAPACITORS
(All polyester C280)
C1-7 . . . . 100n

SEMICONDUCTORS
IC1,2 . . . . LM2877
dual 4 watt power amp
IC3 . . . . NE555
timer
Q1,3,4 . . . . BC182
silicon NPN transistor
Q2 . . . . BFR39
silicon NPN transistor
Q5 . . . . MPSA12
silicon NPN transistor
D1-D4 . . . . OA47
signal diode
D5 . . . . IN4002
rectifier diode
LED1,2 . . . . TIL20
red 0.2" LED
ZD1,2 . . . . BZY88C2V7
400mW zener diode
ZD3 . . . . BZY88C4V7
400mW zener diode

MISCELLANEOUS
L1 . . . . solenoid
(see text)
LS1 . . . . speaker 8-35R
1½"

PCB; micro-switch (4 off); 8 pin DIL socket; motor with integral gear box — 2 off; aluminium sheet; wheels; toes; sprints; steel ball-bearing; clear plastic shell; nuts; bolts; wire; solder etc.

BUYLINES . . . . page 33

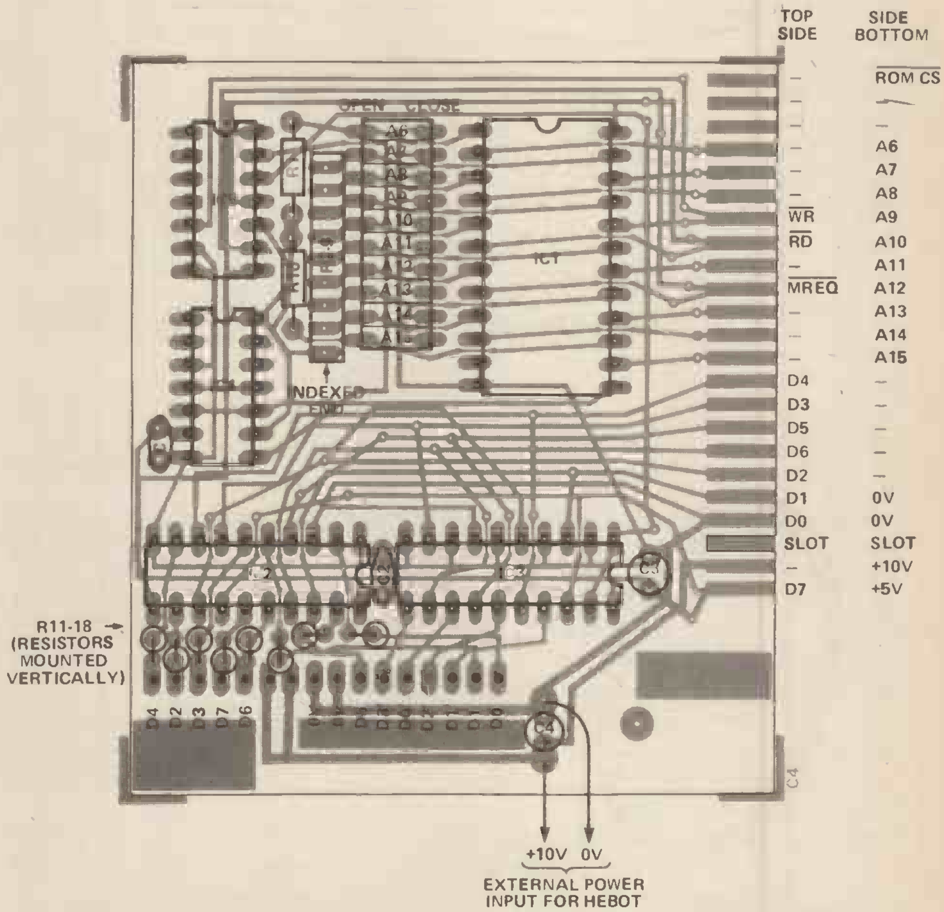


Figure 7. The component layout of the Interface Board. Note that both sides of the double-sided PCB are shown.

that, when it is fully down, it is about 2mm below the level of the tyres. To prevent the spring from ejecting the pen when the solenoid is deactivated, fit a cable tie around the pen, below the solenoid. Lastly, wire up the solenoid, screw on the 'toes' at the front and back of the base plate, attach the shell — and HEBOT is ready to roll! One word of caution however, try not to pick it up by the base of the shell, as this will release the ball-bearing from its mounting. It remains trapped by the microswitches and the plate bolts, but the collision detection will not operate unless the bearing is in the correct position.

The Interface

The interface board has been specially designed for use with HEBOT and should present no difficulties in assembly — just make sure that the ribbon cable wires go to the correct places! As mentioned earlier, any I/O system capable of controlling eight bits of output data and accepting at least four bits of input can be used to control the robot; the ZX I/O board which appeared in the September issue of Hobby Electronics, for example, would be adequate. In any case make sure you know the robot's address. On the HEBOT I/O board, this is

Table 4.

```
10   REM "RECORD MOVES"                    ; comments
20   LET A = 65535
30   DIM Z(5)                              ; set up move array
40   DIM T(5)                              ; set up move time array
50   FOR D = 1 TO 5                        ; move counter
60   FOR N = 1 TO 100                      ; move timer
70   IF INKEY$ <> " " THEN GOTO 100        ; jump if move
80   PAUSE 10                              ; move time increment
90   NEXT N
100  IF INKEY$ = "S" THEN LET M = 0        ; stop
110  IF INKEY$ = "F" THEN LET M = 5        ; forward
120  IF INKEY$ = "B" THEN LET M = 10       ; 'back' (reverse)
130  IF INKEY$ = "L" THEN LET M = 9        ; left
140  IF INKEY$ = "R" THEN LET M = 6        ; right
150  POKE A, M                             ; move
160  LET Z(D) = M                          ; store move
170  LET T(D) = N                          ; store move time
180  NEXT D                                ; next move
190  PAUSE 20
200  REM "PLAYBACK"
210  FOR D = 1 TO 5                        ; set up move counter
220  LET M = Z(D)                          ; recall first move
230  LET W = T(D) + 1                      ; first move time period
240  POKE A, M                             ; playback the move
250  FOR N = 1 TO 100                      ; set up move timer
260  PAUSE 10                              ; move time increment
270  IF N = W THEN GOTO 290                ; at end of move period
280  NEXT N
290  NEXT D
300  POKE A, 0                             ; stop
310  STOP
```

Table 3.

```
10   REM "HEBOT'S MOVE"                    ; comments in this column
20   FAST
30   LET A = 65535                         ; Hebot's address
40   LET X = 0                             ; clear collision flag
50   LET M = 5                             ; movement command
60   POKE A, M                             ; move
70   GOSUB 260                             ; short pause to move
80   POKE A, M+16                          ; flash lights
90   GOSUB 260
100  LET K = PEEK A
110  IF K <> 0 THEN GOTO 150               ; collision!
120  IF X = 1 THEN GOTO 190                ; previous collision
130  IF INKEY$ = "S" THEN GOTO 290         ; emergency stop
140  GOTO 60                               ; continue forward
150  IF K > 6 THEN GOTO 200                ; rear-end collision
160  LET M = 10 + 64                       ; reverse and sound horn
170  LET X = 1                             ; set collision flag
180  GOTO 60                               ; move in reverse
190  LET X = 0                             ; clear collision flag
200  LET M = 8                             ; turn left
210  POKE A, M
220  GOSUB 240                             ; long pause
230  GOTO 50                               ; continue forward
240  PAUSE 50                              ; variable length pauses
250  PAUSE 30
260  PAUSE 10
270  POKE 16437, 255
280  RETURN
290  POKE A, 0                             ; emergency stop
300  STOP
```

set up on the ten-bank DIL switch, as explained. The most convenient address is right at the top of memory — a ReaD instruction to HEBOT will clash with the ZX81's unbuffered memory, however no problems have been experienced using this high address, as the interface board overrides the unbuffered memory.

If the ZX81 is to be used with a RAM pack, then an address between 8192 and 16383 should be used and the 'echo' of the computers ROM should be disabled by pulling $\overline{\text{ROMCS}}$ high with a diode from IC4 pin 8, to that line. This connector will be included on PCBs supplied in Powertran kits. To fit the RAM Pack as well as the Interface board, a 3-way adaptor is required and is available from Powertran. With this, the RAM Pack lies on top of the computer.

Testing

Plug the I/O board into your ZX81 computer and power on. HEBOT will (probably) immediately begin to move in the direction of the nearest exit or table top, due to some random bit-pattern on the control lines! Quickly send the following command: POKE 65535,0. This will stop the robot in its tracks.

Now turn each motor drive preset fully clockwise; then, using a voltmeter, turn each preset back till the voltage has dropped by 1V; this will allow the supply voltage to fall by up to this amount without affecting the robot's speed.

Next, POKE 65535,5 and HEBOT will move forward; RV2 and RV3 must be adjusted to ensure that it travels in a straight line (make sure the rubber wheels are on straight before you do this). Now POKE 65535,10 to move it in reverse, and adjust RV1,4 to match the reverse speed to the forward speed.

To test the remaining functions, POKE 65535,16; HEBOT should stop with the LEDs glowing balefully red; POKE 65535,32 should drop the pen, and POKE 65535,0 should retract it again. POKE 65535,64 will sound the horn in the lower frequency, while sending 192 should increase the pitch.

To test the collision detectors, write a short routine to repeatedly PEEK 65535 and look for 1, 2, 4, and 8 from the respective sensors.

Two Programs

To really give your new pet a workout, try the two simple programs listed in Tables 3 and 4 — but please remember that these are presented only as starting points for further development. Come along to Breadboard '82 and show us what your HEBOT can do — or send in your program on cassette. The best routines will be presented in future issues as an inspiration to all HEBOT trainers. Watch out, Barbara Woodhouse!

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7481	120p
7482	85p
7483A	38p
7484	80p
7485	60p
7486	18p
7489	170p
7490A	20p
7491	38p
7492A	25p
7493A	24p
7494	38p
7495A	35p
7496	36p
7497	90p
74100	80p
74107	22p
74109	25p
74112	170p
74116	60p
74118	55p
74119	80p
74120	60p
74121	28p
74122	30p
74123	36p
74125	30p
74126	30p
74128	38p
74132	30p
74136	28p
74141	58p
74142	175p
74143	200p
74144	200p
74145	40p
74147	75p
74148	60p
74150	50p
74151A	38p
74153	38p
74154	50p
74156	38p
74157	30p
74159	75p
74160	40p
74161	40p
74162	40p
74163	40p
74164	45p
74165	45p
74166	48p
74167	150p
74170	120p
74172	250p
74173	50p
74174	56p
74175	50p
74176	40p
74177	45p
74178	70p
74180	40p
74181	115p
74182	40p
74184A	90p
74185	90p
74186	470p
74188	250p
74190	45p
74191	45p
74192	45p
74193	45p
74194	40p
74195	40p
74196	40p
74197	40p
74198	80p
74199	80p
74221	56p
74251	45p
74273	120p
74278	140p
74279	40p
74283	50p
74284	180p
74290	75p
74293	80p
74298	100p
74351	150p
74365	30p
74366	30p
74367	35p
74368	30p
74376	100p
74390	75p
74393	80p
74490	95p

74LS SERIES

74LS00	11p
74LS01	11p
74LS02	11p
74LS03	12p
74LS04	12p
74LS05	12p
74LS08	12p
74LS07	12p
74LS08	12p
74LS09	12p
74LS10	12p
74LS11	13p
74LS12	13p
74LS13	18p
74LS14	25p
74LS15	12p
74LS20	13p
74LS21	13p
74LS22	13p
74LS26	14p
74LS27	13p
74LS28	14p
74LS30	13p
74LS32	13p
74LS37	14p
74LS40	14p
74LS42	30p
74LS47	30p
74LS51	14p
74LS55	14p
74LS73	18p
74LS74	18p
74LS75	18p
74LS76	18p
74LS83	38p
74LS85	60p
74LS86	18p
74LS90	22p
74LS92	30p
74LS93	30p
74LS95	40p
74LS96	60p
74LS107	20p
74LS109	27p
74LS112	20p
74LS113	20p
74LS114	20p
74LS122	34p
74LS123	30p
74LS124	60p
74LS125	24p
74LS126	24p
74LS132	30p
74LS133	24p
74LS136	24p
74LS138	30p
74LS139	27p
74LS145	46p
74LS147	120p
74LS148	70p
74LS151	30p
74LS153	40p
74LS154	80p
74LS155	30p
74LS156	30p
74LS157	28p
74LS158	30p
74LS160	40p
74LS161	38p
74LS162	38p
74LS163	38p
74LS164	40p
74LS165	38p
74LS166	80p
74LS170	70p
74LS173	55p
74LS174	40p
74LS175	35p
74LS181	90p
74LS190	38p
74LS191	38p
74LS192	38p
74LS193	38p
74LS194	35p
74LS195	35p
74LS196	45p
74LS197	45p
74LS221	50p
74LS240	55p
74LS241	55p
74LS242	55p
74LS243	55p
74LS244	55p
74LS245	55p
74LS251	30p
74LS253	30p
74LS257	30p
74LS258	35p
74LS260	22p
74LS261	50p
74LS266	20p
74LS273	60p
74LS279	38p
74LS283	40p
74LS298	80p
74LS323	180p
74LS324	150p
74LS348	140p
74LS352	80p
74LS353	80p
74LS363	140p
74LS364	140p
74LS365	30p
74LS367	30p
74LS368	30p
74LS373	55p
74LS374	58p
74LS375	55p
74LS377	70p
74LS378	70p
74LS390	45p
74LS393	45p
74LS399	160p
74LS467	80p
74LS540	80p
74LS541	80p
74LS670	120p

4000 SERIES

4000	10p
4001	10p
4002	12p
4006	50p
4007	14p
4008	36p
4009	24p
4010	24p
4011	11p
4012	18p
4013	20p
4014	48p
4015	40p
4016	20p
4017	32p
4018	45p
4019	25p
4020	48p
4021	40p
4022	46p
4023	13p
4024	32p
4025	13p
4026	80p
4027	20p
4028	40p
4029	46p
4030	15p
4031	125p
4033	125p
4034	140p
4035	48p
4036	275p
4037	110p
4039	290p
4040	40p
4041	40p
4042	40p
4043	40p
4044	40p
4076	48p
4077	18p
4078	18p
4081	14p
4082	15p
4086	40p
4089	125p
4093	24p
4094	80p
4095	75p
4096	70p
4097	290p
4098	90p
4099	100p
4500	575p
4502	80p
4503	46p
4505	400p
4507	35p
4508	130p
4510	46p
4511	45p
4512	48p
4514	110p
4515	110p
4516	55p
4518	40p
4520	50p
4521	90p
4526	60p
4527	80p
4528	50p
4532	70p
4534	400p
4536	270p
4538	90p
4539	70p
4543	75p
4553	245p
4555	35p
4556	35p
4560	120p
4568	250p
4569	170p
4572	30p
4583	90p
4584	36p
4585	75p
40085	80p
40097	50p
40102	140p
40103	170p
40106	38p
40109	100p
40163	60p
40174	50p
40175	50p
40193	60p
14495	300p

LINEAR ICs

AN103	200p
AY1-0212	800p
AY1-1313	680p
AY1-1320	225p
AY1-5050	90p
AY3-1350	350p
AY3-8910	560p
AY3-8900	380p
AY3-8912	625p
AY5-4007D	520p
CA3028A5	120p
CA3019	80p
CA3046	70p
CA3048	220p
CA3059	285p
CA3060E	350p
CA3080E	70p
CA3086	48p
CA3089	200p
CA3090AQ	375p
CA3130E	90p
CA3140E	40p
CA3140T	90p
CA3160E	100p
CA3161E	150p
CA3162E	460p
CA3189E	300p
CA3240E	110p
CA3280G	200p
D7002	480p
DAC1408-8	200p
HA1366	195p
HA1388	250p
ICL7106	700p
ICM7216B	£18
ICM7217	750p
ICM7555	80p
LC7120	300p
LC7130	325p
LF347	150p
LF351	48p
LF353	85p
LF356P	85p
LF357	110p
LM10C	325p
LM301A	25p
LM307	45p
LM308	48p
LM310	120p
LM318	150p
LM319	215p
LM324	30p
LM334Z	80p
LM335Z	140p
LM339	50p
LM348	65p
LM358P	60p
LM377	175p
LM380	75p
LM381AN	160p
LM382	120p
LM384	130p
LM386	90p
LM387	120p
LM389	95p
LM391	150p
LM393	100p
LM394	300p
LM709	38p
LM710	50p
LM711	70p
LM723	35p
LM733	80p
LM741	18p
LM747	70p
LM748	30p
LM1014	150p
LM1801	300p
LM2917	200p
LM3302	75p
LM3900	60p
LM3909	65p
LM3911	125p
LM3914	200p
LM3915	200p
LM3916	225p
LM13600	110p
M51513L	300p
M51516L	500p
MB3712	250p
MB3730	300p
MC1310P	150p
MC1445	250p
MC1458	35p
MC1495L	350p
MC1496	70p
MC3340P	120p
MC3403	65p
MK50398	635p
ML920	800p
MN57160	500p
MN6221A	600p
NE531	140p
NE555	16p
NE556	45p
NE564	420p
NE565	120p
NE566	155p
NE567	150p
NE570	410p
NE571	400p
NE5534A	125p
PLL02A	500p
RC4136	80p
RC4151	200p
S566B	250p
SAD1024A	800p
SFF9634	700p
SL490	350p
SN76477	450p
SN76488	450p
SN76495	400p
SP8515	750p
TA7120	150p
TA7204	150p
TA7205	250p
TA7222	150p
TA7310	150p
TBA800	80p
TBA810	100p
TBA820	80p
TBA950	225p
TCA220	350p
TCA940	175p
TDA1004A	300p
TDA1008	320p
TDA1010	225p
TDA1022	500p
TDA1024	120p
TDA1170	300p
TDA2002V	325p
TDA2006	380p
TDA2020	320p
TL081CP	30p
TL062	60p
TL064	90p
TL071/81	30p
TL072/82	50p
TL074	100p
TL084	90p
TL094	200p
TL170	50p
TL430C	70p
UA2240	120p
UAA170	170p
ULN2003	100p
ULN2004	75p
ULN2068	200p
ULN2802	200p
UPC575	275p
UPC592H	275p
UPC1156H	300p
XR2206	300p
XR2207	375p
XR2211	575p
XR2216	675p
ZN414	80p
ZN419C	190p
ZN423E	130p
ZN424E	130p
ZN425E	300p
ZN427E	580p
ZN428E	400p
ZN1034E	200p
ZN1040E	670p
ZNA234	850p

TRANSISTORS

AD161/2	40p
BC107	14p
BC108C	14p
BC117	20p
BC169C	10p
BC172	12p
BC177/8	17p
BC179	18p
BC182/3	10p
BC184	10p
BC187	30p
BC212/3	10p
BC214	10p
BC237	15p
BC327	16p
BC337	10p
BC338	16p
BC461	25p
BC516/7	38p
BC547B	12p
BC548C	9p
BC549C	12p
BC557B	10p
BC559C	16p
BCY70	20p
BCY71	20p
BD135/6	40p
BD139	40p
BD189	80p
BD232	95p
BD233	75p
BD235	75p
BD241	70p
BD242A	70p
BF256B	45p
BF257/8	30p
BFR39	20p
BFR40/1	20p
BFR79	20p
BFR80/1	25p
BFR96	180p
BFX30	34p
BFX86/7	28p
BFX88	28p
BFX89	150p
BFY50	24p
BFY51/2	24p
BFY56	30p
BFY90	75p
BRY39	40p
BSX19/20	20p
BU104	225p
BU105	170p
BU108	250p
BU109	225p
BU126	150p
BU180A	120p
BU205	175p
BU208	200p
BU406	145p
BUX80	400p
BUY69C	200p
J310	50p
MJ8024	£4
MJ2501	225p
MJ2955	80p
MJ3001	225p
MJ4502	£4
MJE340	50p
MJE2955	90p
MJE3055	70p
MPF102	30p
MPF103/4	30p
MPF105	30p
MPSA12	30p
MPSA13	30p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	25p
MPSA70	50p
MPSA93	50p
MPSU06	56p
MPSU07	60p
MPSU45	80p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	50p
TIP32A	40p
TIP32C	45p
TIP33A	90p
TIP33C	80p
TIP34A	90p
TIP34C	80p
TIP35A	120p
TIP35C	150p
TIP36A	140p
TIP36C	160p
TIP41A	45p
TIP41C	55p
TIP42A	50p
TIP42C	60p
TIP54	160p
TIP120	50p
TIP121	70p
TIP122	60p
TIP142	110p
TIP147	120p
TIP2955	80p
ZTX108	10p
ZTX300	13p
ZTX452	45p
ZTX500	13p
ZTX502	15p
ZTX504	30p
ZTX552	55p
ZTX652	60p
ZTX752	70p
VN10KM	56p
VN66	80p
2N697	20p
2N698	40p
2N706A	18p
2N708	18p
2N918	35p
2N930	18p
2N1132	24p
2N1613	30p
2N1711	25p
2N2102	70p
2N2160	295p
2N2219A	25p
2N2222A	25p
2N2369A	25p
2N2484	30p
2N2646	45p
2N2904/5	30p
2N2906A	30p
2N2907A	30p
2N2926	9p
2N3053	30p
2N3054	65p
2N3055	48p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643/4	48p
2N3702/3	12p
2N3704/5	12p
2N3706/7	14p
2N3708/9	12p
2N3773	225p
2N3819	25p
2N3820	40p
2N3823	50p
2N3866	90p
2N3902	700p
2N3903/4	18p
2N3905/6	20p
2N4037	65p
2N4123/4	27p
2N4125/6	27p
2N4401/3	27p
2N4427	90p
2N4871	80p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5194	90p
2N5245	40p
2N5298	65p
2N5401	60p
2N5457/8	30p
2N5459	40p
2N5460	60p
2N5485	40p
2N5875	250p
2N6027	48p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1172	150p
2SC1306	150p
2SC1307	150p
2SC1957	90p
2SC1969	225p
2SC2028	120p
2SC2029	250p
2SC2078	200p
2SC2335	250p
2SC2612	250p
3N128	120p
3N140	120p
3N141	110p
3N201	110p
3N204	120p
40290	280p
40361/2	75p
40408	90p
40409	100p
40410	100p
40411	300p
40594	120p
40595	120p
40673	75p
40871/2	100p

DIODES

BY127	12p
BYX36300	20p
OA47	8p
OA90/91	8p
OA95	8p
OA200	9p
OA202	10p
1N941	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/3	14p
1N5404/7	19p
IS920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p
1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

PCB MOUNTING RELAYS

6 or 12V DC Coil SPDT 2A 24V DC	180p
6 or 12V DC Coil DPDT 5A 24V DC 240V AC	200p
6 or 12V DC Coil SPDT 10A 24V DC 240V AC	225p

SWITCHES

TOGGLE SWITCHES
Subminiature
SPST 60p, SPDT 65p,
DPDT 70p
Rotary Switches
1P12Ow, 2P6W, 3P4w,
4P3w, 55p
DIGITAST
SWITCHES IxP
Push to make (R,G,B) 15p
Push to break (Black) 18p
Slide Switch DPDT 18p
Square PCB Switch 65p

VERO

2.5"x5"	80p
2.5"x3.75"	80p
2.5"x17"	140p
3.75"x3.75"	90p
Vero Block	£3.90
3.75"x5"	105p
3.75"x17"	400p
4.75"x19"	520p
2.5"x1"	110p
Spot Face Cutter	£1.30

OPTO ELECTRONICS

2N5777	45p
OCP71	180p
ORP12	120p
ORP60	120p
ORP61	120p
TIL78	55p

OPTO ISOLATORS

ILD74	130p
MCT26	100p
MCS2400	190p
ILQ74	240p
TIL11	70p
TIL12	70p
TIL13	70p
TIL116	70p

LEDs

0.125"	
TIL32	55p
TIL209 Red	9p
TIL211 Gr	12p
TIL212 Ye	14p
TIL216 Red	18p
0.2"	
TIL200 Red	10p
TIL222 Gr	12p
TIL228 Ye	14p
Rectangular LEDs (R,G,Y)	30p
NS85881	570p
TIL311	600p
TIL312/3	110p
TIL321/2	130p
TIL330	140p
7750/60	200p

DISPLAYS

3101SF	200p
DL704	140p
DL707 Red	140p
FND357	120p
FND500	90p
FND507	90p
MAN3640	175p
MAN4640	200p

DRIVERS

9368	250p
9370	300p
UDN6118	320p
UDN6184	320p

LOW PROFILE SOCKETS BY TI

8 pin	9p
14 pin	10p
16 pin	11p
18 pin	16p
20 pin	18p
22 pin	22p
24 pin	24p
28 pin	28p
40 pin	30p

WIRE WRAP SOCKETS BY TI

8 pin	25p
14 pin	35p
15 pin	40p
18 pin	50p
20 pin	60p
22 pin	65p
24 pin	70p
28 pin	80p
40 pin	100p

VOLTAGE REGULATORS
FIXED PLASTIC

1A	+ve		-ve	
5V 1A	7805	40p	7905	45p
12V 1A	7812	40p	7912	45p
15V 1A	7815	50p	7915	45p
18V 1A	7818	40p	7906	60p
24V 1A	7824	40p	7924	60p
5V 100mA	78L05	30p	79L05	50p
12V 100mA	78L12	30p	79L12	50p
15V 100mA	78L15	30p	79L15	50p

OTHER REGULATORS

LM309K	140p	78HGKC	600p
LM317K	325p	78H06KC	550p
LM317T 1A Adj	140p	78MGT2C	140p
LM337T	225p	78GUIC	200p
LM323K 3A 5V	500p	79HGUIC	225p
LM723 150mA Adj	37p	79HGKC	700p
TL494	300p	TL487	300p
78S40	225p	LM305AH	250p

BOOKS (No VAT p&p £1)

CMOS Cook Book	£7.75
CRT Controller H/Book	£5.95
Programming the Z80	£11.50
Z80 Microcomp. handbook	£6.95
Programming the 6502	£10.25
6502 Assy. Lang.	£12.10
6502 Applications	£10.20
6502 Software Design	£9.05
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UV141 with timer £78.00
(Carr £2/eraser)
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This Z80 micro controlled clock/calender receives coded time data from NPL Rugby. The clock never needs to be reset. The facilities include 8 independent alarms and for each alarm there is a choice of melody or alternatively these can be used for electrical switching. A separate timer allows recording of up to 240 lap times without interrupting the count. Expansion facilities provided.

