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PE ROBOTICS
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ISSN 0032-6372

VOLUME 21 Nº12 DECEMBER 1985

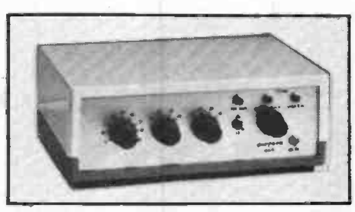
CONSTRUCTIONAL PROJECTS

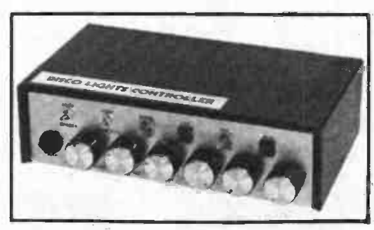
GENERAL FEATURES

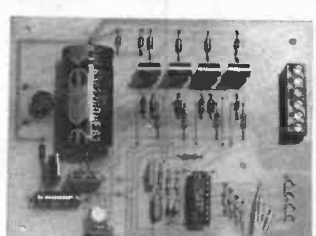
NEWS & COMMENT

FRONT COVER

Artist's impression of Giotto about to encounter Halley's comet. Illustration by Paul Doherty.







OUR JANUARY ISSUE WILL BE ON SALE FRIDAY, DECEMBER 6th, 1985 *(see page 47)*

PE VOLUME 21 Nº12 DECEMBER 1985

TRANSPUTER

IN APRIL '84 we published a feature on the Transputer; that feature was used by INMOS to aid their information to the industry and they reprinted it from PE—a nice compliment to Ray Coles who wrote it and we feel to PE.

At the time the Transputer was expected to be around by the end of the year. In fact INMOS have just recently announced availability of evaluation boards—perhaps not for the hobbyist at around £2,000 to £3,000. The component is significant because as most independent industry watchers acknowledge, it is the shape of things to come. INMOS are keeping the names of buyers and interested industry to themselves but it could lead the way to fifth generation computers, and we are told that it is being used in a number of experimental systems. When asked if Amstrad and Sinclair are showing interest, INMOS declined to comment. However, it is known that to be profitable INMOS must turn over large quantities. Other areas of particular appeal are concurrent workstations—where you can both simulate and create designs at the same time—and robotics.

At the present time a few thousand chips have been made with "a good yield". INMOS claim a capacity of a million a month. If they ever make that many I guess we will all have fifth generation watches! The transputer could be very good for INMOS, it could do a power of good for the UK's standing in high technology, and it could make incredible computing power readily available. Time will tell and much depends on swinging manufacturers away from "traditional" microprocessors.

HOBBYIST

How will it all affect the hobbyist? I doubt if we will ever publish a design using a transputer but we hope before long to be looking at devices which use them and we expect to be able to go on assisting readers' understanding of such devices so that interfacing, etc. can be undertaken. As Ray Coles said in '84 "the age of the truly intelligent supercomputer cannot be far away!"

FREE CHART

We are pleased to carry the free Data Chart in this issue. This is the result of a special arrangement between PE and Electrovalue with assistance from Siemens. The chart will introduce many readers to a new range of i.c.s, and we hope a number of new designs will result. Due to various packages being available for most chips pin data has been omitted but this is available from Electrovalue as are all the featured devices.

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Letters and Queries

We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped addressed envelope, or addressed envelope and international reply coupons, and each letter should relate to **one published project only. We are unable to answer letters relating to articles more than five years old.**

Components are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Old Projects

We advise readers to check that all parts are still available before commencing any project in a back-dated issue, as we cannot quarantee the indefinite availability of components used. **We are unable to answer letters relating to articles more than five years old.**

Technical *and* **editorial** *queries and letters to:*
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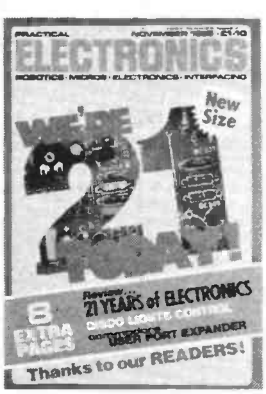
We regret that lengthy technical enquiries cannot be answered over the telephone.

BACK NUMBERS and BINDERS . . .



Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at £1 each including Inland/Overseas p&p. When ordering please state title, month and/or issue required.

Binders for PE are available from the same address as back numbers at £5.50 each to UK or overseas addresses, including postage, packing and VAT.

Halley Comet cash-in

Only once in every 76 years does the cosmos provide us with such a visual treat as Halley's Comet. It is mankind's nature to exploit nature and this cosmic phenomenon will be no exception. Its commercial potential is being pushed to an all time high, the Halley Comet bandwagon is estimated to be worth around $500 million.

A recent *New Scientist* article highlighted the ingenious money making efforts of many groups, General Comet Industries, for instance, has trademarked the words "Halley", "comet" and "official" and is licensing others to use its logo. Besides the usual T-shirts, badges and bags the company have launched a "Pin-the-tail on the comet" game. According to Owen Ryan the founder, his company is likely to reap around $10 million worth of the market.

Andrew Fraknoi, executive director of the Astronomical Society of the Pacific is no exception. He is leading a party of around 80 enthusiasts to a prime viewing location in the outback of Australia. The group will be housed in a make-shift tent city.

Because the comet will be higher in the sky in the southern hemisphere viewing conditions there will be most favourable. The comet will be so far away on its return that it will be a great deal dimmer than it has been on recent visits. The far side of the sun will witness its peak activity.

Many trips to the southern hemisphere are planned, not all of them for dry land observation. A Royal Viking Line cruise from Auckland to Sydney will have Carl Sagan on board to address starry-eyed passengers who could pay up to $10,000 for the privilege. Other global viewpoints will be Argentina, Chile, The Peruvian Andes and South Africa.

Share certificates in Halley's Comet are available from Owen Ryan's company at $9·95 for 100 shares. The reverse of the certificate promises a cometary return on April 29th, 2061. It would seem that Mr Ryan is not a complete capitalist, for when he received an order for 5,000 bottles for his "comet-pills" from a film company wishing to promote the film *Lifeforce*, he would not supply the goods. "The film was negative and contained unpleasant graphic effects," he said. The plot depicted a hostile comet upon which astronauts had managed to land only to be overwhelmed by blood-sucking space vampires—well it takes all sorts.

Halley's Comet is the subject of a feature article, by Dr Patrick Moore OBE, in this issue (see page 28).

PRESTEL FOR AMSTRADS

This special offer from Cirkit should interest Amstrad users who wish to access Prestel. The package comprises modem, interface and software, compatible with the CPC 464, CPC 664 and CPC 6128. The set-up which retails at a fraction under £30 is fully approved by British Telecom.

The modem is British designed and is acoustic, it will fit all standard and Herald type telephones. 1200/75 baud operation allows access to Prestel, Micronet, BT Gold etc.; furthermore 1200 baud half-duplex allows program and data transfer between users over the telephone system. An earpiece allows the progress of a call to be monitored, battery operation gives portability and ease of use.

The interface is housed in a plastic enclosure that plugs into the disc drive port, a through bus connection allows the disc drive to be plugged into the back of the interface.

Full support is provided for the modem, with additional features enabling the driving of further modems, printers, plotters etc. Baud rates supported are 75/1200, 300/300 and 1200/1200.

The software supplies full feature support for the modem, it is supplied on cassette but is fully disc compatible. Information is displayed in real time, allowing page exit as soon as header details have been seen. Full Prestel support is featured, including up to 16 on-screen colours and dynamic frames. The software has many other features including access to BT Gold (and similar), it is supplied with "extensive documentation".

Limited Prestel access can be gained free of charge using the identification code 4444444444 (password 4444).

The menu driven package is priced at £29.99 (inc. VAT and p & p). Access/Barclaycard accepted, cheques payable to Cirkit Holdings PLC. Allow 28 days for delivery. From Cirkit Holdings PLC., Park Lane, Broxbourne, Herts. EN10 7NQ. (0992 444111).

MEMBRANE SWITCH KITS

Swissinco UK Ltd. is now offering a total membrane switch and keyboard service to small users.

Because of the unique membrane switch technology used and the size of the range, it is possible to implement a variety of solutions, ranging from a full custom-design service for large users down to a low-cost, easy-to-use prototyping kit for one-off or small-quantity applications.

Products can also be supplied to special requirements, including environmental protection to different standards and the incorporation of visual, tactile and audible feedback. Details from, Swissinco UK Ltd., Unit 2, 225 Hook Rise South, Surbiton, Surrey KT9 7LD. (01-397 7041).

ROBOT BOOK

Robotics is one of the most rapidly expanding areas within the electronics and engineering world. Recently published *The Robot Book* by Richard Pawson takes a well illustrated look at the world of robotics and would be an ideal Christmas gift.