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RGB Input 18MHz Bandwidth
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Composite Input 18MHz Bandwidth ... £99 + £6.00 carr.
SANYO CASSETTE RECORDER ... £24.50 + £1.50 carr.

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80 cols 30CPS
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MX 80 80CPS 80 COLS
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MX 100 100CPS 136 COLS
£430 + £8 carr.

AS DESCRIBED IN JUNE/JULY/AUGUST ISSUE

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1802 Ref. £7.00

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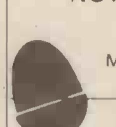
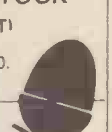
Fitting charge £20.00.





ACORN ATOM

BASIC BUILT 8K + 2K	£135
Expanded 12K + 12K	£180
8K + 5K + Colour Card	£175

(p & p £3.00/unit)

3A 5V PSU £26.00 + £2.00 p & p
Send for detailed Atom list.

MICRO TIMER

The programmable clock/timer is a 6502 based dedicated micro computer with memory and 4 digit 7 segment displays to form an extremely versatile timing device with following features:

- 24 hour 7 day timer
- 4 completely independent switch outputs
- 4 digit 7 segment display output to indicate real time turn-off times and reset times
- Individual outputs to day of week, switch and status LEDs
- Data entry through a simple matrix pad

Further details on request
Complete Kit .... £56.00 + £1.00 p & p
PSU .... £7.00 + 70p p & p
Construction details supplied

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PLEASE ADD 40p p&p & 15% VAT
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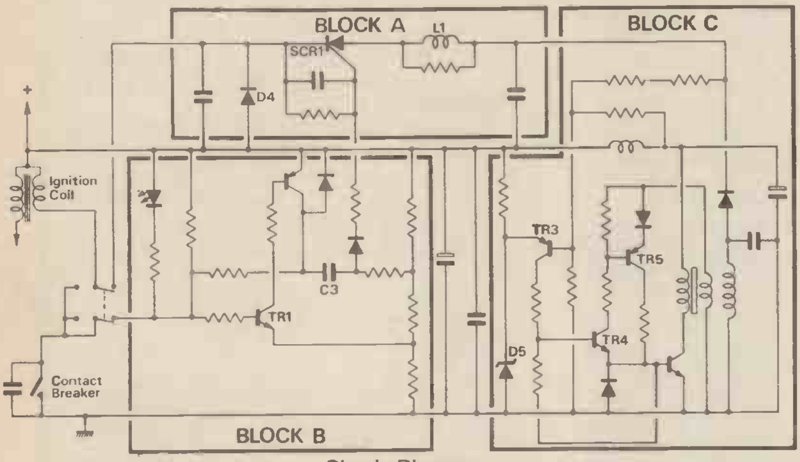
Orders from Government Depts. & Colleges etc. welcome.
Detailed Price List on request.
Stock items are normally by return of post.

electronize **ELECTRONIC IGNITION KITS**

Two years ago we launched the Total Energy Discharge System, we knew it could outperform any competing system and the sales have proved just how good it is. With thousands of systems sold in over 30 countries around the World, from the cold of Norway to the tropical heat of Singapore, the system is an outstanding success.

THIS IS WHAT MAKES TOTAL ENERGY DISCHARGE SO GOOD–



Circuit Diagram

The discharge circuit in block A is the heart of the system. It looks simple but outperforms any other by far. A 2 μF storage capacitor (twice the usual size) charged to + 370 volts, is discharged into the ignition coil primary by SCR1, providing a high energy pulse of the correct polarity. Long after the storage capacitor is discharged, the current in the ignition coil is sustained by 'flywheel' diode D4, preventing energy flowing back to the capacitor and giving 3½ times the spark energy and duration. Instead of relying on the effects of coil 'ringing', inductor L1 commutates the SCR, giving complete freedom from the usual latching problems and allowing the storage capacitor to be recharged whilst the discharge current is still flowing in the coil.

Block B is the trigger circuit and provides faultless spark timing. The emitter of TR1 is biased from the supply to provide a variable trigger threshold, allowing triggering with the supply down to about 3.5 volts but rejecting noise and signals from contact shuffle and vibration. Capacitor C3 and its associated resistors provide a variable inhibit period, after the contacts close, which filters out extreme contact bounce on 4 cylinder engines yet still allows 8 cylinder operation to over 7500 rev/min. In effect the longer the contacts stay open the longer they must remain closed before the next spark can be triggered. (Be warned:- untimed sparks can seriously damage your engines health).

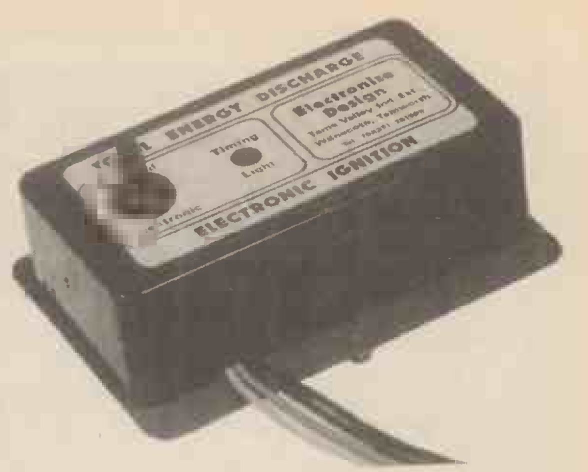
Block C is the inverter, the power behind the spark. It's a 'ringing choke' type. Well designed, this type can not only be regulated and charge the capacitor from zero volts, effectively a short circuit, but is also more efficient than the traditional push-pull type. Even though it provides around 3 times the power, it still doesn't need the usual finned heat sink. Transistors TR4 and TR5 regulate the invertor output, by controlling the amount of feedback, and are in turn controlled by TR3 which compares the voltage on the storage capacitor with the reference zener D5. The output voltage is set by the zener voltage so the full output is available over the whole supply voltage range, a powerful spark is produced even with the battery down to 4 volts.

These are the more obvious features, there are many more details like the absence of 'spikes' and low $^{di}/_{dt}$ and $^{dv}/_{dt}$ applied to the SCR, which together with top quality components make Total Energy Discharge not only a top performer but far more reliable.

This advanced circuitry gives all the well known advantages of the best capacitive discharge systems:

Peak Performance; Improved Economy; Fires Fouled Plugs; Accurate Timing; Smooth Performance;
PLUS
Super Power Spark; Better Starting; Optimum Spark Duration; Correct Spark Polarity; L.E.D. Static Timing Light; Low Radio Interference; Designed In Reliability.

Information disclosed above does not imply any freedom from patent or copyright of Electronize Design.



Electronize Total Energy Discharge Ignition is suitable for use with:

ALL 6 and 12 volt negative earth vehicles fitted with a conventional contact breaker and coil system.

ALL Ballast resistor (cold start/low voltage) systems.

ALL Voltage triggered electronic tachometers. (Some older current impulse types (Smiths pre 1974) require an adaptor)

ANY Number of cylinders up to & including 8.

SPECIFICATION

(using a typical ignition coil)	TOTAL ENERGY DISCHARGE	ORDINARY CAPACITIVE DISCHARGE
Spark Power	140W	90W
Spark Energy	36mJ	10mJ
(stored energy)	135mJ	65mJ
Spark Duration	500μS	160μS
Output Voltage		
clean spark plug	38kV	26kV
fouled spark plug	26kV	17kV
Voltage Rise Time to 20kV	25μS	30μS

You can buy your Total Energy Discharge system as a ready assembled and tested unit ready to fit to your car or as a comprehensive kit of parts containing everything required, even a length of solder and a tube of heat sink compound. The kit comes complete with detailed, easy to follow instructions which enable even a beginner to assemble a kit in just a matter of hours.

The same top performance system is also available, in ready assembled or kit form, to suit cars and motorcycles fitted with twin ignition systems.

STANDARD UNIT Assembled and Tested	**£26.70**
STANDARD UNIT KIT	**£15.90**
TWIN OUTPUT UNIT Assembled and Tested	**£36.45**
TWIN OUTPUT KIT	**£24.55**

All systems are available direct from the manufacturer. Prices include VAT, postage and packing £1.00 extra. Access and Visa cards are welcome, just write or telephone quoting your number.

ELECTRONIZE DESIGN
Dept E · Magnus Rd · Wilnecote
Tamworth · B77 5BY
tel 0827 281000

POINTS OF VIEW

Feel like sounding off?
Then write to the Editor stating your Point Of View!

Beginner's Blues

Dear Sir,
I am a student with many hobbies, including electronics, but I am bad at all of them.

As a beginner, I have been advised to read monthly electronics magazines. I recently came upon Hobby Electronics (May '82 issue) and it was too good for me to believe.

The language does not bother me but I cannot build anything. I can read circuit diagrams but, at this stage, I need something more practical. I have a very strong desire to build something but I have never succeeded. I know the "building by numbers" method is childish but I can see no other solution.

Please help me if you can and I will be most grateful.
M.A.Khoury,
Beyrouth,
Liban.

We all appreciate the difficulties experienced by someone, new to electronics, who picks up our magazine and, fired with enthusiasm, attempts to build a project. However, we cannot include a complete course in every issue! The fact is that we all have to start somewhere and build up knowledge and experience over a period of years — it can't all be grasped in one lump.

From time to time, we present articles which are written especially for beginners. Our long-running "Into Electronic Components" series was intended for newcomers to electronics. We also write single features presenting specific aspects of electronics theory or practice.

Also, we try to help by making our projects as clear as possible, with helpful illustrations and pictures.

So don't be ashamed of "building by numbers". Keep on reading the magazine and keep building projects. You'll be surprised at how much you learn, even from failures.

Thermocoupled

Dear sir,
With reference to your article on transducers and, in particular, thermocouples, there are likely to be heated arguments caused by the statement; 'At some high temperature (the inversion temperature), the output of any thermocouple reaches a maximum and the voltage then reduces as the temperature is taken over this value'. Fortunately for industry, where the thermocouple is the most widely used temperature transducer, this is not so.

When two dissimilar metals or alloys are joined at their ends, a thermoelectric current will flow in the circuit if the two junctions are maintained at different temperatures. This effect is known after its discoverer, Seebeck (1826) and the total EMF produced is the sum of two other effects, the Peltier Effect and the Thompson Effect.

The statement is of course true. One picks a combination of metals whose thermoelectric curves intersect. The point of intersection, known as the 'neutral point', is then the point of maximum EMF, since the Peltier Effect becomes zero. This occurs at about 270° for an iron/copper combination. If the individual thermoelectric curves of the chosen combination do not intersect, then we have no neutral point — and no problem.
I would like to point out that, in making thermocouples, it is better to leave out soldered joints, because they introduce further dissimilar metal interfaces and, if operated above their melting point, will attack many metals (eg copper soldering iron tips), causing inaccurate readings and possible disintegration of the thermocouple.
D. W. A. Ward,
Mickleover,
Derby.

Thank you for bringing this to our notice. In fact, in the course of preparing the Flash Point Alarm (HE October issue) for publication, we had a closer look at thermocouples and so we can confirm that your points are quite correct. You will no doubt be pleased to see that the thermocouple connections in this project are made via a two-way connector block, rather than being soldered. A further explanation of thermocouples is contained in the 'How It Works' section of the Flash Point Alarm.

CB vs The Rest

Dear sirs,
Before CB became legal, there was something in your magazine every month about it, but since legalisation — nothing. I know there are CB mags on the bookstands but I had hoped that you would have a circuit or two for CB nuts, eg matching units etc. Apart from that, a great mag. Keep it up.
J. W. Rogers,
Sheffield.

Yes, many readers are still truly interested in CB! However, we try to present a balanced mix of materials to satisfy the many interests (ranging from CB to audio, music to computers) of our many readers. With the Radio Rules series, and the projects and features presented in 'Into Radio', we have tried to broaden the range a little, to include radio generally, rather than CB specifically.

Switched On Pots

Dear sir,
I am constructing three light dimmers, as published in the October 1980 issue of Hobby Electronics. I have successfully obtained the Q4006TLs but I cannot find a company which supply the 22K linear DPDT switched potentiometers.

I would be most grateful if you could supply me with this information.
J. Living
Wordsley,
West Midlands.

The company to contact is ElectroValue, of 28 St Judes Road, Englefield, Egham, Surrey. They supply a large range of pots including some of the more unusual types such as a dual pot with concentric spindles and a DPCO switch. Exotic, as you might say!

Into Electronics Lost

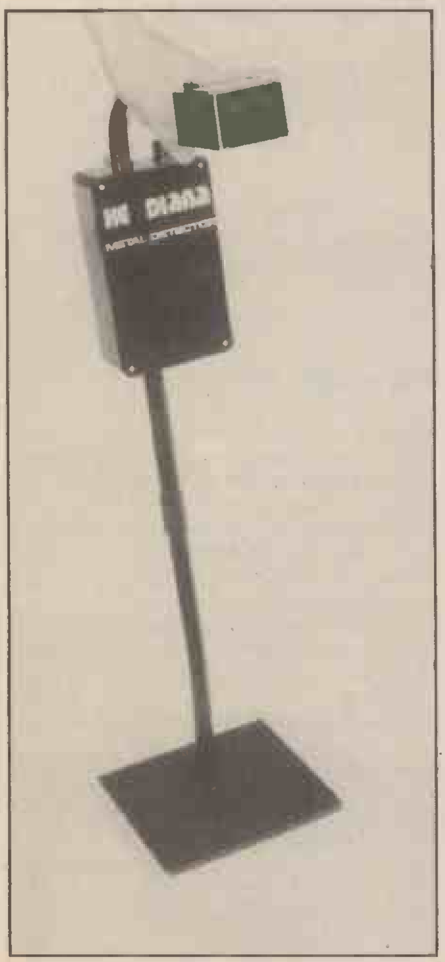
Dear sir,
Recently a friend loaned me one of your books, 'Into Electronics Plus', published in 1979. I found it of great interest and wondered if you could advise whether it is still possible to obtain a copy, and the price.

Three years since publication is a long time, I realise, but if a copy could be located I would very much appreciate it.
D. C. Holmes,
Bury St. Edmunds,
Sufolk.

Unfortunately, we sold out of copies of 'Into Electronics Plus' some months ago. However, those readers who want a similar introduction to electronics, need not worry. A quick glance through the contents pages of the last few months' HEs reveals we've kept up on the plight of beginners with several features and series written at an introductory level. So the *real* answer is just keep reading Hobby! **HE**

Diana VCO

An audio output for our popular metal detector, from the September '81 issue.



THIS DEVICE makes use of the voltage output from the HE Diana metal detector board, which normally drives the meter. It is used, here, to vary the frequency of a Voltage Controlled Oscillator (VCO) which then drives a small crystal earpiece, to give an audible output.

In the circuit, R1,R2 and C1 form a biasing and filter network for Q1, which amplifies and changes the DC level of the input. A proportion of Q1's output is selected by RV1 and passed via R4 and R5 to IC1, an integrated VCO. The voltage appearing at IC1 pin 5 controls (within limits) the frequency of oscillation. The range over which the frequency of oscillation can be varied is determined by R6, C2 and the input voltage. The maximum range is about 10 to 1 for a control voltage change of about 3 V at the IC, or 1V5 (nominally) at the input.

The output from the IC goes via C3 to RV2, which acts as a volume control, and thence to the crystal earpiece. A high impedance device should be used here to avoid overloading the output.

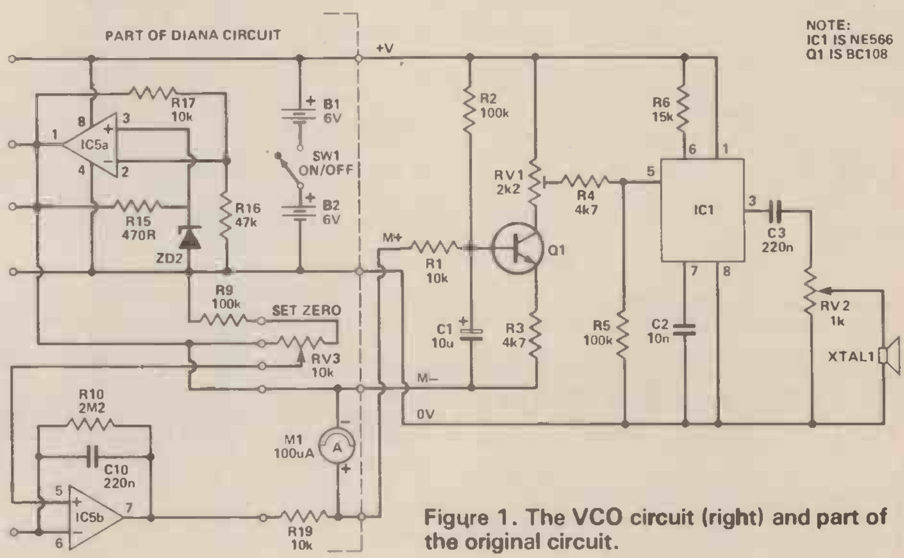
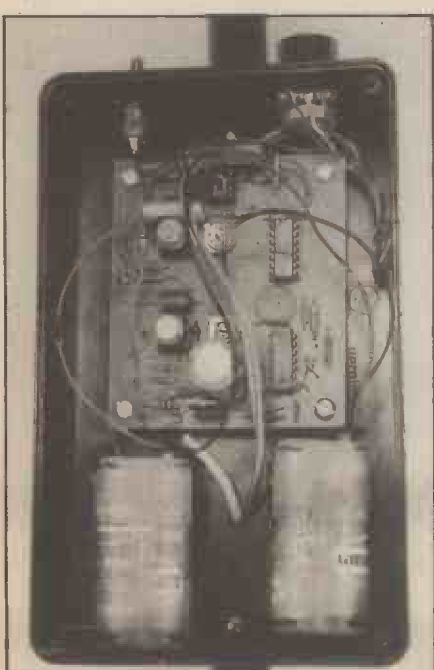
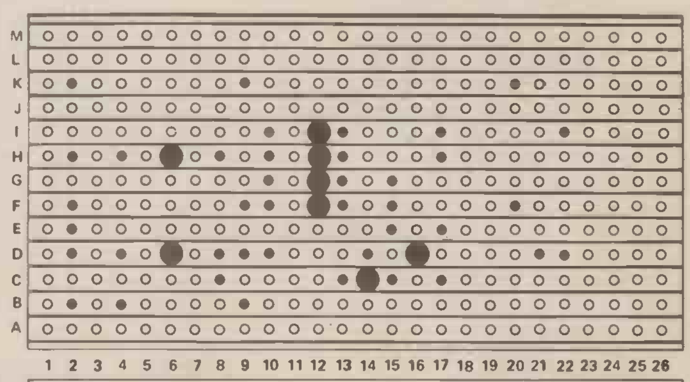


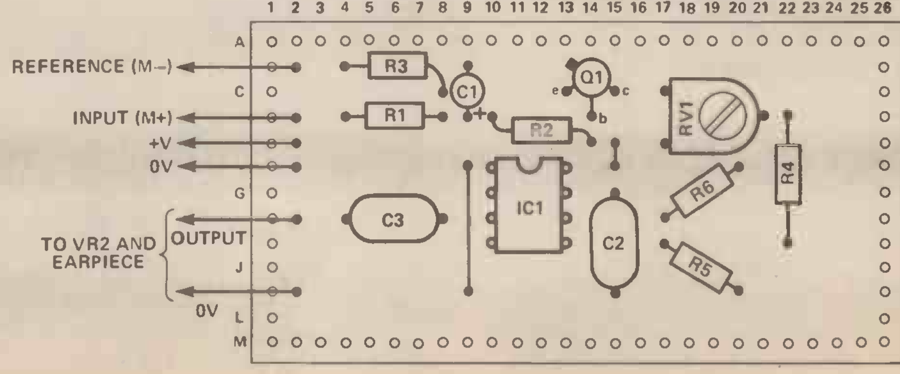
Figure 1. The VCO circuit (right) and part of the original circuit.



There's plenty of room inside the case!

Figure 2. The Veroboard component overlay of the VCO, showing the connections to the orginal PCB (Figure 3).





Parts List

RESISTOR (All ¼ W 5% carbon)

R1	10k
R2,5	100k
R3,4	4k7
R6	15k

POTENTIOMETERS

RV1	22k min. horiz. preset
RV2	1k log carbon

CAPACITORS

C1	10u 25V tantalum bead
C2	10n C280 polyester
C3	220n metallised polycarbonate

SEMICONDUCTORS

IC2	NE566 VCO
Q1	BC108 silicon NPN

MISCELLANEOUS

X1 . . . . crystal earpiece or high impedance 'phones. 3.5mm jack socket (if desired); Veroboard (13 x 26 holes); knob, wire, solder, etc.

BUYLINES . . . . page 33

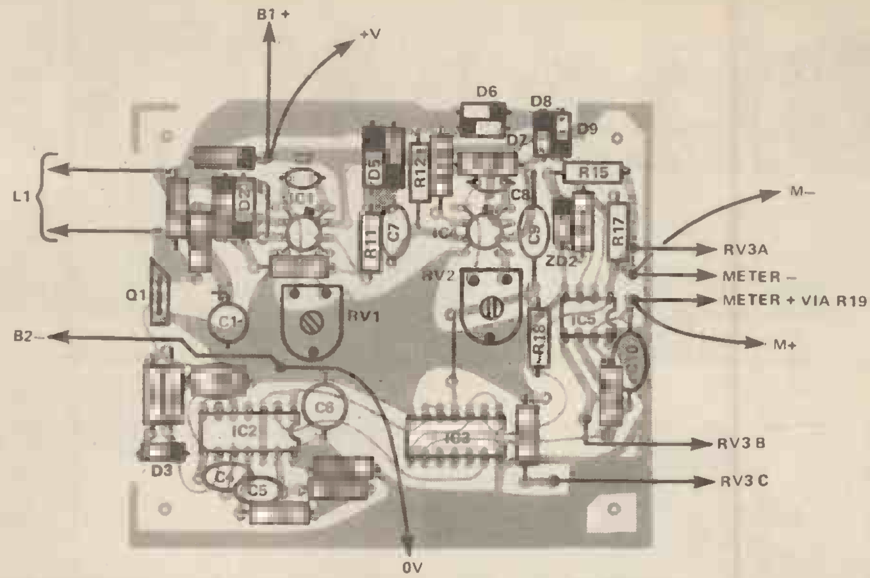


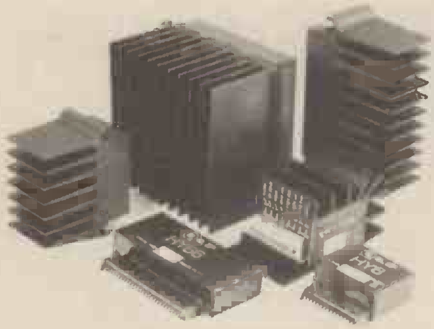
Figure 3. The Diana PCB, indicating the connections to the VCO board.

There are four connections to be made to the Diana main board; two are the power supply wires while the others are from the output which drives the meter. One wire goes to "METER –" on the main board and the other goes to "METER +". The connection to the meter via R19 can be left in place, as it will operate quite normally.

The output from the device is a warble tone whose pitch changes when any metal object is detected. The sensitivity is adjustable using RV1. Set the main circuit control so that the meter needle is near zero with the search head well away from any metallic object, then adjust RV1 on the sound board to about half travel. Now adjust RV2 for a comfortable volume level and try the unit with a metal object, varying RV1 for optimum results.

HE

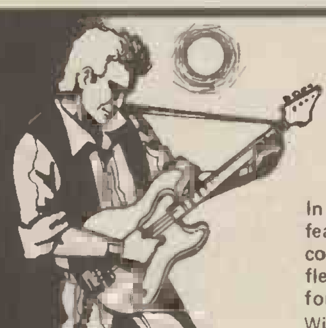
GET BIG POWER



ILP Modular Amplifiers

the third generation

Due to continous improvements in components and design ILP now launch the largest and most advanced generation of modules ever.



WE'RE INSTRUMENTAL IN MAKING A LOT OF POWER

In keeping with ILP's tradition of entirely self-contained modules featuring, integral heatsinks, no external components and only 5 connections required, the range has been optimized for efficiency, flexibility, reliability, easy usage, outstanding performance, value for money.

With over 10 years experience in audio amplifier technology ILP are recognised as world leaders.

BIPOLAR MODULES

Module Number	Output Power Watts rms	Load Impedance Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
HY30	15	4-8	0.015%	<0.006%	± 18	76 x 68 x 40	240	£8.40
HY60	30	4-8	0.015%	<0.006%	± 25	76 x 68 x 40	240	£9.55
HY6060	30 + 30	4-8	0.015%	<0.006%	± 25	120 x 78 x 40	420	£18.69
HY124	60	4	0.01%	<0.006%	± 26	120 x 78 x 40	410	£20.75
HY128	60	8	0.01%	<0.006%	± 35	120 x 78 x 40	410	£20.75
HY244	120	4	0.01%	<0.006%	± 35	120 x 78 x 50	520	£25.47
HY248	120	8	0.01%	<0.006%	± 50	120 x 78 x 50	520	£25.47
HY364	180	4	0.01%	<0.006%	± 45	120 x 78 x 100	1030	£38.41
HY368	180	8	0.01%	<0.006%	± 60	120 x 78 x 100	1030	£38.41

Protection: Full load line. Slew Rate: 15v/μs. Risetime: 5μs. S/N ratio: 100db.
Frequency response (−3dB) 15Hz – 50KHz. Input sensitivity: 500mV rms.
Input Impedance: 100K Ω. Damping factor: 100Hz >400.

PRE-AMP SYSTEMS

Module Number	Module	Functions	Current Required	Price inc. VAT
HY6	Mono pre amp	Mic/Mag. Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble	10mA	£7.60
HY66	Stereo pre amp	Mic/Mag. Cartridge/Tuner/Tape/Aux + Vol/Bass/Treble/Balance	20mA	£14.32
HY73	Guitar pre amp	Two Guitar (Bass Lead) and Mic + separate Volume Bass Treble + Mix	20mA	£15.36
HY78	Stereo pre amp	As HY66 less tone controls	20mA	£14.20

Most pre-amp modules can be driven by the PSU driving the main power amp. A separate PSU 30 is available purely for pre amp modules if required for £5.47 (inc. VAT). Pre-amp and mixing modules in 18 different variations. Please send for details.

Mounting Boards

For ease of construction we recommend the B6 for modules HY6–HY13 £1.05 (inc. VAT) and the B66 for modules HY66–HY78 £1.29 (inc. VAT).

MOSFET MODULES

Module Number	Output Power Watts rms	Load Impedence Ω	DISTORTION T.H.D. Typ at 1KHz	I.M.D. 60Hz/7KHz 4:1	Supply Voltage Typ	Size mm	WT gms	Price inc. VAT
MOS 128	60	4-8	<0.005%	<0.006%	± 45	120 x 78 x 40	420	£30.41
MOS 248	120	4-8	<0.005%	<0.006%	± 55	120 x 78 x 80	850	£39.86
MOS 364	180	4	<0.005%	<0.006%	± 55	120 x 78 x 100	1025	£45.54

Protection: Able to cope with complex loads without the need for very special protection circuitry (fuses will suffice).
Slew rate: 20v/μs. Rise time: 3μs. S/N ratio: 100db
Frequency response (−3dB): 15Hz – 100KHz. Input sensitivity: 500mV rms
Input impedance: 100K Ω. Damping factor: 100Hz >400.

'NEW to ILP' In Car Entertainments

C15

Mono Power Booster Amplifier to increase the output of your existing car radio or cassette player to a nominal 15 watts rms.

Very easy to use.

Robust construction. **£9.14 (inc. VAT)**

Mounts anywhere in car.

Automatic switch on.

Output power maximum 22w peak into 4Ω
Frequency response (−3dB) 15Hz to 30KHz, T.H.D. 0.1% at 10w 1KHz
S/N ratio (DIN AUDIO) 80dB, Load Impedance 3Ω
Input Sensitivity and impedance (selectable) 700mV rms into 15KΩ 3V rms into 8Ω
Size 95 x 48 x 50mm, Weight 256 gms.

C1515

Stereo version of C15. **£17.19 (inc. VAT)**

Size 95 x 40 x 80. Weight 410 gms.

POWER SUPPLY UNITS (Incorporating our own toroidal transformers)

Model Number	For Use With	Price inc. VAT
PSU 21X	1 or 2 HY30	£11.93
PSU 41X	1 or 2 HY60, 1 x HY6060, 1 x HY124	£13.83
PSU 42X	1 x HY128	£15.90
PSU 43X	1 x MOS128	£16.70
PSU 51X	2 x HY128, 1 x HY244	£17.07

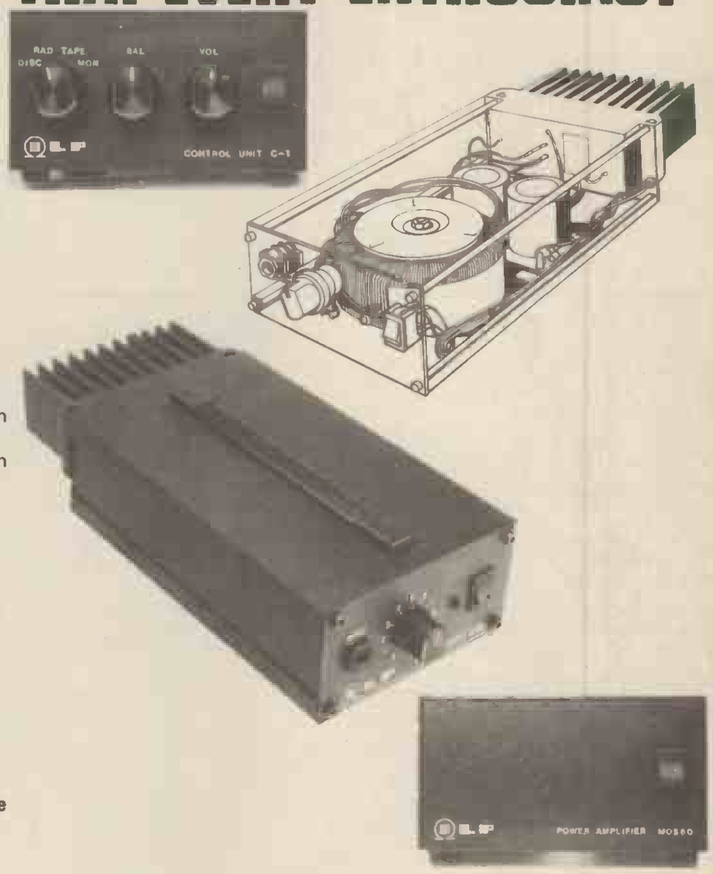
Model Number	For Use With	Price inc. VAT
PSU 52X	2 x HY124	£17.07
PSU 53X	2 x MOS128	£17.86
PSU 54X	1 x HY248	£17.86
PSU 55X	1 x MOS248	£19.52
PSU 71X	2 x HY244	£21.75

Model Number	For Use With	Price inc. VAT
PSU 72X	2 x HY248	£22.54
PSU 73X	1 x HY364	£22.54
PSU 74X	1 x HY368	£24.20
PSU 75X	2 x MOS248, 1 x MOS368	£24.20

Please note: X in part no. indicates primary voltage. Please insert "0" in place of X for 110V, "1" in place of X for 220V, and "2" in place of X for 240V.

WITH A LOT OF HELP FROM ILP ELECTRONICS LTD

PROFESSIONAL HI-FI THAT EVERY ENTHUSIAST CAN HANDLE...



Unicase

Over the years ILP has been aware of the need for a complete packaging system for it's products, it has now developed a unique system which meets all the requirements for ease of assembly, adaptability, ruggedness, modern styling and above all price.

Each Unicase kit contains all the hardware required down to the last nut and bolt to build a complete unit without the need for any special tools.

Because of ILP's modular approach, "open plan" construction is used and final assembly of the unit parts forms a compact aesthetic unit. By this method construction can be achieved in under two hours with little experience of electronic wiring and mechanical assembly.

Hi Fi Separates

UC1 PRE AMP UNIT: Incorporates the HY78 to provide a "no frills", low distortion, (<0.01%), stereo control unit, providing inputs for magnetic cartridge, tuner, and tape/monitor facilities. This unit provides the heart of the hi fi system and can be used in conjunction with any of the UP Unicase series of power amps. For ultimate hum rejection the UC1 draws its power from the power amp unit.

POWER AMPS: The UP series feature a clean line front panel incorporating on/off switch and concealed indicator. They are designed to compliment the style of the UC1 pre-amp. Performance for each unit which includes the appropriate power supply, is as specified on the facing page.

Power Slaves

Our power slaves, which have numerous uses i.e. instrument, discotheque, sound reinforcement, feature in addition to the hi fi series, front panel input jack, level control, and a carrying handle. Providing the smallest, lowest cost, slave on the market in this format.

UNICASES

HIFI Separates					Price inc. VAT
UC1	Preamp				£29.95
UP1X	30 + 30W/4–8Ω	Bipolar	Stereo	HiFi	£54.95
UP2X	60W/4Ω	Bipolar	Mono	HiFi	£54.95
UP3X	60W/8Ω	Bipolar	Mono	HiFi	£54.95
UP4X	120W/4Ω	Bipolar	Mono	HiFi	£74.95
UP5X	120W/8Ω	Bipolar	Mono	HiFi	£74.95
UP6X	60W/4–8Ω	MOS	Mono	HiFi	£64.95
UP7X	120W/4–8Ω	MOS	Mono	HiFi	£84.95
Power Slaves					
US1X	60W/4Ω	Bipolar	Power	Slave	£59.95
US2X	120W/4Ω	Bipolar	Power	Slave	£79.95
US3X	60W/4–8Ω	MOS	Power	Slave	£69.96
US4X	120W/4–8Ω	MOS	Power	Slave	£89.95

Please note X in part number denotes mains voltage. Please insert '0' in place of X for 110V, '1' in place of X for 220V (Europe), and '2' in place of X for 240V (U.K.) All units except UC1 incorporate our own toroidal transformers.

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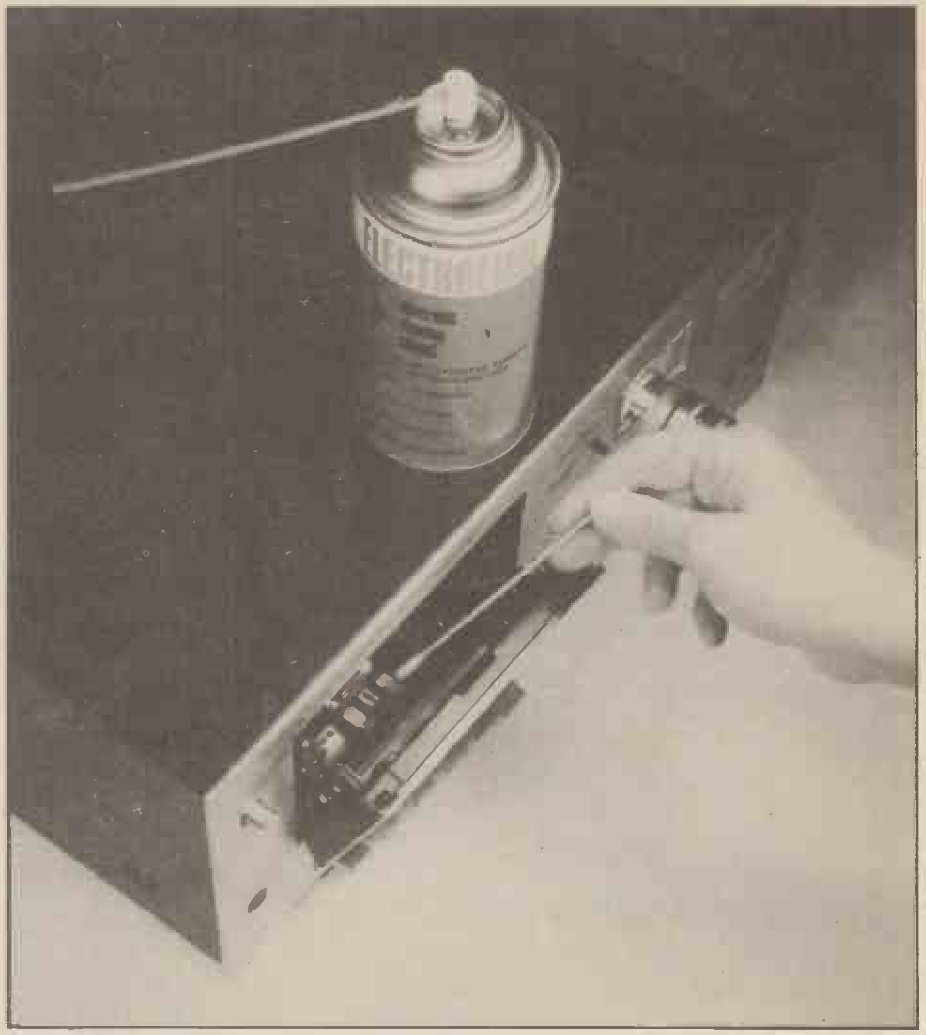
Clico Kingsbury (Electrolube Ltd).



HAVE YOU EVER wasted precious hours locating minor faults in your otherwise beautiful, 'all-singing', all-dancing, electronic equipment? It is a sad but true fact, that all electronic equipment relies on the proper functioning of even the smallest component. Often equipment will start by working well and then, suddenly, its performance declines for any one of a number of reasons. These include dust and dirt, cigarette smoke or extremes of temperature. The overturned coffee mug is a popular contender! These potential tragedies can be minimised by preventive maintenance, under three headings; cleaning, lubrication and protection.

For example, a common fault that can be cured with the right treatment, is the noisy switch, probably caused by dirty contacts or wear. Intermittent faults (the most irritating of all!), are often the result of dry soldered joints; loss of frequency response and faulty read-outs may be caused by dirty record/playback heads, plugs, sockets and edge connectors. The first step on the road to tip-top performance, then, is to ensure that all components are properly cleaned.

Keep It Clean

You can obtain cleaning compounds either on their own, or in combination with specialised lubricants. A simple example: there are now several air dusting aerosols on the market. These are handy, for the hobbyist, as a convenient source of compressed air — extremely effective in removing dust and other airborne contaminants from sensitive equipment and electronic circuitry. Most come supplied with an extension tube, so the direction of compressed air can be carefully controlled and dust in inaccessible places can easily be removed.

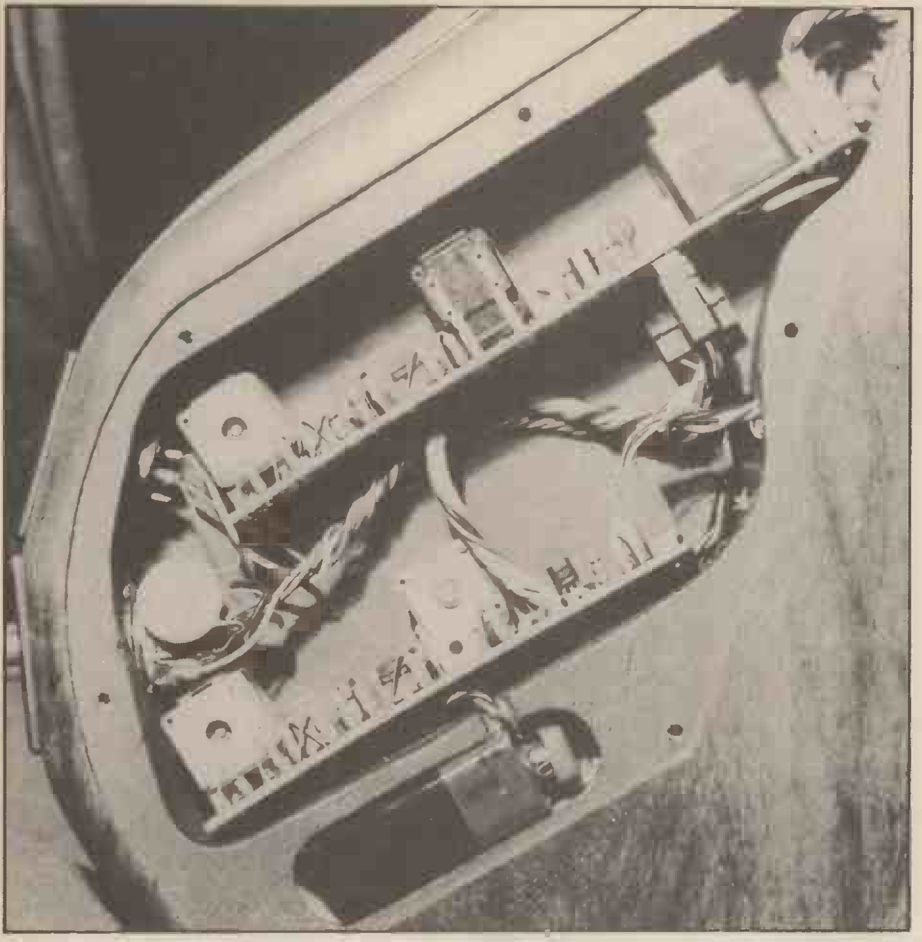
There are also specialist solvents on the market. These provide quick and efficient cleaning of delicate surfaces and do not leave a greasy deposit or harm sensitive materials. Such solvents should be used to clean all electrical contacts, tape heads, components in electronic and video equipment, microcomputers and other precision instruments.

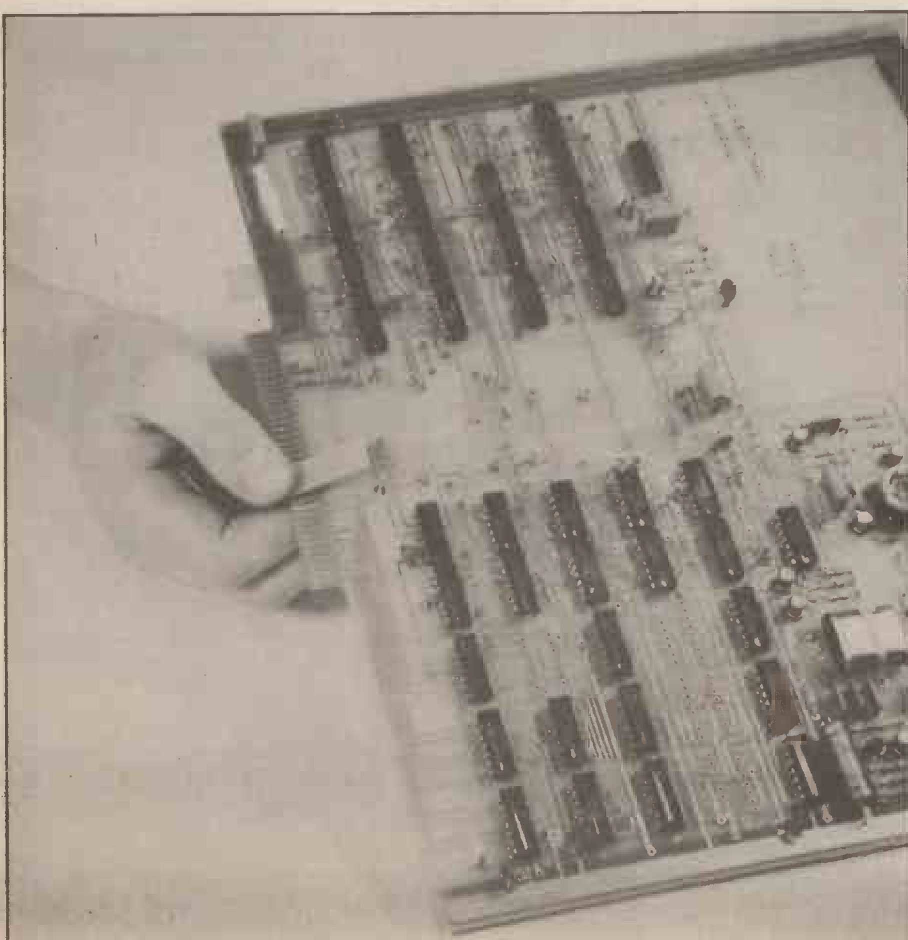
Finally, to keep crackle-finish and plastic cases sparkling, there is now a special anti-static foam cleanser with a "gentle foaming action" that lifts grease and dust from surfaces and leaves behind a protective anti-static film.

Lubrication

Now you've done the cleaning, it is important to lubricate all components immediately. Oxidation or tarnishing of unprotected surfaces starts within a few seconds after the cleaning process. This, if allowed to happen, will seriously increase contact resistance. For this reason, it is a good idea to use specialised lubricants rather than those based on hydro-carbons, which evaporate and carbonise to form insulating resins. Those containing silicones are also harmful, because they 'creep' and form insulating resins and rock-like crystals of silicon carbide. Treating contacts with a specially designed lubricant ensures a low, stable voltage drop when the contacts are closed and minimises the effects of arcing when opened. There are a number of contact lubricants available which, as well as being electrically suitable, are capable of operating over temperatures similar to those encountered by the treated components. They are also non-flammable, non-toxic, anti-static and, most important, safe on plastics. For ease of application, most contact lubricants are available either in an aerosol or pen with retractable snorkel applicator, which is ideal for pinpoint lubrication.

Maintenance of relays involves mak-





ing sure there are no contaminants, especially silicones, left on contact surfaces. A simple, yet effective method of removing these without causing damage, is to use a small strip of card impregnated with a contact lubricant. To clean a pair of contacts, hold the strip between thumb and forefinger and work it back and forth a few times over the surfaces. This action combines the tarnish-loosening properties of the lubricant, with the absorbent nature of the card, to rapidly remove all contamination from both surfaces — the contaminants leave a dark stain on the strip. The strip is then withdrawn and deposits a very thin film of protective contact lubricant on both surfaces. This film has negligible electrical resistance and ensures good contact between touching surfaces. Contact cleaning strips are ideal for use on relays, edge connectors and other small contacts. British Telecom has been using them for years — which might be one reason why Buzby is so chatty!

A recent development, which should prove useful for the electronic hobbyist, is the introduction of a non-silicone heatsink paste. This is used to get a good thermal contact between heatsinks and their associated components. Without such paste, components can overheat and be permanently damaged. For example, it should be used, on semiconductors (diodes, power transistors and the like), instead of silicone pastes, which can lead to problems that are subsequently difficult to trace. At higher temperatures the silicones volatilise and then cause intermittent faults.

Protection

Special lacquers are now on the market which protect printed circuit boards — they are known as conformal coatings. Damage to PCBs can be caused by any number of causes, one of the most common being perspiration during handling. Traditionally, any conformal coating was hazardous as it was made from epoxies or polyurethanes and therefore unsuitable for use in the home. Now, however, there is a new range available, based on a single-part modified resin. This makes it completely safe to use, as supplied, in aerosol form. These new coatings can be removed either by soldering through them or cleaning with a specialist solvent to permit faulty components to be replaced.

Protection from radio interference involves the use of another form of coating. Recent developments in this field have lead to the introduction of a new range of brush-on materials which effectively screen outside electrical interference up to frequencies around 1 GHz. They can be applied to rigid or flexible surfaces, such as plastics. This makes them ideal for use on electric guitar scratchplates and organs, for example. The advantages of these coatings are that they are inexpensive, easy to apply (by brush or spray), even on to complex shapes. They are also used on scientific instruments, measuring apparatus, hi-fi, radio, TV and microcomputers.

Finally we have the special non-staining, non-drying lubricants, which were developed for use on all moving parts such as teleprinter arms and slide wires. These contain a clear, colloidal suspension of molybdenum disulphide, in a thin, synthetic oil base. They were originally developed for use in hospitals, since they are resistant to sterilizing processes and do not 'gum-up' or get thicker in use.

Fault Finding

The hunt for faults on PCBs, and elsewhere, can be speeded up by using a freezing spray. This will lower the temperature of a component down to -50°C in a matter of seconds. Now, almost every electronic component is sensitive to variations of temperature to some degree. Equipment malfunction can be caused by a component overheating due to its physical location in the circuit. Finding this component by normal methods is a very hit-and-miss affair. Indeed, it is likely to prove impossible, as the removal of an inspection panel will often change conditions enough to make the fault to disappar temporarily, before more than one or two connections have been checked.

A freezing aerosol allows a large number of components to be cooled in a very short time. By spraying each component in turn for about a second, the component causing the fault will stop operating and the fault will temporarily disappear until the component warms up again. Some freezing sprays contain a microscopic quantity of coating which, in addition to improving the efficiency of the freezer, provides a protective film between the component and the ice-layer. This film ensures that ferrous (iron based) components are less likely to corrode. The high electrical resistance of the spray prevents an ice layer from forming, causing a short circuit in electronic equipment.

These are just some of the many ways that you can look after your electronic creations. By taking the three basic steps, of cleaning, lubricating and protecting, you will obtain long-term, trouble-free operation and peace of mind!

HE

Rapid Electronics

Tel: 0206 36412
Hill Farm Industrial Estate
Boxted, Colchester
Essex CO4 5RD

BARCLAYCARD VISA

Access

CMOS

		★4017	32	4036	275	4055	95	4082	16	4502	60	4529	150
		4018	45	4039	290	4059	480	4085	65	4503	40	4532	80
4000	10	4019	25	★4040	40	4060	65	4086	60	4507	38	4534	485
★4001	10	4020	50	4041	60	4063	85	★4089	125	4508	150	4538	110
4002	12	4021	50	4042	45	★4066	30	★4093	18	4510	50	4543	100
4006	50	4022	50	4043	50	4067	295	4094	120	★4511	50	4549	360
4007	15	4023	16	4044	50	4068	16	4095	75	4512	50	4553	275
4008	48	4024	33	★4046	45	4069	16	4097	290	4514	120	4555	36
4009	24	4025	16	★4047	40	4070	15	4098	75	4515	120	4556	35
4010	24	★4026	80	4048	40	4071	15	4099	90	4516	65	4559	390
★4011	11	4027	24	★4049	25	4072	15	40106	50	★4518	40	4560	175
4012	15	4028	50	★4050	25	4073	15	40109	110	4520	70	4584	45
★4013	25	4029	60	4051	45	4075	15	40163	100	4521	130	4585	60
4014	50	4030	30	4052	60	4076	50	40173	100	4526	70	4724	140
4015	50	4031	125	4053	50	4077	18	40175	100	4527	80		
4016	20	4034	140	4054	95	4081	14	40193	96	4528	70		

LS TTL

		LS21	12	LS76	18	LS125	26	LS161	37	LS221	54	LS365	30
		LS22	12	LS78	18	LS126	25	LS162	37	LS240	69	LS366	30
★LS00	11	LS26	14	LS83	40	LS132	42	LS163	37	LS241	69	LS367	30
LS01	11	LS27	12	LS85	52	LS136	26	LS164	43	LS242	75	LS368	35
LS02	11	LS30	12	LS86	19	LS138	32	LS165	75	LS243	75	LS373	65
LS03	12	LS32	13	★LS90	28	LS139	32	LS166	75	★LS244	60	LS374	65
LS04	12	LS37	15	LS92	32	LS145	70	LS170	85	★LS245	70	LS375	45
LS05	13	LS38	15	★LS93	28	LS147	150	LS173	65	LS247	50	LS377	70
LS08	12	LS40	13	LS95	40	LS148	85	LS174	45	LS251	35	LS378	60
LS09	12	LS42	32	LS96	95	LS151	38	LS175	45	★LS257	35	LS390	55
LS10	12	★LS47	38	LS107	40	LS153	40	LS190	45	LS258	35	LS393	55
LS11	12	LS48	45	LS109	21	LS154	90	LS191	45	LS259	75	LS399	175
LS12	12	LS51	14	LS112	21	LS155	35	LS192	45	LS266	22	LS541	120
LS13	22	LS55	14	LS113	23	LS156	36	LS193	45	★LS273	68	LS670	150
LS14	38	LS73	18	LS114	22	★LS157	30	LS195	36	LS279	35		
LS15	12	138LS74	18	LS122	38	LS158	30	LS196	50	LS283	40		
LS20	12	LS75	22	LS123	38	LS160	37	LS197	60	LS353	88		

TTL

		7413	18	7442	32	7482	65	74109	25	74156	40	74179	80
		7414	28	7444	90	7483	40	74121	25	74157	30	74180	40
★7400	11	7416	24	7446	65	7485	60	74122	40	74160	60	74181	115
7401	11	7417	24	★7447	40	7486	20	74123	40	74161	50	74182	60
7402	11	7420	15	7448	45	7489	180	74125	35	74162	50	74190	50
7403	12	7421	20	7450	16	★7490	21	74126	36	74163	50	74191	50
7404	13	7422	20	7451	16	7491	45	74132	30	74164	50	74192	50
7405	15	7427	22	7453	16	7492	25	74141	60	74165	50	74193	45
7406	24	7428	26	7454	16	★7493	25	74145	60	74167	150	74194	50
7407	25	7430	14	7460	16	7494	38	74147	90	74170	125	74195	50
7408	14	7432	20	7472	26	7495	35	74148	70	74173	60	74196	50
7409	14	7433	25	7473	28	7496	40	74150	55	74174	66	74197	50
7410	14	7438	25	★7474	20	7497	95	74153	40	74175	55	74198	90
7411	16	7437	25	★7475	25	74100	80	74154	55	74176	40	74199	90
7412	18	7440	15	7480	48	74107	25	74155	40	74177	45		