The introductory pages skip through the ancestry of this fascinating subject, and show how the automatoms (sophisticated clockwork "toys") of the eighteenth century paved the way for present day experimentors.

Subsequent sections deal with all aspects of the science on a fundamental level, from science fiction, films and toys, to interfacing and artificial intelligence. A substantial quantity of pages are dedicated to practical projects using Lego and Fischertechnik constructional components.

This book cannot be regarded as an in-depth reference. It provides, however, a comprehensive insight into the world of robotics. For those requiring information at this level it will provide a fine source of factual and pictorial information. *The Robot Book* by Richard Pawson is published by Frances Lincoln Ltd. Measuring 210 × 280mm and with 192 pages, it is priced at £7.95 paperback (ISBN 0 7112 0414 4); and £12.95 hardback (0 7112 0414 4).

MARKET PLACE

Drawing on experience

Now if you're wondering what to buy for the professor in your life this Christmas, and you have £99.95 to spare, how about this amazing calculator from Casio.

The FX7000G draws graphs, charts statistics and plots data on a screen as well as being a powerful programmable scientific calculator.

Data can be entered as a series of Cartesian points, from which the user can quickly judge the shape on the display, whether it be a straight line, a single exponential or double exponential curve. For linear relationships, the machine can calculate the parameters of, and then actually draw, the regression line through the plotted data.

For visual presentation of statistics bar charts can be displayed, representing populations of data cells, and draw lines to connect peaks together. Approximations to Gaussian or Poisson distributions can be quickly recognised. This is in addition to its routine standard deviation analysis.

In the realm of purer mathematics, FX7000G is equipped with 82 preprogrammed scientific functions, and can directly draw graphs of 20 of them, including trigonometric, hyperbolic and logarithmic functions and their inverses. Graphical representation of more complex equations is obtained through programming—to a maximum of 422 program steps, allowing use of a minimum of 26 memories, and up to 10 program areas.

One graph can be overlaid on another, traced by a cursor and points of intersection assessed with great precision.

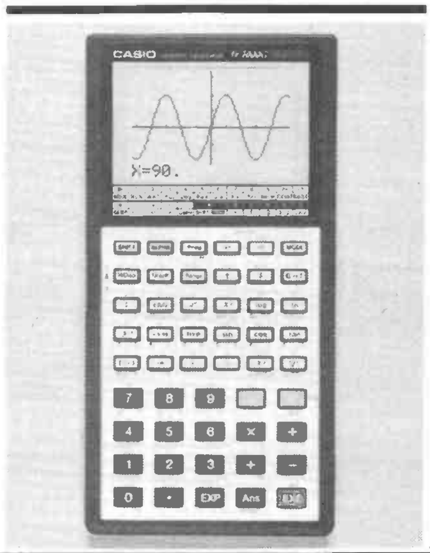
The FX70000G measures 35 × 52mm. It accommodates 63 × 95 dot graphics, or 8 lines of 16 alphanumeric characters for input, output, status display or program listings. Details from Casio Electronics Co. Ltd., Unit Six, 1000 North Circular Road, London NW2 7JD. (01-450 9131).

RADIO FOR THE DEAF?

A recent report in *Electrical and Radio Trading* (Aug. 8 '85) casts a 'gloomy' shadow over the future of the radio world, it shows that listening figures are down. The report is mainly concerned with the dilemma faced by 'brown-goods' business people, and in particular with what can be done to revitalise their industry. Apparently the market is saturated, and listening figures have declined in the last three years to a level where the percentage of the adult population who listen to the radio has fallen from 62 to 54 per cent.

The re-vitalisation of this market could conceivably come from any quarter, but one rather bizarre suggestion has been put forward by Mintel Market Intelligence, the people who provided the facts and figures used in the report. They suggest that the sort of development required might transmit words, via digital technology, that would appear on a visual display simultaneously with the sound output, thus "creating a fashionable new product".

Mintel point out that the average household has access to at least two radios.



FARADAY DAY

British Telecom is presenting the 1985–86 series of Faraday Lectures on behalf of the Institution of Electrical Engineers. Entitled "Beyond the Telephone: the Intelligent Network", the lecture began its tour of 16 towns and cities in October this year and will end in March 1986, playing to an estimated audience of more than 70,000 people.

The lecture explains to the layman how microchip technology is changing telecommunications, and how engineers are bringing its benefits direct to the user.