LINEAR

		ICL7621	180	LM382	120	ML922	400	SL76018	150	ULN2003	85
		ICL7622	180	LM384	130	ML924	195	★SN76477	250	ULN2004	90
555CMOS	80	ICL8038	320	LM386	65	ML925	210	SP8629	250	XR2206	300
556CMOS	150	ICL8211A	200	LM387	120	ML926	140	TBA120S	70	ZN414	100
709	25	ICM7224	785	LM393	100	ML927	140	TBA800	80	ZN423	135
★741	14	ICM7555	80	LM709	25	ML928	140	TBA810	96	ZN424	135
748	35	★LF351	45	LM711	60	ML929	140	TBA820	80	ZN425E	350
9400CJ	350	LF353	85	LM725	350	MM5387A	465	TBA950	290	ZN426E	330
AY-3-1270	840	LF356	90	LM733	75	NE529	225	TDA1008	320	ZN427E	650
AY-3-8910	600	LM10	360	LM741	14	NE531	150	★TDA1022	625	ZN428E	480
AY-3-8912	625	LM301A	25	LM747	75	NE544	205	TDA1024	125	ZN459	285
CA3046	60	LM311	70	LM1458	40	★NE555	16	TL061	40	ZN1034E	200
★CA3080	65	LM318	120	LM2917	200	★NE556	45	TL062	60		
CA3089	215	LM324	40	LM3900	50	NE565	120	TL064	96		
CA3090AQ	375	LM334Z	100	★LM3909	70	NE566	150	TL071	30		
CA3130E	90	LM335Z	125	LM3911	125	★NE567	100	TL072	50		
★CA3140E	45	LM339	50	LM3914	200	★NE570	400	TL074	95		
CA3161E	100	LM348	65	LM3915	220	NE571	400	★TL081	25		
CA3189	290	LM358	50	LM13600	120	★RC4136	68	TL082	45		
★CA3240E	110	LM377	170	MC1496	68	★RC4558	60	TL084	95		
ICL7106	790	★LM380	65	MC3340	135	SL480	170	TL170	50		
ICL7611	95	★LM381	120	★MF10CN	250	SL490	250	UA2240	120		

TRANSISTORS

				BC548	10	BFR80	23	TIP29B	55	ZTX109	12	2N3442	120
				BC549	10	★BFR81	20	TIP29C	60	ZTX300	14	★2N3702	6
AC125	35	BC157	10	BC558	10	BFX29	25	TIP30A	36	ZTX301	16	2N3703	9
AC126	25	BC158	10	BCY70	18	BFX84	25	TIP30B	50	ZTX302	15	★2N3704	6
AC127	25	BC159	8	BCY71	18	BFX85	25	TIP30C	60	ZTX304	17	2N3705	9
★AC128	20	BC160	45	BCY72	18	BFX86	28	TIP31A	45	ZTX341	30	2N3706	9
AC176	25	BC168C	10	BD115	80	BFX87	25	TIP31C	55	ZTX500	15	2N3707	10
AC187	22	BC169C	10	BD131	36	BFX88	25	TIP32A	45	ZTX501	15	2N3708	10
AC188	22	BC170	8	BD132	36	BFY50	23	TIP32C	60	ZTX502	15	2N3709	10
AD142	120	BC171	10	BD133	50	BFY51	23	TIP33A	50	ZTX503	18	2N3772	190
AD149	80	BC172	8	BD135	50	BFY52	23	TIP33C	75	ZTX504	25	★2N3773	210
AD161	40	BC177	18	BD136	30	BFY53	32	TIP34A	60	2N697	20	★2N3819	18
AD162	40	BC178	18	BD137	30	BFY55	32	TIP34C	85	2N698	40	2N3820	40
AF124	60	BC179	18	BD138	30	BFY56	32	TIP35A	160	2N706A	20	2N3823	65
AF126	50	BC182	10	★BD139	35	BRY39	40	TIP35C	180	2N708	20	2N3866	90
AF139	40	★BC182L	8	★BD140	36	BSX20	20	TIP36A	170	2N918	36	2N3903	10
AF186	70	BC183	10	BD204	110	BSX29	35	TIP36C	195	2N1132	22	2N3904	10
AF239	75	BC183L	10	BD206	110	BSY95A	25	TIP41A	60	2N1613	30	2N3905	6
BC107	10	BC184	10	BD222	85	BU205	160	TIP42A	60	2N2218A	45	2N3906	10
BC107B	12	★BC184L	7	BF180	35	BU206	200	TIP120	90	2N2219A	25	2N4037	45
★BC108	9	BC212	10	BF182	35	BU208	170	TIP121	90	2N2221A	25	2N4058	10
BC108B	12	BC212L	10	BF184	25	MJ2955	99	TIP122	90	2N2222A	20	2N4060	10
BC108C	12	BC213	10	BF185	25	MJE340	50	TIP141	120	2N2368	25	2N4061	10
★BC109	9	BC213L	10	BF194	12	MJE520	65	TIP142	120	2N2369	16	2N4062	10
BC109C	12	BC214	10	BF195	12	MJE521	95	TIP147	120	2N2484	25	2N5457	36
BC114	22	★BC214L	8	BF196	12	MJE3055	70	TIP2955	60	2N2646	45	2N5458	36
BC115	22	BC237	8	BF197	12	MPF102	40	TIP3055	56	2N2904	20	2N5459	30
BC117	22	BC238	14	BF198	10	MPF104	40	TIS43	40	2N2904A	20	2N5485	36
BC119	36	BC308	15	BF199	18	MPSA05	22	TIS44	45	2N2905	22	2N5777	45
BC137	40	BC327	14	BF200	30	MPSA06	25	TIS45	45	2N2905A	22	2N6027	30
BC139	40	BC328	14	★BF244B	22	MPSA12	30	TIS90	30	2N2906	25	40360	40
BC140	30	BC337	14	BF245	30	MPSA55	30	TIS91	30	2N2906A	25	40361	50
BC141	30	BC338	14	BF256B	45	MPSA56	30	★VN10KM	45	2N2907	25	40362	50
BC142	25	BC477	30	BF257	32	MPSU05	65	VN46AF	75	2N2907A	25	40408	70
BC143	25	BC478	30	BF258	25	MPSU06	55	VN66AF	85	2N2926	9		
BC147	8	BC479	30	BF259	35	MPSU55	60	VN88AF	95	★2N3053	23		
BC148	8	BC517	40	BF337	40	MPSU56	60	ZTX107	8	2N3054	55		
BC149	9	BC547	7	BFR40	23	TIP29A	30	ZTX108	8	2N3055	50		

HARDWARE

PP3 battery clips	6p
Red or black crocodile clips	6p
Black pointer control knob	15p
Pr Ultrasonic transducers	350p
★6V Electronic buzzer	60p
★12V Electronic buzzer	65p
★PB2720 Piezo transducer	75p
★64mm 64 ohm speaker	70p
★64mm 8 ohm speaker	70p
20mm panel fuseholder	25p

SOCKETS

	Low profile	Wire-wrap
★8 pin	7p	25p
★14 pin	9p	35p
★16 pin	10p	42p
18 pin	15p	52p
20 pin	18p	60p
22 pin	20p	70p
24 pin	22p	70p
28 pin	26p	80p
40 pin	32p	98p
Soldercon pins		60p/100

DIODES

BY127	12	★1N4001	3
OA47	10	1N4002	5
OA90	8	1N4006	7
OA91	7	1N4007	7
OA200	8	1N5401	15
OA202	8	1N5404	16
1N914	4	1N5406	17
★1N4148	2	400mW zen	6

BZX61 Series zeners 1.3W 4V7-39V 15p each

CAPACITORS

Polyester. Radial leads. 250V. C280 type.
0.01, 0.015, 0.022, 0.033 6p; 0.047, 0,068, 0.1 7p; 0.15, 0.22 9p; 0.33, 0.47 13p; 0.68, 20p; 1u 23p
Electrolytic. Radial or axial leads.
0.47/63V, 1/63V, 2.2/63V, 4.7/63V, 10/25V 7p; 22/25V, 47/25V 8p; 100/25V 9p; 220/25V 14p; 470/25V 22p; 1000/25V 30p; 2200/25V 50p.
Tag end Power Supply Electrolytics.
2200/40V 110p; 4700/40V 160p; 2200/63V 140p; 4700/63V 230p
Polyester. Miniature Siemens PCB
1n, 2n2, 3n3, 4n7, 6n8, 10n, 15n 7p; 22n, 33n, 47n, 68n 8p; 100n 9p; 150n 11p; 220n 13p; 330n 20p; 470n 26p; 680n 29p; 1u 33p; 2u2 50p
Tantalum bead
0.1, 0.22, 0.33, 0.47, 1.0 @ 35V 12p; 2.2, 4.7, 10 @ 25V 20p; 15/16V 30p; 22/16V 27p; 33/16V 45p; 47/6V 27p; 47/16V 70p; 68/6V 40p; 100/10V 90p
Ceramic disc. 22p-0.01u 50V 3p each
Mullard miniature ceramic plate
1.8pF to 100pF 6p each
Polystyrene. 5% tolerance
10p-1000p 6p; 1500-4700p 8p; 6800-0.012u 10p
Trimmers. Mullard 808 Series
2-10pF 22p; 2-22pF 30p; 5.5-65pF 35p

OPTO

★3mm red	8	★5mm red	8
★3mm green	12	★5mm green	12
★3mm yellow	12	★5mm yellow	12

Clips to suit 2p each

Rectangular		TIL32	40
★red	12	TIL78	40
green	17	★TIL111	60
yellow	17	ORP12	85
★TIL38	40	TIL100	90
2N5777	45	Dual color	60

Seven segment displays

Com cathode		Com anode	
DL704 0.3"	95	DL707 0.3"	95
★FND500 0.5"	100	FND507 0.5"	100
TIL313 0.3"	115	TIL312 0.3"	115
TIL322 0.5"	115	TIL321 0.5"	115

LCD: 3½ digit 580p 4 digit 620p

TOOLS

Small trimming tool	22p
Small pocket screwdriver	16p
LArge pocket screwdriver	13p
6 piece precision screwdriver set in plastic case	170p
Low cost side cutters	160p
High quality side cutters	650p
Low cost pliers	160p
High quality pliers	650p
Wire strippers	120p
Expo Reliant Drill	695p
Expo Titan Drill	1025p
Drill stand	1200p
Reduced shank drill bits for above 0.8mm, 1mm, 1.4mm	60p each

COMPONENT KITS

An ideal opportunity for the beginner or the experienced constructor to obtain a wide range of components at greatly reduced prices.
¼W 5% Resistor kit. Contains 10 of each value from 4.7Ω to 1M (650 resistors) 480p
Ceramic Capacitor Kit. Contains 5 of each value from 22p to 0.01u (135 caps) 370p
Polyester Capacitor Kit. Contains 5 of each value from 0.01 to 1uF (65 caps) 575p each
Preset Kit. Contains 5 of each value from 100 ohms to 1M (total 65 presets) 425p each
Nut and Bolt Kit. Total 300 items 180p

25 6BA ¼" bolts	25 4BA ¼" bolts
25 6BA ½" bolts	25 6BA ½" bolts
50 6BA nuts	50 6BA nuts
50 6BA washers	50 6BA washers

CONNECTORS

DIN	Plug	Skt	Jack	Plug	Skt
2 pin	9p	9p	2.5mm	10p	10p
3 pin	12	10p	3.5mm	9p	9p
5 pin	13p	11p	Standard	16p	20p
Phono	10p	12p	Stereo	24p	25p
1mm	12p	13p	4mm	18p	17p

UHF (CB) Connectors
PL259 Plug 40p Reducer 14p
SO239 square chassis skt 38p
SO239S round chassis socket 40p
IEC 3 pin 250V/6A

Plug chassis mounting	38p
Socket free hanging	60p
Socket with 2m lead	120p

SCRs

★C106D	30
400V 8A	70
400V 12A	96

POTENTIOMETERS

Rotary. Carbon track Log or Lin 1K-2M2
Single 32p; Stereo 85p; Single switched 80p;
Slide 60mm travel single Log or Lin 5K-500K 63p each
Preset. Submin. hor. 100 ohms-1M 7p each
Cermet precision multiturn, 0.75W ¾in 100 ohms to 100K 88p each

TRIACS

400V 4A	50
400V 8A	65
400V 16A	95
BR100	25

ORDERING INFO

All prices exclude VAT. Please add to total order.
Please add 50p carriage to all orders under £15 in value. Send cheque/PO or Access/Visa number with your order. Please note new address. Callers most welcome — we are just 10 minutes from the centre of Colchester. Telephone orders welcome with Access and Visa. Official orders welcome from colleges and schools etc. Export orders no VAT but please add carriage. All components brand new and full spec.

SOLDERING IRONS

Antex CS 17W Soldering iron	450p
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Solder pump desoldering tool	480p
Spare nozzle for above	70p
10 metres 22swg solder	100p

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2A 400V	45
6A 100V	80
6A 400V	95
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HT-120 4,000 opv
A smart looking 11 range pocket sized multimeter with an impressive spec. Complete with battery etc.
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Highly sensitive 19 range multimeter including transistor tester. Overload protection. DC volts — 1000, AC volts — 1000; DC current 0.25A. 4 resistance ranges. Complete with batteries, leads etc.
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¼W 5% Carbon film E12 series 4.7Ω-10M 1p each
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Simply phone 0206 36412 with your order

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7812	40	7912	45
7815	40	7915	45
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LM317T	120	78H05	
LM323K	360	5A 5V	550

PCB MATERIALS

Alfac transfer sheets — please state type (e.g. DIL pads etc) 45p
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Submin toggle
SPST 55p SPDT 60p DPDT 65p
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Standard toggle SPST 35p DPDT 48p
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Our latest catalogue has just been released containing over 2000 stock lines all at extremely competitive prices backed by Rapids return of post service. Stocks include Denco coils, tools, Verocases, data sheets etc. etc. Send 45p for your copy now (sent free of charge with all orders over £10).

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★ Verobloc 350p ★

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81LS96	85
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20 metre pack single core connecting cable ten different colours	65p
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Please add carriage charges to our normal post charges

Miniature mains
606V, 909V, 12012V all @ 100mA 100p each
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3VA 0-6, 0-6 @ 0.25A; 0-9, 0-9 @ 0.15A; 0-12, 0-12 @ 0.12A 200p each
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High quality. Split bobbin construction
6VA 0-6, 0-6 @ 0.5A; 0-9, 0-9 @ 0.4A; 0-12, 0-12V @ 0.3A 220p each
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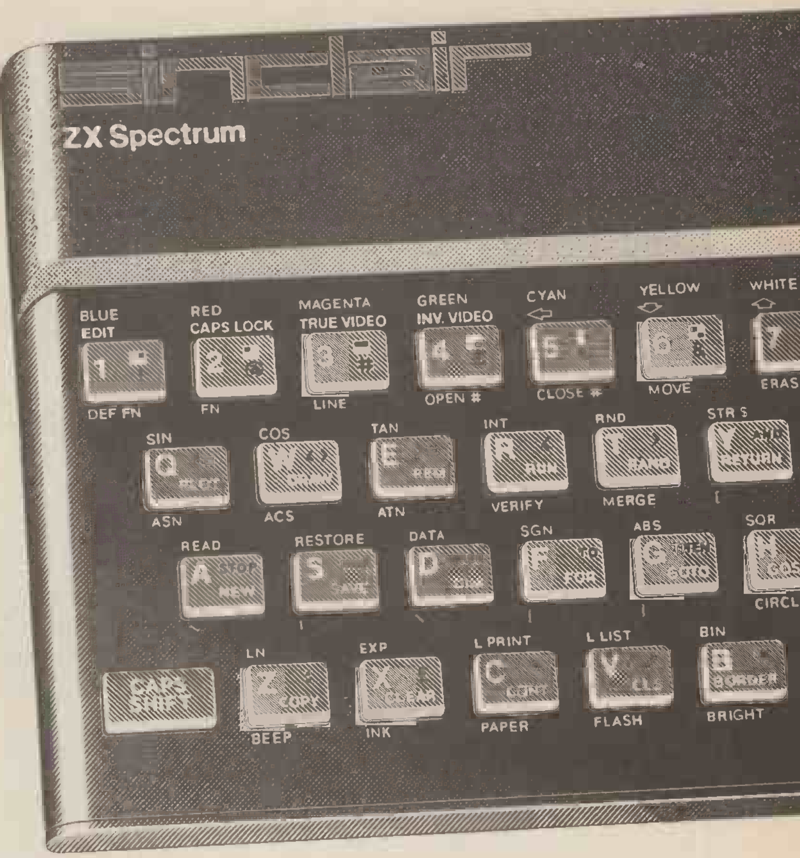
Sinclair ZX Spectr

16K or 48K RAM... full-size moving-key keyboard... colour and sound... high-resolution graphics...



From only £125!

First, there was the world-beating Sinclair ZX80. The first personal computer for under £100.

Then, the ZX81. With up to 16K RAM available, and the ZX Printer. Giving more power and more flexibility. Together, they've sold over 500,000 so far, to make Sinclair world leaders in personal computing. And the ZX81 remains the ideal low-cost introduction to computing.

Now there's the ZX Spectrum! With up to 48K of RAM. A full-size moving-key keyboard. Vivid colour and sound. High-resolution graphics. And a low price that's unrivalled.

Professional power–personal computer price!

The ZX Spectrum incorporates all the proven features of the ZX81. But its new 16K BASIC ROM dramatically increases your computing power.

You have access to a range of 8 colours for foreground, background and border, together with a sound generator and high-resolution graphics.

You have the facility to support separate data files.

You have a choice of storage capacities (governed by the amount of RAM). 16K of RAM (which you can uprate later to 48K of RAM) or a massive 48K of RAM.

Yet the price of the Spectrum 16K is an amazing £125! Even the popular 48K version costs only £175!

You may decide to begin with the 16K version. If so, you can still return it later for an upgrade. The cost? Around £60.

Ready to use today, easy to expand tomorrow

Your ZX Spectrum comes with a mains adaptor and all the necessary leads to connect to most cassette recorders and TVs (colour or black and white).

Employing Sinclair BASIC (now used in over 500,000 computers worldwide) the ZX Spectrum comes complete with two manuals which together represent a detailed course in BASIC programming. Whether you're a beginner or a competent programmer, you'll find them both of immense help. Depending on your computer experience, you'll quickly be moving into the colourful world of ZX Spectrum professional-level computing.

There's no need to stop there. The ZX Printer – available now – is fully compatible with the ZX Spectrum. And later this year there will be Microdrives for massive amounts of extra on-line storage, plus an RS232 / network interface board.

Key features of the Sinclair ZX Spectrum

- Full colour – 8 colours each for foreground, background and border, plus flashing and brightness-intensity control.
- Sound – BEEP command with variable pitch and duration.
- Massive RAM – 16K or 48K.
- Full-size moving-key keyboard – all keys at normal typewriter pitch, with repeat facility on each key.
- High-resolution – 256 dots horizontally x 192 vertically, each individually addressable for true high-resolution graphics.
- ASCII character set – with upper- and lower-case characters.
- Teletext-compatible – user software can generate 40 characters per line or other settings.
- High speed LOAD & SAVE – 16K in 100 seconds via cassette, with VERIFY & MERGE for programs and separate data files.
- Sinclair 16K extended BASIC – incorporating unique 'one-touch' keyword entry, syntax check, and report codes.

Hobby Electronics

Components Order Form

Use this convenient form to order components from suppliers advertising in Hobby Electronics!

PART	CODE	UNITS	PRICE	COST

Hobby Electronics Component Order Form

N.B. Hobby Electronics is not a supplier of electronic components

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**Delete as necessary*

Debit my *Access/*Barclaycard

My Cheque*/Postal Order*/International Money Order* for £ ______________ is enclosed.

BUYLINES

Pedometer/Odometer

The only unsual component in the Pedometer is the mercury switch. Since we used these in April's Bike Alarm, **Magenta** will have a small stock of them. They also appear in the RS catalogue (code no 339-881). The 40103 is sold by **Technomatic**, though most other suppliers will probably be able to obtain one for you. The remaining components are all fairly easy to buy — just shop around!

The two batteries (5V6) can be purchased from larger chemists or photographic shops and the case is a potting box from the **BICC**-Vero range. Total cost should be about £12.

Check List
RESISTORS
(All ¼ watt 5% carbon)
1M5; 22k; 47k; 1k
CAPACITORS
33n; 1n ceramic; 47u 16V tantalum
SEMICONDUCTORS
40103; 2 x 4026 ICs; 2 x DL704 7 seg LED displays
MISCELLANEOUS
Mercury tilt switch or reed switch; DPDT slide switch; 2 x sub-min push-buttons; 2 x PX23 batteries; case

Diana VCO

A simple one this, since the parts were obtained from the Hobby 'Junk Box'. The only components that might prove tricky to find are the VCO IC — one source is **Bi-Pak** — and the crystal earpiece — try the **Watford** catalogue (the old one — we still haven't received their new one!)

The complete project can be built for under a fiver — well worth it for adding sound to the original metal detector. And for those of you interested in building the HE Diana as well, the issue in which it appeared, September '81 is still available from our Backnumbers service.

Check List
RESISTORS
(All ¼ watt 5% carbon)
10k; 2 x 100k; 2 x 47k; 15k
CAPACITORS
10u 25V tantalum; 10n polyester C280; 220n metallised polyester
SEMICONDUCTORS
NE566 IC; BC108 transistor
MISCELLANEOUS
Crystal earpiece; 3.5mm jack socket; Veroboard (13 x 26 holes); knob

HEBOT II

Complete kits of parts for both HEBOT and ZX81 Interface Board are available from **Powertran Cybernetics**, Portway Industrial Estate, Andover, Hants SP10 3NW.

The kit for HEBOT itself contains all the eletronic components, motors, mechanical parts, perpex dome and all fixings etc, and is priced at £86.25

The ZX81 Interface Board is available seperately for £11.50; the 23-way edge connectors are priced at £2.88 and the three-way adaptor boad (which is necessary if the ZX81 is to be used with a RAM pack while controlling HEBOT) is £3.45. All prices include VAT and carriage is free.

The foil patterns for the double sided PCB for the Interface Board are reproduced on the PCB Printout page; only experienced PCB constructors should attempt to make this for themselves!

Interface Board Checklist

RESISTORS
(All ¼ watt 5% carbon unless noted)
2 x 4k7 SIL resistor package, 8 x 4k7; 8 x 1k.
CAPCITORS
Ceramic disc: 1 x 680p; 1 x 47n.
Tantalum bead: 1 x 1u 16V; 1 x 10u 16V.
SEMICONDUCTORS
ICs: 1 x DM8130; 1 x 74LS373; 1 x 74LS11; 1 x 74LS11; 1 x 74LS04.
MISCELLANEOUS
10-way DIL switch; cable clip; 2 x 14-pin IC sockets; 2 x 20 pin IC sockets; 2 x 23-way edge connectors (polarising pin in position 3); wire wrap pins; 16-way ribbon cable.

HE

BREAD BOARD 82

THE EXHIBITION YOU CAN'T AFFORD TO MISS

EXHIBITION GUIDE

Introduction

BREADBOARD exhibition has now been on the scene for five years and has proved that there is a place for an exhibition for the serious electronics hobbyist. We normally use the term electronics enthusiast but one must remember that often beginners are as enthusiastic as those of us with many years experience — often more enthusiastic!

Various local exhibitions or club shows occur during the year, all of which offer something of interest to see and often to buy. Breadboard, being a centralised exhibition professionally run, can offer facilities a local club show cannot. As well as having the venue and stands that you'd expect at the premier amateur exhibition, we are fortunate in being able to attract exhibitors more used to professional exhibitions, and who are perhaps unwilling, for whatever reason, to attend the smaller shows.

Breadboard '82 not only has the stands you would expect with components, books, magazines, computers, kits etc, but also there will be a series of lectures and demonstrations for those that wish to improve their minds (or rest their feet!).

We will also be introducing a **Computer Forum** for the newcomers to computing, where some of the more popular home computers will be available for you to try out. Our staff wil be on hand to help you understand those areas that are giving you a late-night nervous breakdowns!

This year we are fortunate in having two particularly interesting exhibitions/demonstrations. One is a computer moderated wargame using computers together with a scale terrain, troops, etc., that enables the visitor to assume command of the overall tactics of a modern battlefield. Should be interesting to see if Ruritania really could be next years number one super-power! Secondly we will be having a fascinating exhibition of holograms. These will be supplied by Light Fantastic and really have to be seen to be believed. For not even an arm or a leg could you buy one for your own home.

For those parts that need special restoration we will have the usual bar and restaurant open for your use beneath the exhibition hall. Don't miss Breadboard '82, you could even save yourself some money on some of the exhibition's special offers!

Peter Freebrey, Exhibition Manager

SPECIAL ATTRACTIONS

COMPUTER MODERATED WAR-GAMES

Dave Rotor sponsored by Amplicon Micro Systems, Brighton; figures supplied by Adventure Worlds, London, SW1

Wargames give you the chance to be your own general! The game that will be played at the exhibition is based on a small-scale encounter somewhere in Europe during World-War II. The players each have a small force at their command — made up of infantry, tanks and/or artillery — and have to fight out their encounter on the terrain of the board. Each game turn represents a relatively small interval of time (eg, 3 minutes) and during one move, the commander of each side can tell any or all of his forces to move or fire selected weapons. The men and machines involved in the conflict will be represented by 1:1/200 scale models specially for the humans, however the computer will have an 'image' of the battle-field stored in memory.

Fed with each players' move, the computer works out the practical consequences, governed by data on the weapons in the possession of each side, the conditions of the terrain, the men, the weather, etc. The performance of the weapons, and even the men, is deduced from known details of real-life battlefield performance.

Suppose you have a squad of ten men and you decide to move them into battle; it's known that armed men can travel at 3 miles an hour in reasonable conditions. Depending on the time that each move represents, the squad will move a proportional scaled distance (worked out by he computer) in the direction you specify. If you order them to fire their weapons (or if your opponent's tank fires at them, for instance), the effectiveness will be gauged by the distance, the known effectiveness of the weapons against the type of target they are firing on, and all the other factors programmed. The computer will then tell you what degree of damage you have inflicted on each other.

The sort of calculation involved in the evaluation of the tables, etc, used to take human moderators some considerable time; now a fair sized home-computer can do the calculations involved in less than a second. During the exhibition, both war-gamers and computer programmers will be on hand to give detailed explanations of the programming and the theory behind the game.

HOLOGRAMS

Light Fantastic Gallery, Covent Garden, London.

Light Fantastic is the first permanent gallery of holography in Britain, and was set up after the success of the 1977 and 1978 Light Fantastic exhibitions at the Royal Academy.

Holography itself has progressed a long way since the first indistinct three-dimensional images were produced in 1947 by Gabor, a scientist working at the Rugby Electrical Company in Scotland. Gabor was subsequently áwarded a Nobel Prize for his invention.

The invention of lasers in 1960 made holography much more of a practical proposition. Most of the early laser-produced holograms had to be lit by laser in an area with low ambient light level. Later in the 1960s, the technique was improved to allow holograms to be lit with a standard tungsten halogen light source. The development continued from here, now allowing low cost high-volume production in acceptable commercial quality.

Holographic Exhibitions Ltd (holding company for Light Fantastic) provide a total design to installation service for commercial holography.

Light Fantastic will be showing a selection of some of the most striking items from their permanent collection.

EXHIBITORS

Here are just a few of the many leading companies who will be exhibiting their latest lines. More and more companies are booking all the time, and electronics is a rapidly changing field, so we won't have full details of all the exhibitors until the last minute — this is just a foretaste of what is to come. A full catalogue will be available at the exhibition.

ELECTRONICS TODAY INTERNATIONAL

You've read the magazine, you've built the projects, now visit the stand and meet the people who are responsible for it all.

On display will be a large number of our projects, including the brand new 16-bit home computer, the robot arm, and many, many more, all springing into action before your very eyes! Besides this, you'll be able to put your questions to us, and we'll do our best to help. So come and see us on our stand.

HOBBY ELECTRONICS

An intelligent robot in a plastic basin is but one of the marvels on show to those of you who come to visit the Hobby Electronics stand at this year's Breadboard Exhibition.

As well as being able to see some of our best projects at close quarters — yes, they really do exist — you will get the chance to meet the people who produce HE. So, if you've been having some problem with getting your prototypes to work, or you'd just like to air your views on the mag, then pop along and we'll do our best to enlighten you. Even if you're the shy retiring type, don't be discouraged, just stroll up and play with something that takes your fancy — there's so much to choose from amongst test gear, audio, RF, gadgets, games and the like, that we'll be surprised if you *want* to look at any of the other exhibitors. Though, of course, there are plenty of others around, should you be that way inclined!

COMPUTING TODAY

Computing Today is the leading magazine for the serious home computer user looking for the professional approach. Written by micro users for micro users, inside each issue you will find feature articles, projects, general topics, software listings, news and reviews. You'll also be able to buy copies of the current magazine (as well as back issues where available) and any of our popular range of CT Software. So, if you're a committed micro user, come and meet the editorial staff and we'll show you a truly personal approach to microcomputing.

PERSONAL COMPUTING TODAY

Since its first issue in August of this year, PCT has become **the** magazine for the not-so-experienced computer enthusiast. We provide lots of helpful advice on choosing and using a home computer and associated peripherals, a directory of off-the-shelf software, plus lots and lots of programs from the very simple to the stunningly sophisticated. Come and visit our stand, and see how we can help you find your way through the maze of computing.

ETI, HE, CT and PCT are all magazines published by ARGUS SPECIALIST PUBLICATIONS LTD. Other magazines include **Electronics Digest, ZX Computing** and **Personal Software.**

ARGUS SPECIALIST PUBLICATIONS LTD, 145 Charing Cross Road, London WC2H 0EE, Tel 01-437 1002/3/4/5

BRADLEY MARSHALL LTD

Bradley Marshall is one of the leading electronic component distributors in the UK, building a reputation for the highest quality items in every area of the micro-electronics business. At Breadboard '82 they will be exhibiting a select range of items from their diverse spectrum covering over 3,000 individual product categories.

Whilst it is almost impossible to keep pace with change in the electronic market, Bradley Marshall feel confident that their new 1983 catalogue is as up-to-date as it is possible to be. As well as the complete range of Bradley Marshall components, the catalogue contains a great deal of component data to aid the hobbiest. Bradley Marshall are delighted to be able to make available advance copies of the catalogue exclusively for Breadboard '82 at a special exhibition price of 50p.

Bradley Marshall are the sole London distributors of **Crimson Electrik** Professional Audio Amplifier Modules. Crimson Electrik Modules are internationally renowned with a reputation based on quality, reliability and value for money as witnessed by the BBC, IBA and KEF to name but three. Bradley Marshall will be displaying the complete range of these extraordinary amplifiers at Breadboard '82.

Thandar and **Leader** are names that need no introduction to either the professional engineer or dedicated hobbyist as makers of some of the finest precision test equipment and accessories on the market today. Bradley Marshall will be displaying and demonstrating a selection from this high quality range.

They say a bad workman blames his tools — but not **Bahco,** the foremost quality tools from Sweden. The complete range is available from Bradley Marshall and will be on display at the exhibition.

BRADLEY MARSHALL LTD, 325 Edgware Road, London W2 1BN. Tel: 01-732 4242

Booking If your company would like to take a stall at the exhibition, ring Colin Mackenzie on 01-286 9191 **soon.**

Breadboard '82
10-14 November
The Royal Horticultural Halls
Vincent Square London SW1

Admission £1.00 (50p under 16's & OAP's)

Open	Wednesday 10 November	1000-1800
	Thursday 11 November	1000-2000
	Friday 12 November	1000-1800
	Saturday 13 November	1000-1800
	Sunday 14 November	1000-1600

Enquiries: Administration & Publicity
Peter Evans
0747-840722

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Our series of titles is one of the largest available and covers practically every aspect of radio, electronics and computers with subjects to interest all enthusiasts from the complete beginner to the highly experienced.

All our books offer extremely good value, being inexpensive paperbacks ranging from 20p to £3.50. Our new 1982/83 catalogue covering all our books is available FREE to all visitors to our stand and we strongly advise you not to miss it!

BERNARD BABAANI (Publishing) Ltd, The Grampians, Shepherds Bush Rd., London W6 7NF, Tel 01-603 2582/7296

BRADFORD CONSULTANTS LIMITED

Bradford Consulants Ltd are manufacturers and distributors of a comprehensive range of ABS plastic multipurpose boxes, designed for the professional, with the hobbyist in mind. Due to the large turnover but with the relatively small overheads of a small company, we are able to offer comparatively low prices and a personal service.

As an additional extra, we offer a large range of unusual items not normally found elsewhere, at prices the amateur can afford. An early visit to our stand may prove very worthwhile.

Bradford Consultants Ltd, Prospect House, 39 Leeds Road, Rawdon, Leeds, LS19 6NW, Tel: 0423-506406

CHORDGATE LIMITED

We are suppliers of electronic components and equipment to the hobby electronics/amateur radio market. We specialise in the resale of manufacturers' surplus to the retail customer. We advertise in the popular magazines and our catalogue/special offers list wil be available on our stand.

We have retail shops at 75 Farringdon Road, Swindon, Wilts, Tel 0793 33877, and at 21 Deptford Broadway, London SE8, Tel 01-691 5106.

CHORDGATE LIMITED, 194A Drove Road, Swindon, Wilts, Tel 0793-33348

ELEKTOR PUBLISHERS LTD

Elektor magazine provides practical and reliable circuit designs as well as an unequalled printed circuit board service (EPS) for many of the constructional projects published. In addition, there is the Elektor software service (ESS) of programs for microcomputers on disc or tape.

Elektor books will be available from our stand. Besides books containing large numbers of constructional projects, the stand will feature books for those who would like to learn more about computing, electronics, etc.

The Elektor technical query service (TQ) is available should unforeseen problems occur, and members of the technical editorial staff will be present at the stand to answer any questions.

Working projects will be on display. All visitors will be able to buy annual subscriptions to Elektor at the stand.

ELEKTOR PUBLISHERS LTD, Elektor House, 10 Longport, Canterbury, Kent. Tel 0227 54430/54439

JPR DISTRIBUTORS

JPR are wholesale dealers in all types of electronic components from industrial surplus and other sources. We will be offering for sale a wide range of useful components including: switches relays, transformers, capacitors, semiconductors, P.S.U's, converters, ni-Cads, module cases, hardware packs, etc. etc. Also a varied selection of assemblies and part assemblies at unbelievable prices for home constructors. For audio equipment constructors we wil be exhibiting a range of loudspeakers and cabinets at very competitive prices.

Trade enquiries are welcomed, and we are always interested in purchasing large quantities of redundant or surplus components.

JPR DISTRIBUTORS, 49 Wadeson Street, London, E2 9DP, Tel: 01-980 1028/9

LIGHT SOLDERING DEVELOPMENTS LIMITED

Litesold products have been supplied to professional and hobby users throughout the world for over 25 years. The projects on which today's electronics hobbyist is working frequently embody high technology components, and professional quality soldering irons and hand tools are essential for the best results. We have a wide range of soldering irons, from miniature irons suitable for very fine work (and to fit the hands of young beginners), general purpose irons for electronic work, and electronically temperature-controlled irons and stations. There are also re-chargeable cordless irons, and instant heat soldering guns. Also on display are top quality soldering aids, pliers, cutters, screwdrivers, de-soldering tools, wire strippers, miniature tool sets, and solder. Whether you are a beginner or an expert you will find essentials for your work bench on the LITESOLD stand.

LIGHT SOLDERING DEVELOPMENTS Ltd., 97-99 Gloucester Road, Croydon, CR0 2ND, Tel 01-687 0574

Booking If your company would like to take a stall at the exhibition, ring Colin Mackenzie on 01-286 9191 **soon.**

ROADRUNNER ELECTRONIC PRODUCTS LTD

As manufacturers and distributors of a wide range of electronic and computer related products Roadrunner is striving for continual growth and development of its product range.

A combination of a competitive pricing structure and guaranteed 'same-day' service on most items helps to ensure customer satisfaction. The Electronic Products catalogue, available at the show, features a wide range of cuircuit board and enclosure accessories.

Highlighted at the show will be the Roadrunner wiring system which makes prototyping of electronic circuitry up to five times faster compared with other techniques. Available at the show will be the system and the full range of our other products, including 19" subracks, Roadrunner Handiracks, Eurocard and S100 prototyping boards, DIN 41612 two-part connectors, DIP sockets, soldering irons and much more.

Available now from Roadrunner is an all in one development instrument called the Powerlab. Ideal for schools, colleges and universities and industrial establishments, as well as computer and electronic clubs, this single instrument provides several linear power supplies, waveform generator and two-phase clock generator, plus other unique and useful features. Details available from the stand.

New from Roadrunner is an excellent range of branded products to support the word processing revolution. Printers and printer supplies from Diablo, Qume, Wang, NEC and Xerox, including a comprehensive range of ribbons and accessories to fulfil most computer and word processing requirements. An extensive series of acoustic hoods from Viking and Grenadier. Quality ranges of diskettes from Dysan, Maxell, Verbatim and Nashua. Microcomputer systems from ITT/Apple and Commodore; plus a comprehensive stock of printer, telex, typewriter and photocopier consumables available for 'same-day' despatch.

Full details of these computer products at the show.

ROADRUNNER ELECTRONIC PRODUCTS LTD, 116 Blackdown Rural Industry, HAste Hill, Haslemere, Surrey, GU27 3AY, Tel 0428 53850.

VELLEMAN (U.K.) LIMITED

Velleman electronic kits were introduced to the U.K. market nearly a year ago. They had their public debut at Breadboard '81 where they attracted immense interest. Since then they have been enthusiastically purchased throughout the U.K. where they are fast earning a reputation for their originality, high quality and excellent service.

The kits are graded by difficulty and cover a wide field of applications. They include kits using microprocessors, infra-red systems, power supplies, dimmers, motor control units, amplifiers, sound and light units, digital counters, timers, and many more including their popular Eprom programmer.

Velleman have a design and development laboratory in their Belgium factory where new, exciting kits are regularly produced to add to their range. They undertake major development projects for large companies throughout Europe and this highly qualified technical expertise is responsible for their successful range of kits.

They are designed to interest not only those just beginning the addictive hobby of electronics, but also those engineers and enthusiasts who have experience in this area of technology and are able to use the Velleman kits for many of their projects and equipment.

Velleman will have a large selection of their kits available at Breadboard for inspection and sale, and an engineer will be on hand for most of the time to advise and answer questions. Their illustrated catalogue will be obtainable from the stand and is always available on request from the UK office.

VELLEMAN (U.K.) LIMITED, P.O. Box 30, St. Leonards on Sea, East Sussex, Tel 0424 753246.

WATFORD ELECTRONICS

Watford Electronics was established just over nine years ago. From a very modest start, we have now grown to our present size which makes us one of the leaders in the hobbyist/OEM Electronic components supplier's market. In 1973 our range of components was no more than 500 items; today the range has increased to more than 8000 items and keeps on increasing every week to keep pace with the changing technology.

Our two aims at Watford Electronics are to supply first grade components at very competitive prices and to provide an excellent service to both mail order and shop customers. The former we have been able to achieve by bulk buying direct from the manufacturers wherever possible, thus eliminating the middleman and passing the price advantage over to our customers. The latter we have been able to achieve by sheer hard work and dedication on the part of our staff. 80% of the mail-order orders received are processed and despatched the same day. The remainder (except where items may be out of stock) are despatched the next day. Access orders received by telephone are processed and despatched the same day.

We stock a comprehensive range of components, including linear, computer, CMOS and TTL ICs, transistors and other discrete semiconductors, nearly every variety of passive component, transducers, hardware and a large variety of connectors at very reasonable prices.

On our stand at Breadboard Exhibition, we shall be displaying some of the thousands of components that we sell. (N.B. We shall **not** be selling components from our stand due to sheer volume and variety that we would have to transport every day, but we will be accepting orders for postal dispatch. As a special concession, all orders over £5 accepted at the exhibition will be post free.) We shall be demonstrating our latest 'Ultimum' Micro Expansion System linked to various Micro Computers. Our Managing Director, Mr. N. Jessa will be in attendance. He will be pleased to meet and have a chat with the thousands of our customers who we have no opportunity to meet otherwise.

WATFORD ELECTRONICS, 33/35 Cardiff Rd, Watford, Herts. WD1 8ED, England, Tel Watford 40588/9

Booking If your company would like to take a stall at the exhibition, ring Colin Mackenzie on 01-286 9191 **soon.**

Lectures and Demonstrations

Wednesday 10th November	1100	ETI Music Demonstration
	1200	Cable TV
	1300	ETI Music Demonstration
	1400	BICC-Vero: Speedwire
	1500	Gateway to Electronics
Thursday 11th November	1100	ETI Music Demonstration
	1200	Cable TV
	1300	BICC-Vero: Wire-wrapping
	1400	The Digital Solution
	1500	ETI Music Demonstration
Friday 12th November	1100	ETI Music Demonstration
	1200	Cable TV
	1300	The Digital Solution
	1400	BICC-Vero: Speedwire
	1500	ETI Music Demonstration
Saturday 13th November	1100	Electronic Music Techniques
	1200	The Digital Solution
	1300	BICC-Vero: Wire-wrapping
	1400	Holography
	1500	Electronic Music Techniques
	1600	Cable TV
Sunday 14th November	1100	ETI Music Demonstration
	1200	BICC-Vero: Speedwire
	1300	Cable TV
	1400	ETI Music Demonstration

ALL LECTURES WILL TAKE PLACE IN THE LECTURE THEATRE, WHICH IS APPROACHED BY THE LIFT OR STAIRS IN THE MAIN FOYER

WHILE EVERY EFFORT HAS BEEN MADE TO ENSURE THE ACCURACY OF THIS PROGRAMME, PLEASE CHECK FOR DETAILS OF ANY CHANGES WHEN YOU ARRIVE

ETI Music Demonstration
Music projects that have appeared in ETI over the past few years will be put through their paces by a professional musician. This is a good opportunity to decide, with your ears, which synthesiser or fuzz-box to build.

Cable TV — G. Brant, BSc
Cable and satellite TV systems are the newcomers to the broadcasting world of the '80s. A brief description of the existing transmission network will be given, followed by a look at these new media.

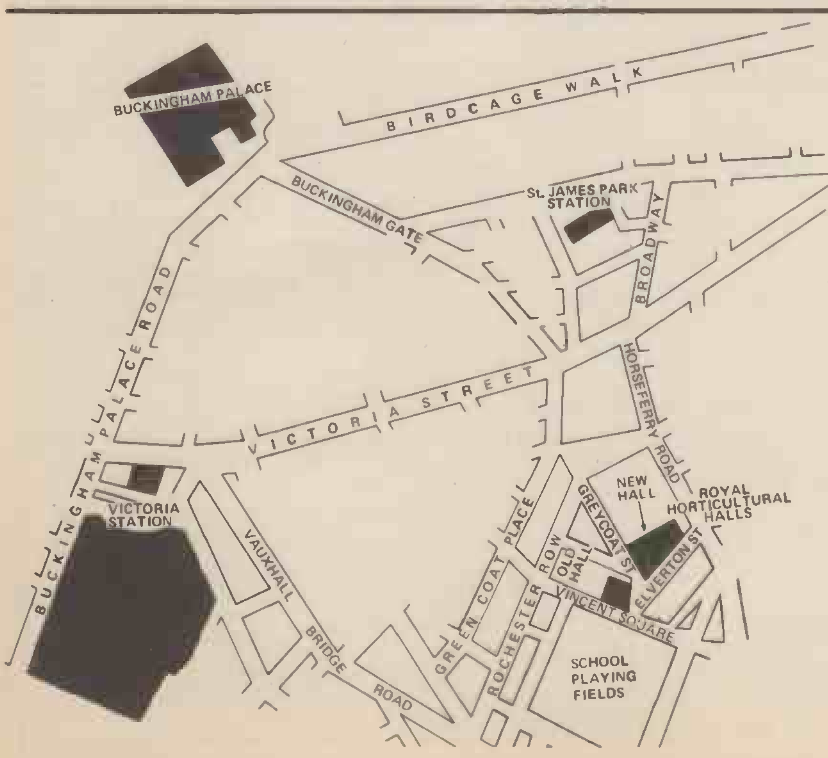
BICC-Vero
BICC-Vero Electronics will be giving audio-visual demonstrations of their new insulation displacement system called Speedwire, ideal for fast positive contacts. On alternate days, there will be lectures on wire-wrapping, an alternative system for solderless connections.

Gateway to Electronics — Dave Bradshaw, MSc
This is a lecture for beginners in electronics, and will offer a mixture of very basic circuit theory and practical advice.

The Digital Solution — Owen Bishop, BSc
In these lectures I propose to cover the whole range of applications of digital electronics, including digital computing, D—A conversion, digital recording, remote control, etc. There will be a selection of working demonstration circuits to illustrate points made in the lectures.

Electronic Music Techniques — Tim Orr, BSc
The lecture demonstration will consist of a technical explanation coupled with a musical demonstration of a polyphonic music synthesiser, a digital delay line and a vocoder: all these have been designed by the lecturer.

Holography — Andrew Pepper
This will be an introduction to the principles, methods and techniques of practical holography.



Other exhibitors will include:

BICC-Vero
Leighton Electronics
Micro Aids Electronics
British Amateur Electronics Club
Assn of London Computer Clubs
Thames Valley Electronics
Marco Trading
Electronics & Computing Monthly
SGS Electronics
Expo Drill Company

and many more.

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6	PB104	3060	32	49.00	58.07	
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- Floating point arithmetic.
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- Upper and lower case ascii character set.
- 24 x 32 character flicker-free display.

The Jupiter Ace uses FORTH

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FORTH's unique combination of speed, versatility and ease of programming has already made it a prime choice for professional applications as diverse as pub games and radio telescopes, and gained it an enthusiastic national user group. Now the Jupiter Ace can bring this addictive language into your own home.

Designed by Jupiter Cantab

Leading computer Designers Richard Altwasser and Steven Vickers have a reputation for pushing technology forwards. After playing the major role in creating the ZX Spectrum they formed Jupiter Cantab to develop their latest brainchild the Jupiter Ace.

Technical Specification

Hardware

Processor/Memory
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40 moving-key keyboard with auto-repeat on every key.

Output
Memory-mapped 32 x 24 character display with high resolution user graphics. Output to drive normal UHF TV set on channel 36.

Sound
Provided by internal loudspeaker.

Cassette
Load Save & Verify at 1500 baud, separate data storage.

Software, FORTH

Data Structures
Integer, Floating point and String data may be held as constants, variables or arrays with multiple dimensions and mixed data types.

Control Stuctures
IF-THEN-ELSE, DO-LOOP, BEGIN-WHILE-REPEAT, BEGIN-UNTIL, all may be mixed and nested to any depth.

Operators
Mathematical +, —, X, ÷.
Logical AND, OR, NOT, XOR.
Comparison <, >, =.

Program Editing
FORTH words may be listed, edited and redefined. Comments are preserved when words are compiled.

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The Jupiter Ace is available only by mail order. Please allow up to 28 days for delivery.

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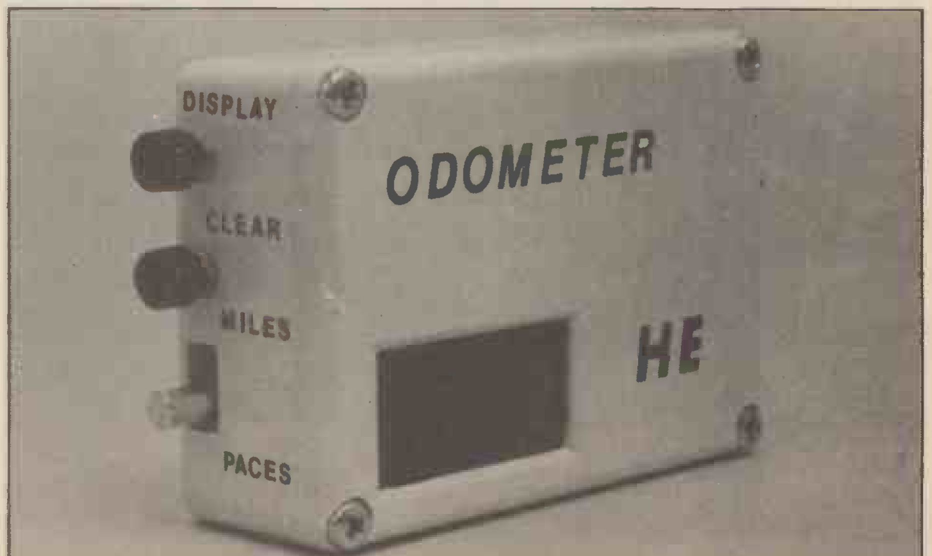
The HE Odometer

A versatile project that functions as a Pedometer, clocking up miles or paces, a bicycle Odometer, or as a tally counter.

THIS PROJECT is the ideal companion for nature lovers and fitness fanatics, who can now record the exact distance of their country walks or cross-country runs, or cyclists can see how far they've pedalled.

The HE Odometer is a digital 'milometer' that can be programmed to your own pace length or wheel size. By using a compact PCB we have managed to squeeze a two decade counter, seven-segment displays, batteries, control switches, and a programmable pre-scaler, into the smallest general purpose Vero box. To achieve this degree of miniaturization and to keep the unit as light as possible we have used two photographers 5V6 flashbulb batteries. The standing current is only a few microamps, removing the need for an on/off switch and allowing the log to count paces for hundreds of miles.

There are only three control switches; a push-to-display switch (for battery economy) which illuminates the LED's, a Reset pushbutton, and a Mode switch. The Mode switch allows counting either in miles (up to 9.9 miles in tenths of a mile), or paces (up to 99). An inclined mercury switch is used to



detect each pace. The milometer works by counting the number of paces and deriving the distance in miles on the basis of pre-programmed value for the number of paces taken in one-tenth of a mile.

In use, the Odometer can be attached to your ankle or to a side hip pocket, using 'Velcro' sticky pads; the mounting angle must be adjusted for reliable counting. It can also be used on a bicycle, to count wheel revolutions, by connecting a remote reed switch in place of the mercury switch, activated by a small permanent magnet mounted to the wheel rim.

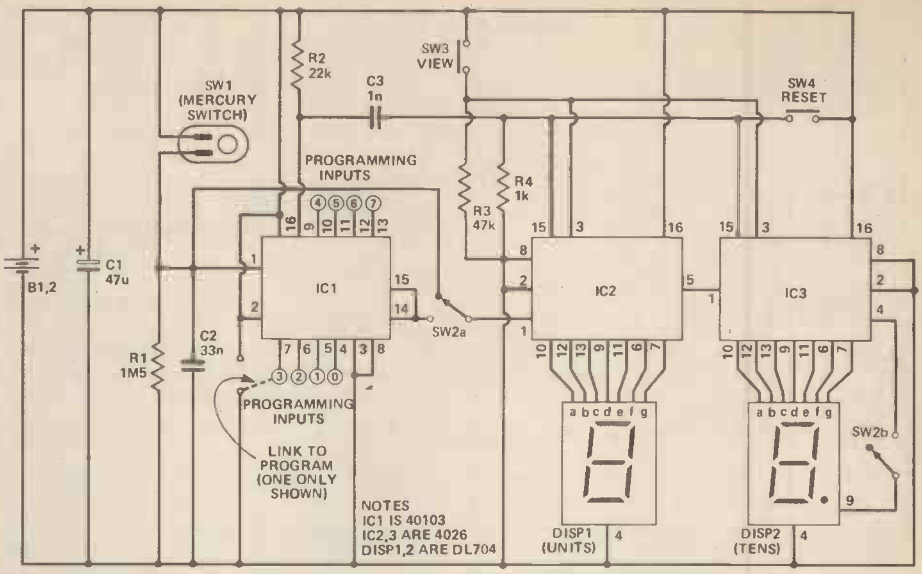


Figure 1. The circuit details.

The Circuit

The basis of the circuit is a two-decade counter build from IC2 and 3. These IC's (CMOS 4026s) are decade counters/dividers with seven-segment decoded outputs. They will directly drive the common cathode LED displays, DISP1 and 2. IC2 registers one count for each clock pulse received on pin 1. The divide by ten output (pin 5), which goes high on the tenth count is used to clock the following counter stage, IC3, which displays the tens count.