Many of those attending will be students from schools and colleges, and British Telecom's lecture aims to give them a greater understanding of how modern telecommunications operate.

Mr Bill Jones, British Telecom's Chief Executive of Technology and the senior Faraday lecturer, said: "As we move into the information age it is becoming increasingly important that people understand the technology that is changing our lives. Young people, who may be about to choose a career, will be a particularly important part of the audience."

There are usually three performances at each venue. Morning and afternoon performances are attended by local schools; the evening performance plays to the general public, members of the IEE and their families. For venues, dates and (free) ticket information contact: The Faraday Officer, The Institution of Electrical Engineers, Station House, Nightingale Road, Hitchin, Herts. SG5 1RJ. (0462 53331).

POINTS ARISING . . .

NOV '85
Disco lights controller
The captions for the photographs on page 47 (3 and 4) should be transposed.

Countdown . . .

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below. Note: some exhibitions may be trade only. If you are organising any electrical/electronics, radio or scientific event, big or small, we shall be glad to include it here. Address details to Brian Butler.

Compec Nov. 12–15. Olympia. **A**
Electron & BBC User Nov. 14–17. New Horticultural Hall, London. **B**
What Telephone & Communications Show Nov. 17–19. Novotel, Hammersmith. **C**
Computers In The City Nov. 19–21. Barbican Centre. **D**
Acorn User Christmas Show Nov. 22/23. Central Hall, Westminster. **E**
Scottish Home Computer/Electronics Show Nov. 22–24. Anderston Centre, Glasgow. **F**
6809 Show Nov. 23/24. Royal Horticultural Halls, London. **E**
International Test And Measurement Nov. 27–29. Olympia. **G**
Which Computer Show Jan. 14–17. NEC, Birmingham. **H**
Hi-Tech And Computers In Education Jan. 22–25, Barbican Centre. **I**

A	Reed Exhibitions ☎ 01-643 8040
B	Database ☎ 061-429 8157
C	Judith Patten PR ☎ 01-940 6211
D	Online ☎ 01-868 4466
E	Edition Scheme ☎ 01-346 6566/7
F	Trade Exhibitions Scotland ☎ 041-248 2895
G	Network ☎ 0280 815226
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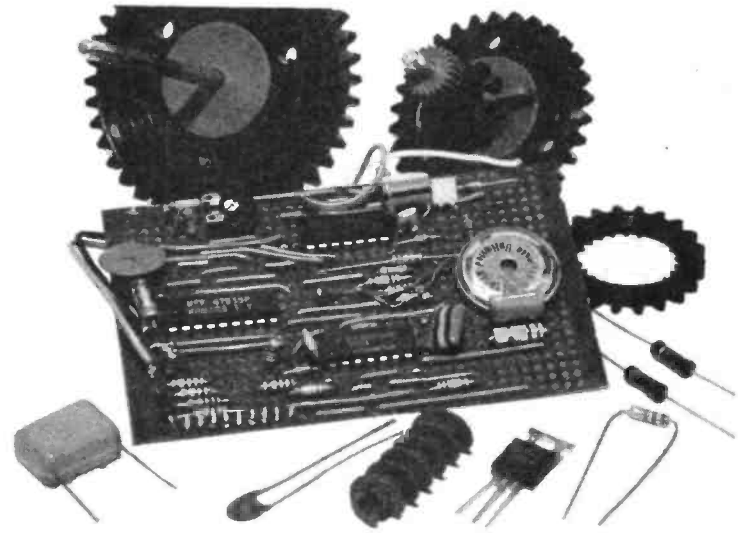
I	BEEA & Computer Marketplace ☎ 01-930 1612

Experimenting with ROBOTS

Mark Stuart Part 4



High Performance Stepping Motor Driver

THE current interest in robotics, and the interfacing of computers to a wide variety of mechanisms, has led to the extensive use of stepping motors. The principles of stepping motor operation have been described in many recent articles, notably *Everyday Electronics* August 85 issue. An accompanying article in the same issue described a simple interface for driving such motors from a computer user port. This interface used the very popular SAA1027IC which provides a simple low cost circuit with a minimum of components. Because of its simplicity the SAA1027 i.c. is incapable of extracting anywhere near the full performance from a motor. The maximum stepping rate and the high speed torque are limited and there is no facility for half step operation.