A push switch, SW3, is provided to illuminate the display only when required, thus allowing a very long life from small batteries. The display is kept normally off by holding the display enable inputs, pin 3 of ICs 2, 3 at logic zero, via the resistor R3. Closing SW3 takes these pins to the positive rail, turning on the display. The pin 4 output from IC3, which goes high when the display enable input is taken high, is used to illuminate the DISP2 decimal point. This is connected to pin 4 via the mode switch, SW2b, thus the decimal point only appears when miles are being counted.

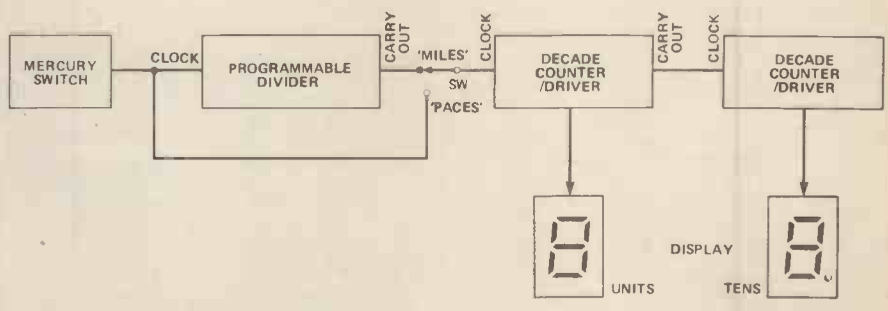
SW4 is the reset switch; pressing it resets the counter to '00' and also presets the divider, IC1. The reset inputs (pin 15) of IC2 and 3 are both held low by R4, which allows the counters to operate and ensures that C3 is charged up through R2. On closing SW4, both resets are taken to the positive rail, resetting the counters and discharging C3 through R2. When SW4 is released, the preset input (pin 9) of IC1 receives a negative going pulse from C3 as it charges up again. IC1 is a eight bit programmeable-counter. It is loaded with an eight bit binary value set-up on the 0 to 7 inputs (with soldered links) and proceeds to count down from this value towards zero as clock puses are fed to pin 1. The preset input (pin 9) is normally held high by R2 and loads the eight bit counter, IC1, with the pre-programmed binary value when it receives a negative pulse. When the count reaches zero the carry-out output, pin 14, goes low, also taking the synchronous preset input (pin 15) low. On the next clock pulse, the preset number is again loaded into the counter from the progamming inputs 0-7, and the carry-out line goes high once more. This process repeats, producing one carry-out pulse for every N clock pulses, where N is the preset number of paces per tenth of a mile.

The memory switch, SW1, provides a pulse for each pace. It is normally closed, putting a high on the clock input (pin 1) of IC1, and keeping C2 fully charged positive. When any rapid movement forces the mercury to break contact, R1 will discharge C2, taking the clock line low; it goes high again when the mercury switch closes. C2 and R1 provide a debouncing time constant to overcome mercury splashing problems. The clock pulses so generated are fed directly into the divider, IC1. For the Miles Mode, SW2a routes the divider's carry-out pulses to the decade counter IC2, thus counting in tenths of a mile up to 9.9 miles. In Pace Mode, IC2 is clocked directly from the mercury switch, counting up to 99.

An eleven volt power source is provided by two 5V6 flashbulb batteries. The quiescent current is only a few microamps. eliminating the need for an on/off switch; however quite high currents are required to illuminate the display. Capacitor C1 provides the required supply decoupling.

How It Works

An acceleration detector, consisting of an inclined Mercury switch and R/C debouncing network, is set up to generate a clock pulse for each pace taken. Since the unit is mounted on the hip or at the ankle, the acceleration produced at each stride forces the blob of mercury to break its contact. The voltage pulses thus produced are used to clock a two-decade counter which receives clock pulses either directly, in Pace Mode, or via a programmable divider in the Miles Mode. Thus in Pace Mode the two-digit seven-segment LED display can show the number of paces counted directly, as a number from 0 to 99. In Miles, the pulses are fed to a progammable divider. This divider, or counter, gives one output pulse for every N input pulses, where the number N can be preset between 0 and 255, using soldered links. The counter is pre-programmed with the number of paces in one tenth of of a mile (ie, 176 yards), and its output is fed via the Mode switch to clock the decade counters. Assuming a correct value has been chosen the two-stage decade counter will then read in tenths of a mile, up to a maximum range of 9.9 miles. Alternatively, a reed switch and magnet may be used in place of the mercury switch, counting wheel revolutions for use as a bicycle milometer. The programming number is now determined by the wheel size (see text).



Parts List

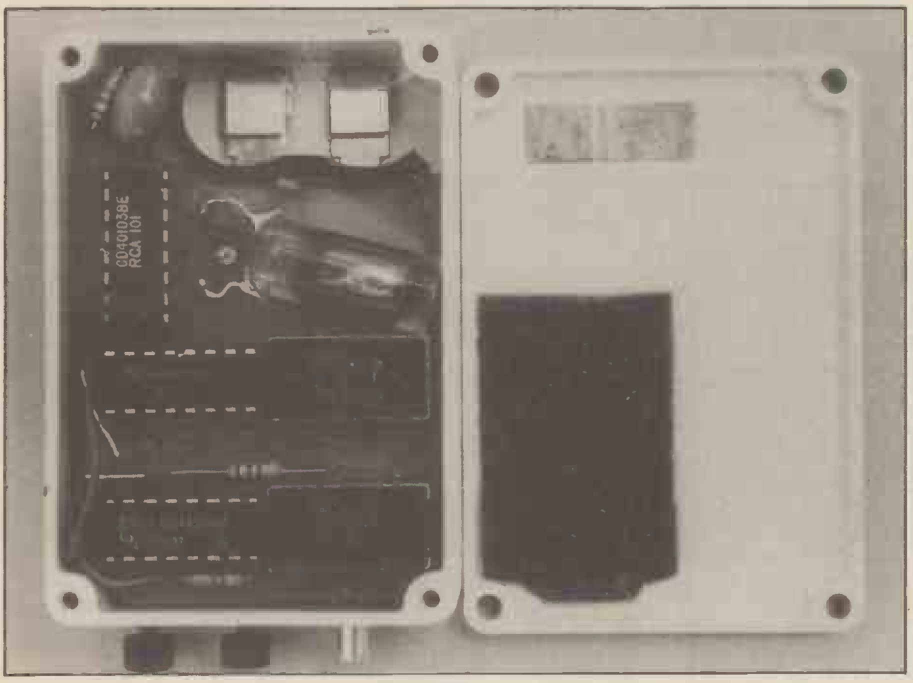
RESISTORS
All ¼ W, 5% carbon
R1 . . . . 1M5
R2 . . . . 22k
R3 . . . . 47k
R4 . . . . 1k

CAPACITORS
C1 . . . . 33n ceramic
C2 . . . . 1n ceramic
C3 . . . . 47u 16V tantalum bead

SEMICONDUCTORS
IC1 . . . . 40103 CMOS 8-bit presettable counter
IC2,3 . . . . 4026 CMOS counter/divider/decoder
DISP1,2 . . . . DL704 7 segment LED display (common cathode)

MISCELLANEOUS
SW1 . . . . mercury tilt switch or reed switch
SW2 . . . . DPDT miniature slide switch
SW3,4 . . . . sub-miniature push-button switch
B1,2 . . . . PX23 Duracell 5V6 camera battery
PCB; case (see Buylines); solder, etc.

Buylines . . . . page 33



Construction

The circuitry is constructed on the PCB as shown in the overlay diagram of **Figure 2.** Sockets must be used for the CMOS ICs and also on the seven-segment displays to acheive the required display height. The board has been designed to exactly fit the box and its corners must be filed to fit as shown on the overlay diagram.

Take a careful look at the photographs of our completed prototype before commencing. The three control switches are first mounted along one end, followed by the PCB (component side up) which is supported on small insulating blocks. The flashbulb batteries are mounted vertically and are held in place by the PCB cutout. The case lid needs a cutout for the displays and piece of copper contact strip glued on, to make the connection across the top of the batteries.

Assemble the PCB first, paying special attention to the orientation of the ICs and C1, and inserting two Veropoins at the points shown for connection to the Mercury swtich. The three control switches are connected up with short lengths of insulated wire and soldered to the pads, as shown on the overlay, from underneath the PCB. Also connect short lengths of insulated wire to the positive and negative supply points — (again from underneath the board). SW1, the mercury switch, is mounted using copper wire links to connect between the Vero pins and the switch terminals (this provides a measure of adjustment for sensitvity). Care must be taken to avoid a short across R1 or C2. The switch body is initally angled as shown. Before testing the board and assembling the case the programmable divider, IC1, must be set up using soldered links.

All eight programming presets (0-7) of IC1 must be linked to either positive rail (for logic 1) or the 0V rail (for logic

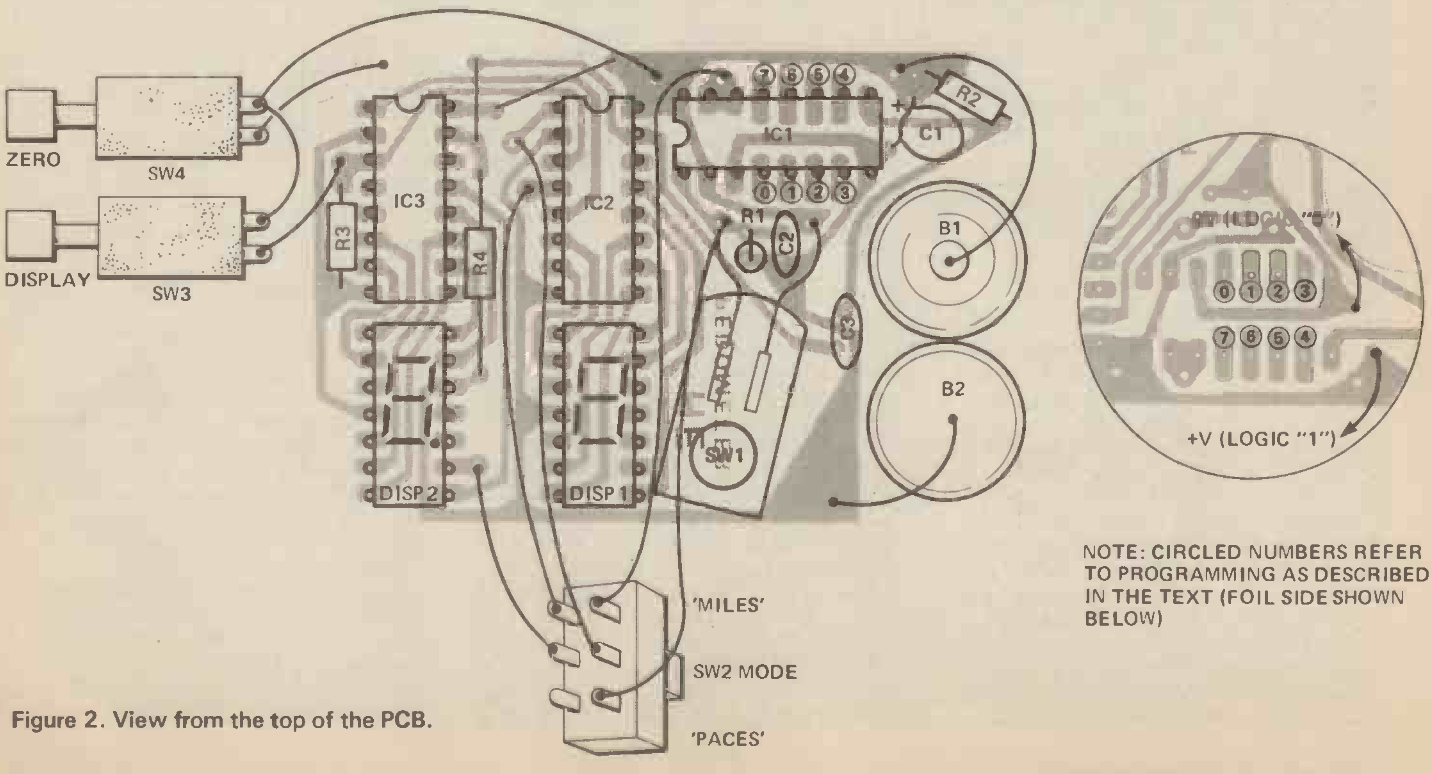


Figure 2. View from the top of the PCB.

0). The diagram in **Figure 2** shows the copper track pattern beneath IC1 with the preset inputs, pins 4, 5, 6, 7, 10, 11, 12, and 13. Any count-down number between 1 and 255 can thus be programmed in binary by soldering links to the supply rails as shown. Having worked out the average number of paces, or of bicycle wheel revolutions, in a tenth of a mile, the number can be set up as an eight bit binary value.

Each preset input of IC1 corresponds to a single bit of an eight-bit binary number as follows:

0	1	2	3	4	5	6	7
1	2	4	6	16	32	64	128

Thus any number up to 255 can be programmed by connecting the appropriate preset inputs to either the positive rail or ground. For example, let's say you average 122 paces per tenth of a mile.

Now:

122 = 0x128 + 1x64 + 1x32 + 1x16 + 1x8 + 0x4 + 1x2 + 0x1

which is 01111010 in binary. This number is preset by making the link connections on the foil side of the PCB. Thus:

Preset 7 goes to 0V
Preset 6 goes to +ve
Preset 5 goes to +ve
Preset 4 goes to +ve
Preset 3 goes to +ve
Preset 2 goes to 0V
Preset 1 goes to +ve
Preset 0 goes to 0V

A word of caution: the preset inputs 0-7 do not correspond to the IC pin numbers, so be careful to cross-check!

Since there are 176 yards in a tenth of a mile, the average number of paces is easily calculated; simply count the number of paces (using the HE Odometer, of course!) over a known distance and convert to find the number in a tenth of a mile. For example, if you take 69 paces to cover 100 yards, the number over 176 yards is:

(176x69)/100 = 122 paces, approximately.

Alternatively, walk 100 paces and then measure the distance. Since an average stride is about one yard, the number is certain to lie between 0 and 255.

To calculate the number of bicycle wheel revolutions per tenth of a mile, use the formula:

$$N = \frac{176 \times 3 \times 12}{3.14 \times D}$$

where D is the wheel diameter in inches. The number must be rounded to the nearest integer.

A reed switch should be used in place of the mercury switch, mounted on the wheel fork and connected by two wires. A magnet, glued to the wheel rim with epoxy, will trigger the reed swich at each revolution.

Testing

The board can be wired to an ordinary 9 V battery for testing purposes. Start with SW2 in Pace Mode; on pressing SW3, the display will illuminate with a random number. Pressing the reset switch (SW4) should return the display to '00'. Hold the PCB vertically with the battery cutout facing the ground; if the board is now moved back and forth horizontally the mercury blob will make and break contact, due to the acceleration, and for each shake the pace counter will advance by one.

Changing to Miles Mode, the decimal point should appear. Press Reste and shake the PCB for the preset number of times. Pressing the display switch should now show '0.1', indicating that a tenth of a mile has been counted and all is well.

Holes can now be drilled in the base of the box to take the three switches. The PCB should be supported above these, about 1 cm from the base of the box. Insulating pillars (or pieces of cork and adhesive pads) provide good fixing. Two pieces of copper contact strip or tinned wire form the battery connectors. They should be stuck to the bottom of the box to make contact with each battery terminal; the supply leads are then soldered to these connectors — do remember that the batteries must be fitted opposite ways round, with the right polarity!

The display hole, cut out of the lid, can be covered from the inside with a piece of red plastic or polarizing sheet. A further contact strip glued into the lid, above the battery compartment, connects the two batteries together when the lid is screwed down. The unit is now complete and should be mounted in a suitable position for field-testing!

Wearing the Odometer on the hip will probably give the best results, although the position may need adjusting to suit individual characteristics. The sensitivity of the unit can be varied by adjusting either the tilt of the mercury switch, inside the case, and/or the tilt of the unit itself; the greater the tilt, the greater is the force needed to break the switch contacts. **HE**

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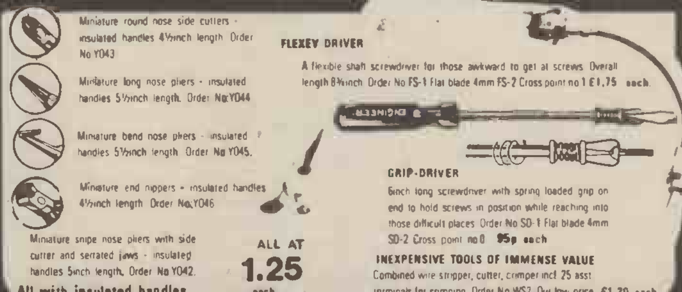

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William Shockley

Ian Sinclair

Co-inventor of the transfer-resistor

SHOCKLEY, Bardeen and Brittain are three names that ring across the post-war years like a summons to a new age. And new age is just what they started, with their invention of the bipolar transistor in 1948, but there were years of painstaking research before that triumphant announcement in the journal, "Physics Review". Shockley was one of the men who changed the 20th Century more abruptly than anyone else, and this is how it happened . . .

William Bradford Shockley was born in London in 1910 but was educated in the US where his family had moved. He started work, after University, at the Bell Telephone Laboratories in 1936. This, in itself, must have been a remarkable experience because of all the research laboratories around the world, the Bell labs were foremost in telecommunication research, nourished by the profits of the Bell Telephone Corporation. Yes, it's possible to have a telephone system which offers low prices to the user and still make profits for the provider – but don't tell Buzby!

Solid States

Throughout the 30s, the Bell labs had pursued a lot of very fundamental physics research into the nature of solids, the kind of research which in this country is normally carried out only by Universities. Solids, you see, are rather remarkable and when you look at their electrical properties, they seem even more remarkable. Why should one solid element be a metal, bright and lustrous, conducting electricity well, and another solid element be a non-metal, dull and shapeless and an insulator? The nature of gases was dimly understood in the 17th Century, and our understanding greatly increased during the great years of discovery in the 18th and 19th Centuries. The liquid state was being unravelled by theorists in the 19th and 20th Centuries, but the solid state remained very much of a mystery. The main problem was that the atoms of a solid are packed together so tightly that they affect each other much more than happens in gases and liquids. Any theory that took account of the effect that atoms have on each other was likely to become too complicated to solve. The big breakthrough came early in the 20th Century, as a result of work by the great theoretical physicists Planck and (later) Dirac — and the steady follow-up to their work continued in laboratories all around the world. Bell Telephone Laboratories were concentrating on the electrical aspects of solid materials, in the hope that something of importance would emerge. Research is like that; providing that it's genuine scientific research, then there's always some useful outcome, even if it's years later or in some quite unexpected way.

In particular, Bell labs were following up the work on hole conduction in crystals, which had been discovered at the tum of the century, and on the properties of semiconducting materials; it was in these materials that the effects of impurities on conduction (an important clue to what was going on) were most marked.

Foundation Stories

The foundations for the invention of the transistor were being laid, then, all through the 30s. There was no great pressure for spectacular results, but there was a steady stream of publications which map out for us how much progress was made. When war broke out, Shockley, along with most of his research team, was seconded to the US Navy to become Director of Research in the Anti-submarine Warfare Operations Group. He worked on all aspects of submarine detection and the effect of depth charges, returning to the Bell Laboratories early in 1945 to resume his research on semiconductors.

By this time, the work was beginning to bear recognisable fruit. The importance of purity was recognised, and the method of re-crystallising Germanium by zone refining was developed, leaving the way clear to investigate the doping of the material without the complicating effect of other, stray impurities. It was with such a doped sample that the team, following work which had been done in the 20s with copper sulphide crystals, was able to produce the point-contact transistor.

We should remember that the principles which were being followed were quite old. All the way through the 20s, the crystal-and-catswhisker had been used as a sensitive detector (demodulator) for radio waves. The principle was that certain types of crystals, of which metal sulphides were the most useful, conducted; when a fine wire contact, the catswhisker, was allowed to touch the surface of the crystal, a rectifying contact or diode was created. These early detectors used natural crystals and their behaviour was unpredictable and unsatisfactory. You could be listening (using headphones) to a broadcast which would suddenly vanish until a new sensitive spot was found on the crystal. The problem was that the material of the crystal was never pure and the rectifying action, caused by the material of the catswhisker doping the crystal, would eventually overdope the crystal and stop the action.

There had been reports, too many of them to ignore, of amplifying action obtained by using more than one catswhisker on such crystals, and Shockley's team were hoping that their thoroughly purified materials would allow more consistent results to be observed. They had produced some N-doped germanium crystals and were making contact to them with fine metal wires spaced very close together, in the hope of finding some amplifying effect. The results must have been most gratifying. Those first point-contact transistors were unreliable and had either too little gain for practical use, or so much that they were unstable — but they worked, and worked well enough to allow their characteristics to be studied.

Naming Names

The crystal of germanium was dubbed the "base", because it was on this slab of material that the fine wires were located. One wire was called the "emitter", because it appeared to be emitting holes into the base; the other wire was called the "collector", because it appeared to be collecting the holes emitted by the emitter, rather than allowing them to be carried into the base. The circuit was what we would now call a common-base amplifier, and it was this circuit that dominated early transistor technology. The action, by the way, seemed to be that of a resistor which could transfer current to a third connection, so it was called a *trans*fer-res*istor*, and it was no time at all before someone shortened that to transistor.

The importance of the invention was recognised at once and Shockley, now head of the Transistor Physics Research Dept, initiated a new programme of research to improve the primitive point-contact transistor design. The faults were obvious — instability when used as an amplifier, manufacturing difficulties and unreliable operation. By this time, the reasons for transistor action, which had been worked out in the long years of research, were increasingly better understood and the team was able to turn to better methods of creating the junction between P-type and N-type material, which was so crudely achieved by the point-contact method. It's a matter of history that they succeeded, using the well-documented method of making a sandwich of N-type crystal wafer with contacts of P-type impuritiy on each side and then heating the sandwich so that the P-type impurity diffused into the germanium, creating regions of P-type germanium on either side of the N-type. This "diffused junction" technique was to dominate transistor construction until the advent of silicon transistors, bringing new techniques that were readily useable only with silicon.

Shockley was appointed visiting Professor at California Institute of Technology, Pasadena, in 1954, and was further honoured by the Nobel Prize for Physics in 1956. He had, by this time, left Bell Laboratories to join Beckmann Instruments, founding the Shockley Semiconductor Laboratories. From there on, his career turned in a more academic direction as he became, in 1958, a lecturer at Stanford University and, in 1963, the first Poniateff Professor of Engineering Science. In these latter days, he has been more noted for outspoken comment on the topic of genetics and inheritance, than on the subjects which made him one of the most illustrious of our Famous Names.

HE

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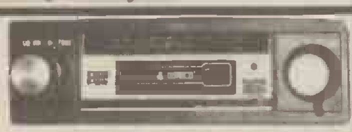

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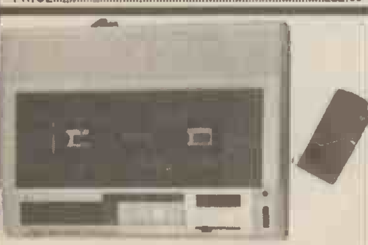

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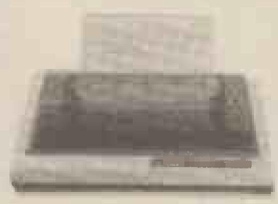

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Clever Dick

This month CD takes on the grovelling 'binder beggars' — and wins!

An intriguing and mysterious group of people seem to be reading HE these days! Our office (cubbyhole, that is) is inundated with letters from anonymous writers (perhaps too ashamed to sign their names?) and, of course, from representatives of 'Groveller's International'. Lately, too many letters are in the latter category so to emphasise that this page is not a charity for hapless cases, I've decided to print this, the most boring, abject letter I've ever received. Please take note that my Binder Award is for humorous,intelligent and witty letters about interesting or unusual subjects. This example does not qualify . . .

Dear Ultra sophisticated, highly intelligent, witty, gifted (and so on for several boring lines), *Clever Richard,*
Grovel grovel grovel (and on and on and on—for 200 times, so he says . . . and I'm not going to bother counting!) *Yours grovellingly humble,*
The Phantom Groveller
Ipswich,
Suffolk.
PS Do I get a binder for grovelling more than anybody else (200 times, approximately).

The answer to your question (tricky one this!) is no, no and thrice no, OK? Potential grovellers, take note: remember what happened to Uriah! Right, now that's out of the way, let's get down to some genuine questions. Here's a bright young lad, though not I regret, a regular reader.

Dear CD,
I am eleven years old, and have been alarmed to find a mistake on the ''Intruder Confuser''. Capacitor (C1) has been connected (not across) but in the same direction as the copper strips and there is no break between the two terminals. Also (according to the schematic diagram) the integrated circuit has been connected the wrong way round, there is also another problem . . . . I have, nowhere to store my Hobby Electronics magazine.
Yours Faithfully,
R Einstein
Ipswich
Suffolk

(hint, hint). Life isn't all problems though, because I think your magazine's great

Correct on both points—though the issue was raised in a previous HE (June '82, I think). As for the mag, I also think it's great (especially this page), but then I am a little biased!

Readers sometimes write saying they've experienced problems obtaining the current edition of HE. In most cases, this situation is easily rectified by our distributors, ensuring local newsagents have enough issues to go round. However, this is only possible if you write and tell us —remember, one day you could be the unlucky person without a copy of HE (perish the thought!).

Dear CD,
I have a few questions to ask you about the Hobbit stereo amp in your first mag; 1) Which of the capasitors are of Tantalum type (because I have lost the components list) 2) Would it be possible to use a rotary switch for an input selecter switch with a tape monitor switch.
Yours despretly,
A.C. Baker
Stockport
PS The page wouldnt have got ript if I had a b-n-e-

The name of Hobbys first stereo amplifier was, in fact, The Hobit (for obvious reasons!), and very popular it was, too. Now regarding your question the simple answer is that any electrolytic capacitors under 100u can be replaced by tantalum types, so long as you're prepared to pay the extra costs. The project specified C6, 11, 30, 31 (4u7) and C16, 21 (1u) as being tantalum. As for the switch, it all depends on what you want to monitor—but it should be possible to wire a rotary switch to suit your requirements.

Sorry, no luck on the binder (if that's what you were on about), though I did consider sending a dictionary!

Our designers are very clever lads, (though naturally I have to help them out from time to time, when something really difficult comes up) but they are not yet able to whip-up a new transistor type, as the next writer seems to imply.

Dear Most Intelligent Richard,
Don't worry, I'm not going to grovel for a much loved binder. I'm not like that! Please, just help me if you can. Where do I purchase the ZTX650 NPN transistor your team 'invented' for last November's Sound Torch. Nobody sells it!
G. Foreman,
Colchester,
Essex.

PS I promised I wouldn't grovel!!
PPS Keep up the brilliant work.

Of course I can help you, my son. But shall I? Oh well, it's only a two-word answer, so here it is: Magenta Electronics.

Dear DC,
That's supposed to be a joke.
Back to the subject of your youngest reader. It involves a certain boy at my school who has had copies of HE since he was nine years old. He is not a regular reader because of pocket money but he borrows my mags occasionally.
I'm 14 and have been doing electronics for almost six years, but I have only subscribed to HE for just over a year, after I discovered it by accident in a newsagents, next to the dirty section.
Hope that binds up the prob. for you.
J. Kitchen,
Epsom,
Surrey.

Fourteen years old and he's hanging around the wrong end of the bookshelves, already? This boy will go far — which direction, I can't say.

Dear CD,
In your July issue you published a list of next months projects, one of which I was very interested in.
I eagerly waited for my August issue to drop through my letter box, so that I could start to make it. But on opening it, I found that no such project was included & no apology was given for not printing it.
To say I was disappointed would be putting it mildly, or as ''Chad'' would say ''What no Odometer Project''!!!
If you are not going to put this in the Mag, could you supply me with the drawings.
F. Johnstone
Stanmore
Middx.

Sounds like fighting talk to me (go for your blagger etc). However,before you march around here to seek a horrible vengeance, let me remind you to read the line at the bottom of the 'Whats on next' page; ''circumstances'' have kept the Odometer on the sidelines for a month or two, but I'm told it will be appearing shortly!

And finally (as they say) . . . if you're all wondering where this months binder is going, I'll tell you: it's staying right here on my desk until I receive a neatly written, amusing, original letter of interest to Hobby readers. Am I asking for too much? . . . we shall see! **HE**

LEARNING FROM THE MICRO-PROFESSOR

Paul Kelly

Single board computers are useful for controlling external hardware, for experiments and as a teaching aid. But just how much can you learn from them?

"THE FIRST 50 years of the 20th century witnessed the invention of the internal combustion engine, which greatly extended the physical strenght of the human body. In the second half of the century, the birth of the microprocessor further extended our mental capabilities. Applications of this amazing product in various industries have introduced so much impact on our lives, hence, it is called the second industrial Revolution." It is with these words of immeasurable wisdom that the Multitech Industrial Corporation of Taiwan introduce their MPF-1 micro-computer to the markets of Western civilisation.

Cleverly named the "Micro-Professor" (MPF), the machine is a low-cost, Z80-based, microprocessor training/development tool, distributed in the UK by Flight Electronics Ltd of Southampton. For a sum of £69.95 including VAT & postage, mail order customers receive a single-board computer neatly packaged in the guise of a book, a mains adaptor (with the correct plug fitted!) and a 350-page manual.

Functionally, the MPF offers little more or less than the many similar machines that have been on the market and have fallen into obscurity with the advent of the high-level language 'personal' computer (remember the Sinclair Mk14?). Like its predecessors, the MPF has a keyboard and an LED display, which enables the user to enter, in hexadecimal, machine code programs and to run them; it has a cassette interface for program storage, a simple audio output and facilities for parallel input/output and memory expansion. A detailed examination of each of these facilities does, however, reveal an attempt to refine and improve upon the small substance of many other training machines.

The hardware of the MPF is constructed to a very high standard with a tidily laid out, gold-flash, through-hole-plated board, with all the main ICs socketed and with an excellent keyboard. This keyboard deserves special praise, particularly when compared with those of other development systems, for its well-spaced keys (36 of them) with a very positive action, clear markings and generally sturdy construction. The six digit LED display is used in several formats; when memory is being examined or modified, the first four digits display the memory address and the latter two display the data, both in hexadecimal; when examining registers, the latter two digits hold a symbol representing a register-pair (some of these, eg IX are, of necessity, poorly represented) whilst the contents are displayed in the first four digits. The system flags may be displayed in binary, again within the first four digits while certain conditions, such as reset or stack overflow, bring up symbolic messages across the whole display. This very flexible use of just six seven-segment displays allows the operation of the machine to be more clearly understood.

Functions

The functions of the MPF are provided by 2K byte monitor. In addition to those commands which permit modification and examination of registers and memory locations, there is a single-step feature, a breakpoint routine, insert and delete keys, cassette tape load and save and a few other minor but useful functions. The 'STEP' command allows a single Z80 instruction to be executed followed by a return to the monitor, so that the registers and memory can be inspected by the user. A second debugging feature (SBR) allows a single breakpoint to be set at any memory address, causing program execution to stop, and control to return to the monitor, when the PC reaches this address. The process of hand-assembling programs written in mnemonic form requires only a table of op-codes and a means of calculating address references. The first of these is taken care of in the manual, and the calculation of relative addresses is made easy by the 'RELA' function of the MPF. This reduces considerably the number of errors in assembly, and makes debugging programs simpler.

A cassette tape recorder can be connected to the MPF by means of two jack sockets on the back of the board. It is necessary to connect to the 'EAR' and 'MIC' sockets of the recorder so that the replay signal during loading can be adjusted by the volume and tone control. Cassette storage systems are notoriously difficult to set-up and maintain but the MPF proved to be one of the better machines in this respect. I was able to get the system operating on several, cheap mono recorders, after a few minutes trial and error experimenting with the volume setting and, once set-up, they seemed reliable as long as the tape heads were clean.

The data storage/retreival operates at a tolerable transfer rate (it takes about a minute for 1K bytes of data, including the tone leader). The operating system requires a start address and an end address as well as a four digit Hexadecimal 'handle' to specify the program to be stored. During program retreival, only the program 'handle' needs to be specified so that it can be sorted from several programs on one tape, the program itself providing details of the memory locations. In addition, during program searching, all programs found prior to the one required are displayed by their 'handles'. Clearly, the cassette system is very neat for a machine of the MPF's class, with features normally found only on medium and high-priced personal computers.

A small loudspeaker, mounted on the MPF board, gives an audible blip when keys are depressed and also serves to

echo the sound of serial data transfer during cassette operations. The speaker output is accessible to the users program, (via the 8255, which is also used for keyboard and display scanning) and is the subject of several 'musical'experiments found at the back of the manual. This is not a very necessary feature but it does add to the completeness of this well thought out machine.

Hardwares

A single 24-pin socket (U7) provides the only on-board memory expansion facility. According to Multitech, this socket will accommodate types 2516, 2532 or 2732 EPROMS or type 6116 RAM. However as the board stands, a 2516 or 2532 may be directly fitted, whilst to fit 2732s or a 6116 RAM it is necessary to cut and link jumpers on the PCB. The term 'jumper' is misleading, because it involves cutting tracks on the underside of the PCB, with a scalpel or similar tool, which are uncomfortably close to a ground track. The fact that the socket is wired for an EPROM rather than a 6116 RAM, as standard, may at first sight seem surprising; the intention here is that programs, having been developed on the MPF for dedicated control type applications, can be fixed in EPROM using Multitech's EPROM programmer add-on, and then fitted into the spare socket so that the MPF becomes the dedicated system.

If the RAM expansion (6116) option is chosen, the extra memory is located immediately following the standard RAM in the memory map (2000H-27FFH). Since the MPF monitor uses locations 1F9FH-1FF3H as a scratchpad, the user RAM does not run in one contiguous block but this is hardly a serious problem, since well written programs consist of small subroutines which can be placed anywhere in RAM.

However, it is a little clumsy and could so easily have been avoided. The Z80 busses are brought out on to a connector at the top left hand corner of the board, providing a means of expanding memory externally, in the unlikely event that this should be required.

Two further sockets are provided for the addtion of a Z80 PIO (parallel input/output device) and Z80 CTC (counter timer circuit), which are not supplied with the basic machine. Of these, the PIO is undoubtedly the most useful, providing an interface between the MPF and external devices or circuits. A connector, below the main bus connector on the left of the board, holds all the interface lines of these two devices. Both devices are I/O mapped and are therefore accessed via the Z80 special I/O handling instructions. Together with the 8255, they are partially decoded from the address bus so as to repeat over addresses 00H to BFH. Any additional I/O devices that the user requires to connect to the bus must, therefore, be restricted to the address range C0H to FFH.

On the right-hand side of the PCB is an array of DIL pads, described as the "breadboard or user area". Exactly what this is intended for is not expressed anywhere in the manual, but it would seem to accommodate about 8 small (14 or 16 pins) DIL wire-wrap sockets (my estimation). Whatever circuit you may devise for this area of the board, if it is in anyway associated with the MPF itself, will require a loom of wires to span across the board (top or underside), to make connections with either the Z80 bus or the PIO(!). My personal feeling is that such practices are best left alone. The presence of this breadboard obviously does not subtract from the rest of the machine, but the board area could have been more usefully employed in extra RAM or PIO sockets, or a socket for another device.

Being, myself, in the field of hardware and software design, I could not avoid a careful scrutiny of the circuit diagrams and monitor listing given in the manual. The hardware and the monitor program are designed very competently, but not without a few points to question. For example, the breakpoint facility is implemented in hardware but under software control (this refers to the STEP and SBR functions). Without going into too much detail, a single output line from the 8255 device is used by the monitor to generate an NMI (non-maskable interrupt), delayed a few instruction cycles by a counter (type 74LS90). You will have to take my word for it that both these faciltiies could be provided purely by software! It would involve rewriting some of the existing routines to make space for the additional (fairly simple) software, but would eliminate the counter chip and, more importantly, release the NMI input on the Z80 for user applications. On the same point, there is no reason why the SBR function could not be allowed to set more than one breakpoint.

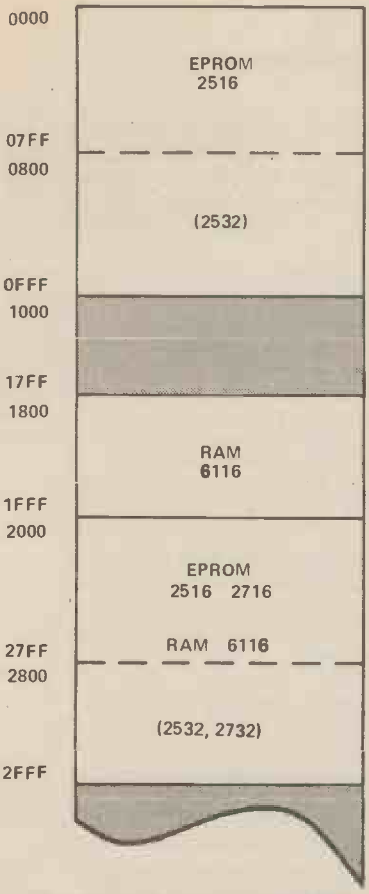
The choice of the Z80 microprocessor in the MPF is probably due to the immense popularity of this device in industry and, as such cannot be criticised. Personally, I feel that it is too complex a device for beginners, with its vast instruction set and large assortment of registers. In my experience, once the basics have been grasped it is a relatively simple matter to 'relearn' another machine, even if it is more complex. Therefore, perhaps the 6800 or 6502 (or even the 1802!) with more compact instruction sets and fewer register types would have been a better choice.

Manual Matters

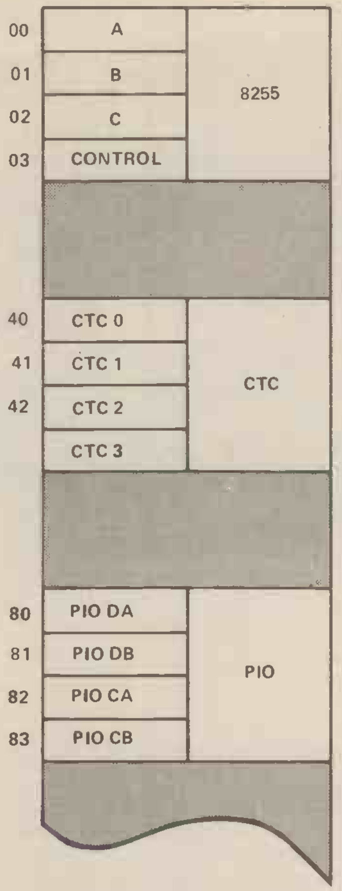
All the advertising literature and, indeed, the MPF manual itself make it clear that the Micro-Professor is a teaching aid, aimed at the uninitiated amongst students, hobbyists and engineers, and it is in that context that the machine must also be judged. Now, while no machine can *alone* teach the fundamentals of micro-processor operation or machine code programming, a well-written book, on the other hand, can. However, a teaching tool like the MPF can support a well-conceived manual or course of lectures by adding enjoyment and inspiring imagination in what may otherwise seem a very dry subject. It must also be said that seeing and believing (ie, "hands on experience") is the larger part of understanding.

In the initial stages of learning, then, the MPF manual must be taken as of primary importance and the machine secondary, despite relative costs. Against this philosophy, I cannot find kind words for the manual supplied with the Micro-Professor, though, if, in concession, the manual is assessed on the basis of the owner being fully conversant with microprocessor principles, it is adequate — but barely so.

The manual is in three parts; the operating instructions together with hardware details, a listing of the MPF monitor, and a course of 'experiments'.



The memory-map of the MPF.



The I/O address map.

It is very apparent that the text has been translated (from Taiwanese?) for, as is invariably the case, words have been translated reasonably accurately but grammar has been doubtfully touched. There are numerous scratch-outs and handwritten corrections which, when taken with poor printing of tables and diagrams (obviously photocopied from their original sources), leave a sad impression, compared with the machine itself. My main critisism, however, is related to the actual content and layout of the manual. The only sections that deal in fundamentals are the preparatory paragraphs at the beginning of part III; there are only eight pages which deal (very superficially) with some, but not all, of the important subjects.

There is little point in discussing the manual in any greater detail. It is sufficient to say that if you already have an understanding of Z80 fundamentals, then you should be able to extract the information you want; however, this could have been made very much easier.

In summary, the Micro-Professor is a well designed well constructed piece of hardware, with most of the facilities required by its area of application; that is, as a low-cost training tool or development system. But if, as a newcomer to the subject of microprocessors and/or electronics, you are considering the purchase of this machine, I advise investigating the availability of additional literature or teaching on these subjects, to supplement or, better still, supplant the supplied manual. **HE**

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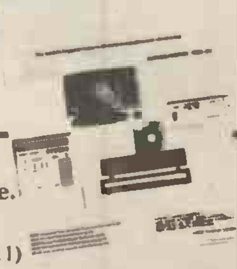

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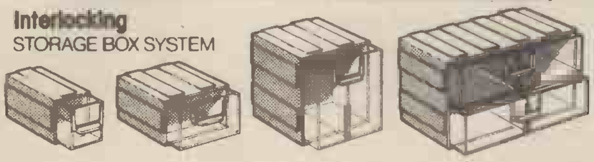

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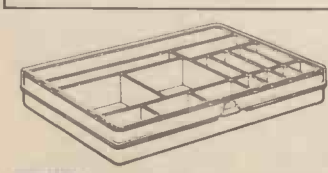

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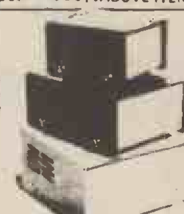

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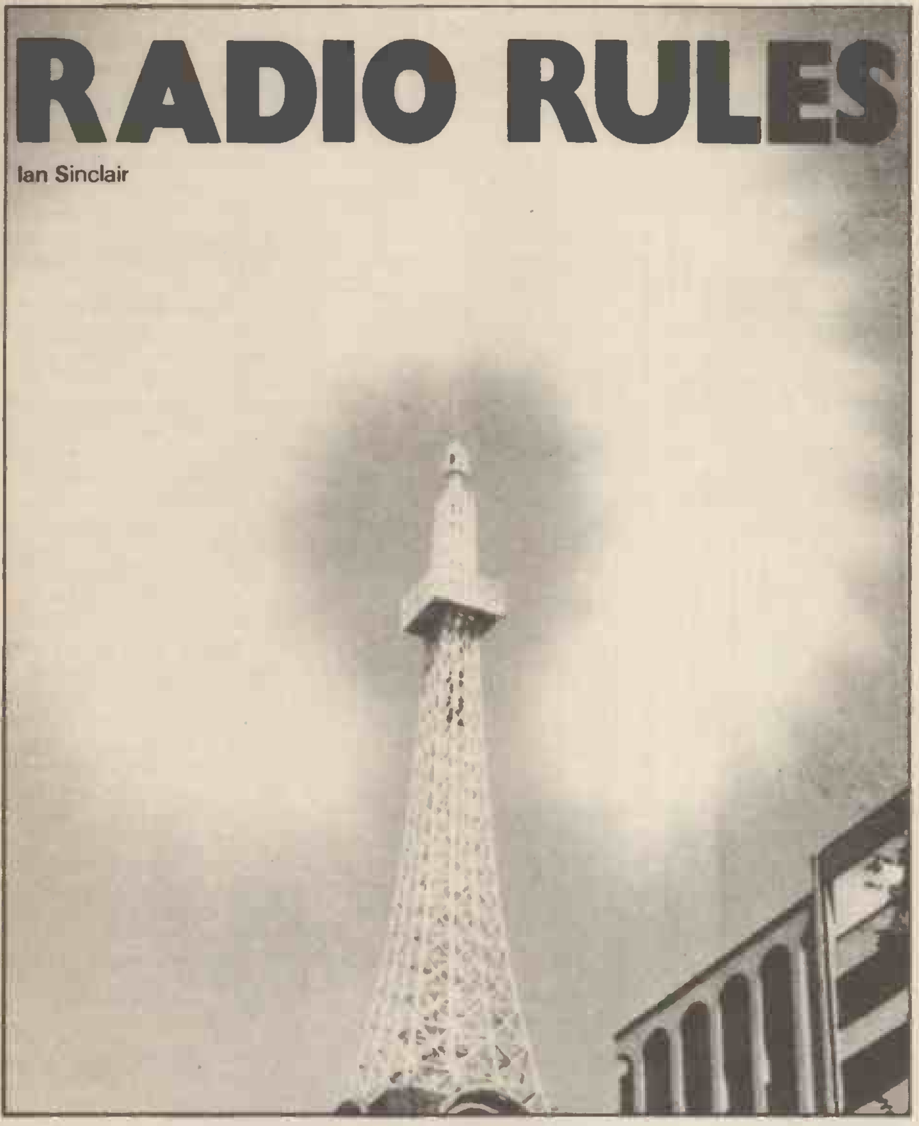

RADIO RULES

Ian Sinclair

FM

LAST MONTH we looked at amplitude modulation and RF power stages. It only remains to mention briefly the PA modulation stage and interference problems, before we can move on to looking at FM.

The established method of modulation is at the PA stage, for AM transmitters. If the carrier is modulated at an earlier stage then the PA will have to be linear, rather than Class C. Though this allows a much simpler modulator to be used, the disadvantage of using linear PA (remembering that only a fraction of the power is useful) in place of the cheap and simple Class C design usually outweighs the advantages.

Modulation at the PA is carried out by altering the supply voltage to the stage. Instead of taking the supply directly from the power pack, the supply current passes through the secondary of a modulator transformer (for high-power stages) or a modulator transistor (low power). The effect of an audio signal into the modulator is to make the supply voltage to the PA stage rise and fall in time with the audio waveform. The minimum voltage on the PA stage will supply DC minus the audio peak voltage, and the maximum voltage will be supply DC plus audio peak, so that the resulting signal is still symmetrical around the DC supply voltage, as it must be. This means that the amplitude of the unmodulated carrier will be greater than the amplitude of the unmodulated carrier for half of the AF cycle, and less for the other half cycle. The modulator, in fact, contributes to the carrier power and at 100% modulation depth the extra power added to the carrier by the modulator is 50%. This means that a carrier of 150 W (remember that's the DC power from the supply) will need a modulator stage with a power output of 50% × 150 = 75 W to modulate it fully. This is a minimum figure, disregarding losses and general inefficiency, so that a figure of 100 W would be a better one to aim at.

Some modulator circuits are illustrated in **Figure 1**.

Problems Of Interference

All transmitters are potential sources of interference, and one of the conditions of obtaining and holding an amateur licence is that you should be aware of how interference can be caused and what can be done about it.

In general, there are three main ways in which a transmitter can interfere with reception on other bands. One is by excessive bandwidth, so that your transmission overlaps an adjacent frequency, like the CB guy near me who manages to get out on several channels at once! The second possibility is harmonic radiation, so that you interfere with broadcasts which are at a multiple of your output frequency (or other frequencies used in the transmitter, for example by multiplier stages). The third possibility is self-oscillation at the PA stage, which can cause interference with a wide range of frequencies that are not in any way related to the band in which you are operating. This last is the most serious, because its effects are so unpredictable. We'll deal with these problems in more detail later, but some points are worth stressing at this stage.

Adjacent frequency interference is caused by using an excessively wide bandwidth, or by drift. Drift is a problem that can be tackled by attention to the oscillator, and we've looked at that in detail already. The bandwidth problem can be tackled by restricting audio bandwidth, using a low pass filter in the audio circuits prior to the modulator stage, and by avoiding overmodulation, which always causes excessive bandwidth ("splatter"). Overmodulation results when the amplitude of the carrier decreases to zero on each audio cycle **Figure 2**; this causes the waveshape to become very distorted,

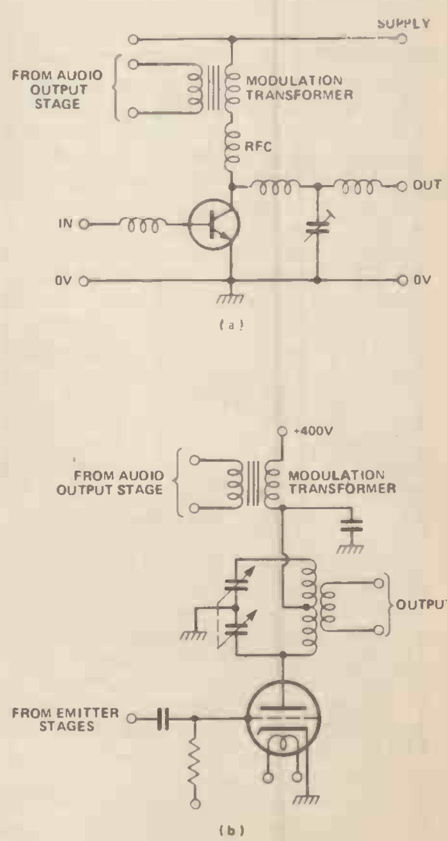

Figure 1. The most common modulation system for AM transmission uses a modulation transformer in series with the supply to the collector of a transistor (a) or (b) the anode of a valve.

so that both harmonic and adjacent band interference are caused. Overmodulation isn't easy to avoid because the way the microphone is used can make a considerable difference to the audio signal. The problem is best tackled by using an AGC circuit (similar to the automatic recording level circuits of tape recorders) in the audio stages.

This also increases efficiency by keeping the modulation close to 100% while you are transmitting, making the best use of the carrier power. A cheaper, but less satisfactory, alternative is to use a modulation indicator which will warn you when you are approaching 100% modulation.

Harmonic interference occurs on frequencies which are an exact multiple of the frequency of the transmitter; a transmission at 28.4 MHz is likely to cause interference at 56.8 MHz, 85.2 MHz, 113.6 MHz, and so on, these being 2 ×, 3 × and 4 × the transmission frequency. Some of these harmonics may coincide with heavily-used bands, and severe interference will be tracked down very quickly, so avoiding harmonics is important if you want to keep that precious licence.

Harmonics are caused by non-linear stages; class C stages used as PAs are the main offenders. Since harmonics are inevitably at a much higher frequency than the transmitter output, they *should* be comparatively easy to eliminate from the aerial circuit by using low-pass filters, such as the all-useful pi-filter. Unfortunately, because harmonics *are* at high frequencies, they radiate easily from wiring, so that careful attention to screening, construction and biasing of high-frequency stages is needed. It isn't enough to connect a low-pass filter in place and assume that all your worries are over!

Self-oscillation can arise because of stray capacitance, RF chokes and decoupling components all resonating in addition to the 'official' tuned circuits. It can be eliminated by the use of 'lossy' cores in RF chokes and resistors in series with some decoupling capacitors, so as to put a load onto any potential resonant circuits. Every tuned circuit can have a series resonance as well as a parallel one and every choke can resonate with its own capacitance, as well as with decoupling capacitors. By following a tried and tested circuit, using the correct components, the risk of self-oscillation is minimised. If you find that the final PA stage current fluctates considerably when you put your hand anywhere near the stage (but don't touch it!), that's an indication that there may be unwanted (parasitic) oscillation occurring. The presence of 'parasitics' can be confirmed with an instrument such as an absorption wavemeter, which can detect radiation over a wide range of frequencies. If you find, on checking, that your transmitter has an output only on its stated frequency, having used the wavemeter over its full range, then you can be reasonably sure that no unwanted oscillations are occurring.

Frequency Modulation

Modulation, you recall, means changing some feature of a high frequency carrier signal so that it carries another, lower frequency signal, which in our case is usually an audio signal of some sort. Amplitude modulation means that the maximum amplitude of the carrier is altered (modulated) by the low frequency signal. Frequency modulation, proposed by Edwin Armstrong 'way back in the 30s, varies the frequency of the carrier to convey the audio signal. Somehow, a frequency modulated wave is less easy to imagine than an amplitude modulated one, and it becomes easier to see what is happening if we take number examples, even if they are figures we wouldn't use in practice.

Suppose we have a 1 MHz carrier and we have decided that we will frequency modulate it. We first of all have to decide how much we can shift the frequency; this is a quantity called the 'maximum deviation', or 'peak deviation'. Suppose we make this quantity 20 kHz; what this means is that when we modulate with the largest amplitude audio signal we can use, the positive peak of the audio signal will cause the carrier wave frequency to be shifted to 1.02 MHz (1 MHz + 20 kHz) and the negative peak of the audio signal will cause the carrier wave to be shifted to 0.98 MHz (1 MHz − 20 kHz). If the amplitude of the audio wave is less, then the deviation of frequency is also less; it might well be less than 1 kHz, for example.

As the audio modulates the carrier, then, the frequency of the carrier is shifting up and down around the central value (1 MHz, in this example) and the rate at which it changes is equal to the frequency of the audio signal. At 100 Hz, an audio signal of the maximum amplitude would cause the frequency of our imaginary carrier to change from 1 MHz to 1.02 MHz, then down to 0.98 MHz and back to 1 MHz one hundred times per second. That's a lot of frequency shifting, and it uses a lot of bandwidth — more than you would expect because of what are called 'sidebands', of which more later. For the moment lets just say that these always amount to a lot more than the maximum deviation, so that the FM system is not one we would want to use in bands where we are short of space for sidebands.

Why use FM, then? There are several reasons and one very important one is that the amplitude of the carrier wave is constant. This means that there is always a large amount of signal being sent out, so that the ratio of carrier amplitude to noise should always be fairly good. The other feature is that all forms of natural interference affect the amplitude of the signal, not its frequency, so that it's possible to make FM systems which are practically free of natural interference.

Broadcast FM services use a peak deviation of 75 kHz on the band between 90 MHz to 108 MHz but, for amateur use, narrow-band FM (NBFM) is much more common, using peak deviations of around 2 to 3 kHz. One great advantage of NBFM is that, since interference to TV is caused mainly by amplitude modulated signals, narrow-band FM will cause much less interference, even when the signals are on almost the same frequency.

Receiver Differences

The use of FM in place of AM leads to some differences in the design of receivers, but not quite so many as you might expect. The mixer and IF stages are pretty much the same, though the IF stages may have to be stagger tuned or loaded with parallel resistors to allow a wider bandwidth than is usual for AM. In addition, there may be at least one extra IF stage, used as a "limiter". This is designed to remove any trace of amplitude modulation from the signal, because most types of FM de-modulator circuits will demodulate AM to some extent. A really good FM receiver will use more than one limiting stage, one with a short time constant, which will remove impulse noise (pulses, such as are produced by car ignition circuits) and one with a longer time constant, to remove the modulation from AM carriers so that they are not demodulated by the FM receiver circuits. Nowadays, an IC is more likely to be used, and **Figure 4** shows the old-style CA3028A in this role.

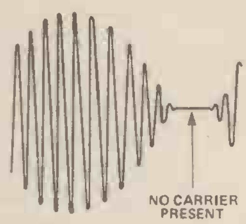

Figure 2. Overmodulation causes the carrier to be cut off for part of the modulation cycle, causing excessive distortion.

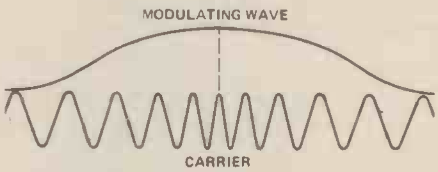

Figure 3. Frequency modulation; the carrier frequency is altered by the amplitude of the audio signal. When the amplitude is maximum, the carrier frequency is also maximum.

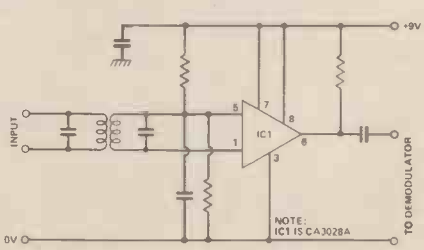

Figure 4. A limiter circuit, using an old-fashioned CA3028A IC.

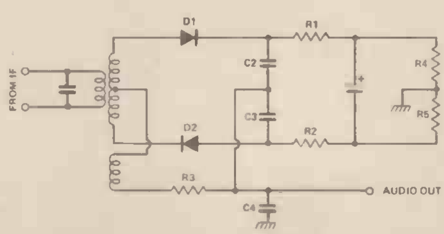

Figure 5. The ratio detector, at one time the most commonly used FM detector circuit, is still much used because of its simplicity.

The simple diode demodulator, which is favoured for amplitude demodulation, is of little use for FM demodulation (except in cases of desperation!) so that specially-designed demodulators, called discriminators, have to be used for good results. The ratio detector (Figure 5) is a circuit that is much favoured in commercial FM radios, mainly because it can be used without a limiter, thus cutting costs. For amateur radio narrow-band work, however, a better standard of performance is needed, and the choice is usually between a crystal discriminator and a PLL (phase-locked loop) IC.

A typical crystal discriminator is shown in Figure 7. Its operation is by no means simple but, briefly, it depends on phase shifts. C1 and L1 are tuned to the IF centre frequency (the frequency of an unmodulated carrier) and have a much wider bandwidth than the crystal, which is also tuned to the IF centre frequency. Capacitors C1 and C2 take signals in the same phase to diodes D1 and D2 and, when the input is at the centre frequency, there is no output because the voltages across the diodes are in anti-phase, cancelling each other. When the frequency changes, however, there is a violent phase shift across the crystal and the voltages across the diodes are no longer 180° out of phase, thus causing an output. This output reverses polarity as the frequency shifts from higher-than-centre frequency to lower-than centre frequency, providing the audio signals. The main advantage of the crystal detector is that it needs no specialised setting-up procedure, in the way that ratio detectors and Foster-Seeley discriminators do, and it is, in addition, particularly well suited to narrow-band work, being much less effective for wide-band operations.

The PLL is a much more modern method. A phase-locked loop is an IC which includes a phase detector, a filter, a DC amplifier and a voltage controlled oscillator (Figure 8). The voltage controlled oscillator (VCO) is set up, using an external resonant circuit, so that it runs at around the IF frequency, the centre frequency. The phase detector will produce a DC voltage whose size depends on the phase difference between the incoming IF signal and the oscillator signal. This DC voltage is filtered, to remove any trace of modulation, and used to change the frequency of the VCO so as to lock it to the incoming signal both in frequency and in phase.

When the signal input to the PLL is frequency-modulated, the "DC" voltage that is used to correct the VCO will have to vary, to keep correcting the VCO frequency, and so will vary according to the frequency modulation. In other words, it's the audio signal that we want and no tricky adjustments are needed to obtain excellent results. The earlier PLL ICs had rather restricted frequency ranges, around 500 kHz, but later types such as the NE561 can be used up to 30 MHz. The circuits following these PLL discriminators, as with any discriminators, are low-pass filters to suit the audio bandwidth needed.

One feature of FM which sets it apart is its noise-suppressing ability. A good FM signal is practically free of any type of interference and will be received with a silent background by a good quality receiver (yes, they do exist — don't go by the CB rigs you've heard!). This can have its disadvantages if you are trying to hear a weak FM signal because weak signals will simply disappear in the presence of a stronger signal of around the same frequency. This is called "capture effect"; what happens is that the signals mix together at the front end of the receiver, and the weak signal modulates the strong one. In such a mixing, the modulation is amplitude modulation and since the receiver removes all traces of amplitude modulation, only the strong signal is detected. This can cause very disconcerting effects at times when several users are on about the same channel!

Transmitters And Recievers

The differences between FM and AM transmitters are considerably greater than the differences between FM and AM receivers. If you are transmitting FM you can forget about Class C output stages to start with, because a Class C stage simply doesn't cope with varying output frequencies. Modulation methods, in particular, are very different, as you might expect.

Since there's no simple way that you can modulate frequency after it has been generated, modulation is carried out at the oscillator. Unless a VFO is used (and that's not a particularly good idea, because the frequency stability is not really good enough), the amount of modulation will be very small because a crystal oscillator does not change frequency very much, even when the capacitance across it is changed. Fortunately, the way we use crystals helps here. If we are working in the 144 MHz band, for example, using a 6 MHz crystal, then we need to multiply the crystal frequency by 24 and any frequency deviation that is caused at the crystal is *also* multiplied by 24. In this way, if we want to work with a deviation of 5 kHz at 144 MHz, the deviation of the crystal frequency need only be 1/24th of this, which is only 208 Hz. As a percentage of the crystal frequency, this is about 0.004%, and it's easily achieved by circuits such as the varactor diode modulator shown in Figure 9. Remember that FM is permitted only in the higher frequency bands, so that this multiplier effect will always be working.

The PA for such a system must be Class B or Class A-B, rather than Class C and to avoid *unwanted* modulation, the power supply to the modulator circuits must be well stabilised because any voltage change will affect the varactor diode and cause a change of frequency.

Direct modulation of the oscillator is by far the best and most popular method of achieving frequency modulation, but it is not the only possibility. An alternative is to use a fixed frequency crystal oscillator stage and to 'phase-modulate' at a later stage. If the audio amplifier circuits, used prior to modulation, are filtered with the correct amplitude frequency characteristics, phase modulation can produce a signal which is indistinguishable from that of FM and will be decoded by any FM receiver. Phase modulation is far from being a simple method, and is best suited to higher power transmitters than can be licenced in the UK, so that the simple frequency-modulated crystal oscillator method is the best bet.

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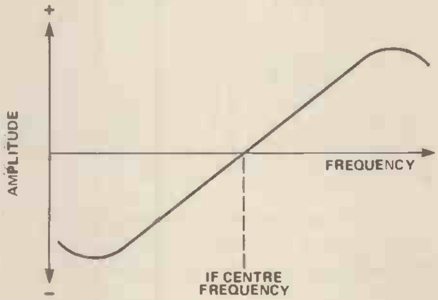


Figure 6. The idealised frequency-vs-amplitude graph of a discriminator.

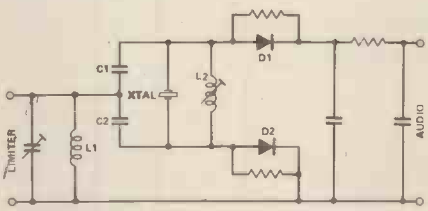


Figure 7. The circuit of a crystal discriminator.

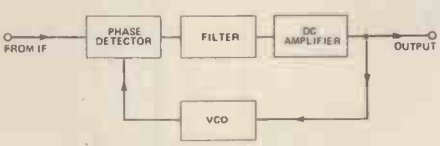
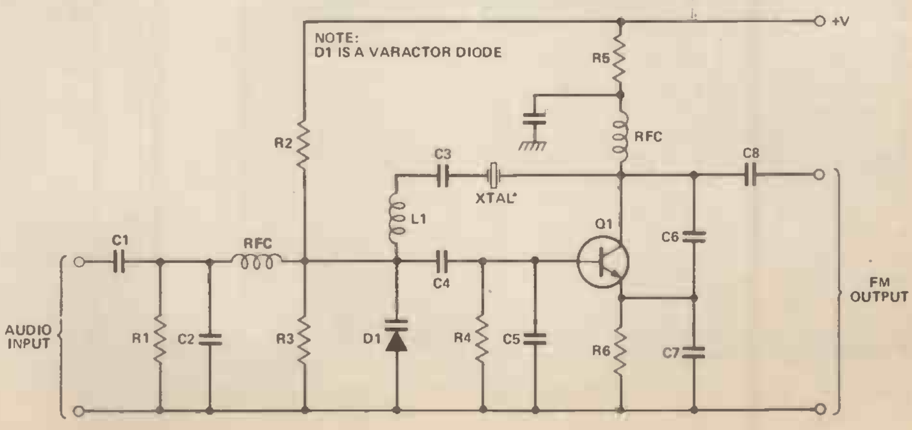


Figure 8. The PLL (phase locked loop) circuit is conveniently packaged in a single IC.

Figure 9. A typical FM modulator, based on a varactor diode.▼



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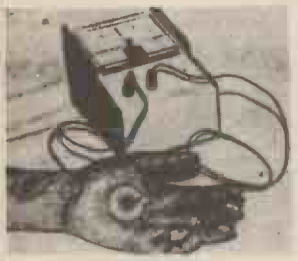

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Breadboards

The design and development of an Audio Phaser.

JUDGING by the number of letters we received following the Tone Control design in September's Breadboards, it seems that you'd prefer more 'project-like' circuits to be developed. So, we've decided to hold over your designs (until next month) to present one more breadboard *project* . . . and go out 'in a blaze of glory'. This circuit will, in a subsequent edition of HE, develop into a full length project — a high spec phasing unit.

A Passing Phase

Professional phasing units achieve this well-known effect by splitting an input signal into two separate paths; one of which is delayed before being re-mixed with the other. By carefully controlling the delay time, the phasing sound is produced. However, such effects' units do not come cheap and even home built devices must contain certain expensive ICs to obtain reasonable results. So, the alternative is to produce a sound effect that is similar; but without employing complex delay circuitry. The basis for such a unit is a phase shifting network that can be swept across a frequency band. This is the subject of our breadboards circuit — a single op-amp phase shifter.

The circuit of the shifter is shown in **Figure 1**. It can be looked on as a differential amplifier configured as a high pass filter, with time constant (and corner frequency) dependent on the values of R3 and C1. However, the most interesting feature of the circuit is that by changing the time constant (ie by varying R3) there is an associated phase change.

The phase change could be achieved by placing a 10k pot in place of R3, but is here done by voltage control via Q1. The voltage on the gate of Q1 alters its drain-to-source resistance, which is in parallel with R3. In fact, the FET's resistance changes from a few hundred ohms up to several megohms, so the actual resistance at the ends of R3 will range from this value up to 10K — when the drain-to-source resistance of the FET is high, the parallel value with R3 is not altered significantly. So, the voltage on the gate controls the time constant and phase shift of the circuit. Apply a varying control voltage to the gate and you can sweep across a range of frequencies.

Clean Sweep

The sweeping, in our circuit, is provided by RV1, but in the phaser which will appear later, the sweep will be provided by a triangle wave generator, as shown — with a few modifications — in **Figure 3b**. The complete phaser will comprise four shift networks, a sweep generator, a buffer and a mixer connected as in **Figure 3c**. Each phase shifting network (**Figure 3a**) has a separate FET and all their gates are joined and fed from a single triangle wave. This produces a 'comb' filter sweeping across the audio spectrum.

The breadboard layout for our single stage phase shifter is shown in **Figure 2**. If you have a 'scope to hand you will be able to see the phase shift by comparing the input and output (with a sine wave source) — a dual beam 'scope is particularly useful for this — and rotating RV1 to produce the effect. By changing the value of C1 you can vary the frequency bands. Values down to around 10n may be used. If you're feeling adventurous you can build other shifters and wire them in series (cascade), controlled by a single voltage (all the FET gates connected together). This will give you a deeper effect — don't forget each stage requires power from the batteries — but don't be too ambitious!

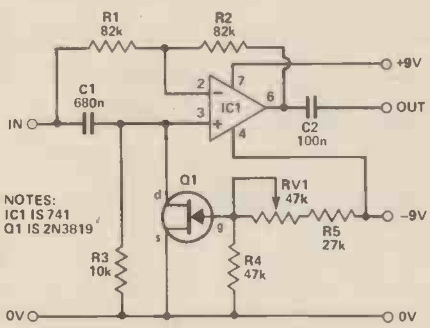

Figure 1. The circuit of an experimental single stage phase shifter.

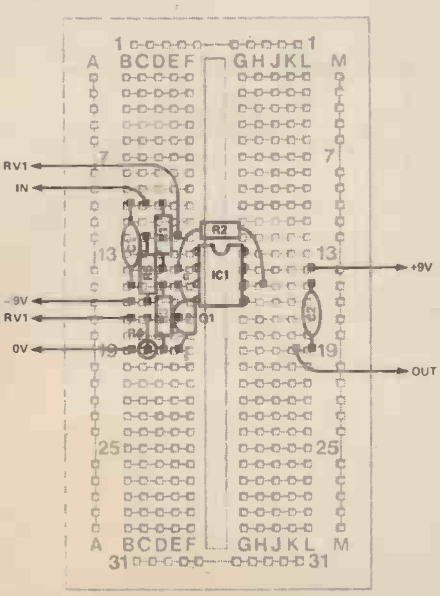

Figure 2. A breadboard layout for the circuit of Figure 1.

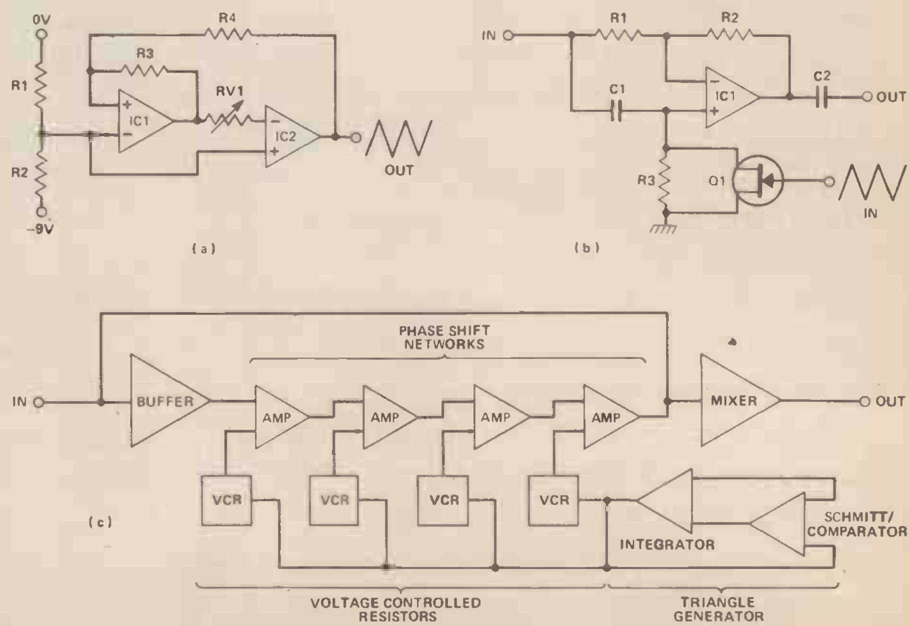

Figure 3. Development of a complete functional phase shifter; (a) the triangle wave sweep generator; (b) a single stage shifter with sweep input; (c) block diagram of the complete four-stage phase shifter.

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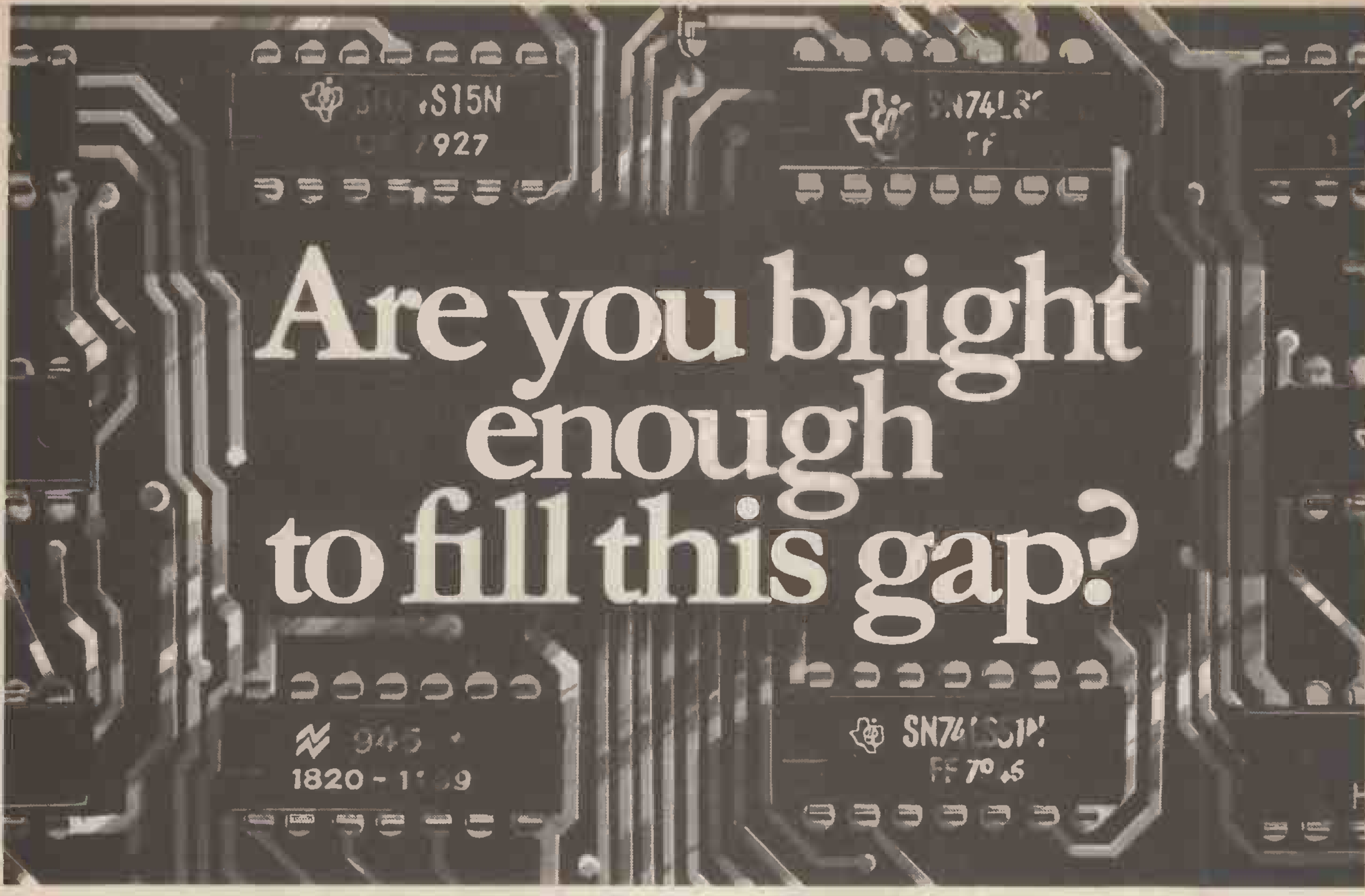

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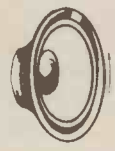

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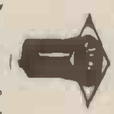

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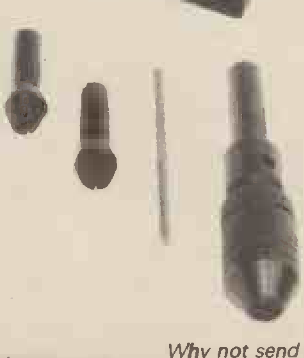

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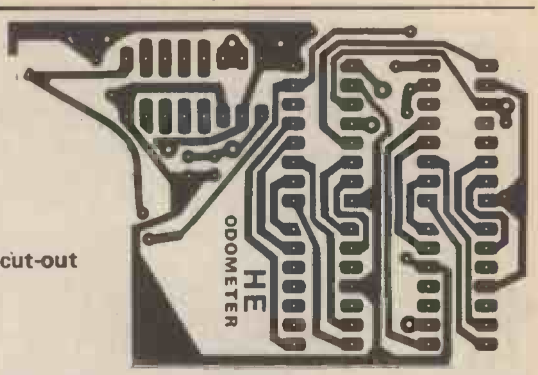
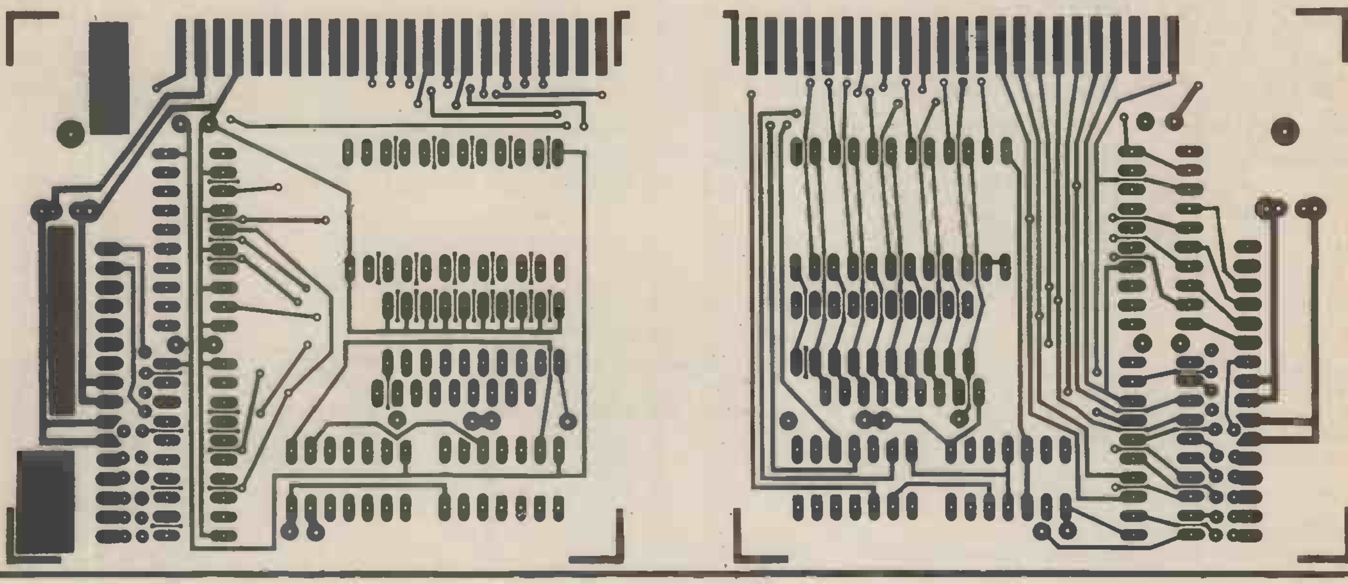
The PCB foilside pattern of the Pedometer/Odometer. The curved cut-out is to keep the batteries in place.





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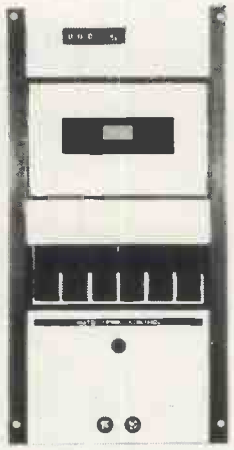

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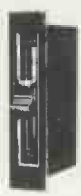

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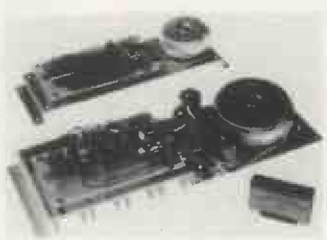

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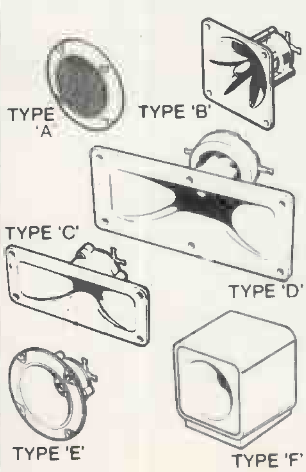

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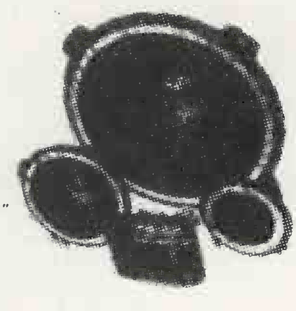

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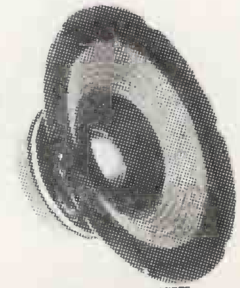

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