To obtain the highest performance from stepping motors it has been necessary to use complex control circuits built from discrete components and logic i.c.s. Now, however, a new i.c. is available developed exclusively for driving unipolar 4 phase stepping motors. It provides all the switching functions for forward and reverse stepping in half and full step mode. Four inputs are required by the i.c. and these are all TTL compatible. The i.c. is not designed to drive stepping motor coils directly. Instead four outputs are provided which are capable of sinking up to 50mA. These are used to drive external power transistors.

THE TEA1012

The i.c. is known as the TEA1012. A functional diagram is shown in Fig. 1. Four inputs are required to control the i.c. These can be derived from any four bits of a computer user port (hence two drives could be handled by a standard 8 bit port).

Their functions are as follows.

PIN 14	$F/\overline{H}$	— Selects full or half step operation
PIN 13	$\overline{CW}/CCW$	— Selects direction of rotation
PIN 12	$\overline{STOP}$	— Holds the motor in its present position disregarding further clock pulses
PIN 15	CL	— Clock. The motor moves one step or half step on each low to high transition of this pin

The operation of these four inputs from a computer is quite logical. When the direction and step mode are set up and the stop condition disabled the motor steps each time a pulse is sent to the clock pin. As with all stepping motors there are limits to the maximum pulse rate and motor acceleration. These limits must be taken into account in the computer program.

STEPPING MOTOR DRIVE CHARACTERISTICS

When stepping motors are driven from a constant voltage source the torque decreases at higher step rates because the winding current has insufficient time to rise to its full value.

One way of overcoming this is to feed the motor with a higher voltage. This is fine at high stepping rates. At low stepping rates, however, the coil current has plenty of time to rise and the motor will overheat. A means of control is needed that produces a fast rising of motor current limited to the motor's maximum rating.

The TEA1012 offers two alternative methods of such control. These are: BI-Level Voltage Drive, and Constant Current Chopper Drive.

BI-LEVEL VOLTAGE DRIVE

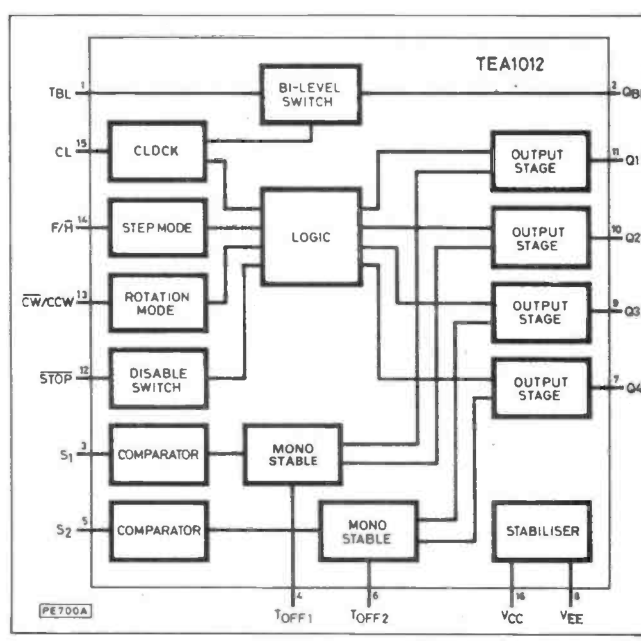
In bi-level voltage drive the motor is driven from two supplies. At the start of each step a high voltage supply is switched on to the motor for a predetermined time. This time is set to be just long enough for the current to rise rapidly to the maximum rated value for the motor. After this the high voltage is disconnected and the second lower voltage supply takes over. The lower voltage is equal to or less than the motor rated voltage so that the motor current is held safely at or below its maximum rated value.

In this mode of operation the TEA1012 uses a resistor and capacitor connected to pin 1 (TBL) to determine the pulse width of a monostable which sets the time for which the high voltage is applied. The output from the monostable appears on pin 2 (QBL). It is used to drive external devices which switch the high voltage supply.

This method is simple to understand and has advantages where a motor is stationary for a large part of the time. In such applications where only a low holding torque is required the lower voltage can be well below the rated motor voltage so that the motor can run very cool and power consumption is minimised.

Its only disadvantage is that two supply voltages are required. It is possible to use just a single high voltage supply and obtain the lower voltage by means of resistors, but this method is inefficient.

Fig. 1. TEA1012 block diagram



CONSTANT CURRENT CHOPPER DRIVE

In this method the motor is driven from a single high voltage supply which is switched to the windings according to the step sequence.

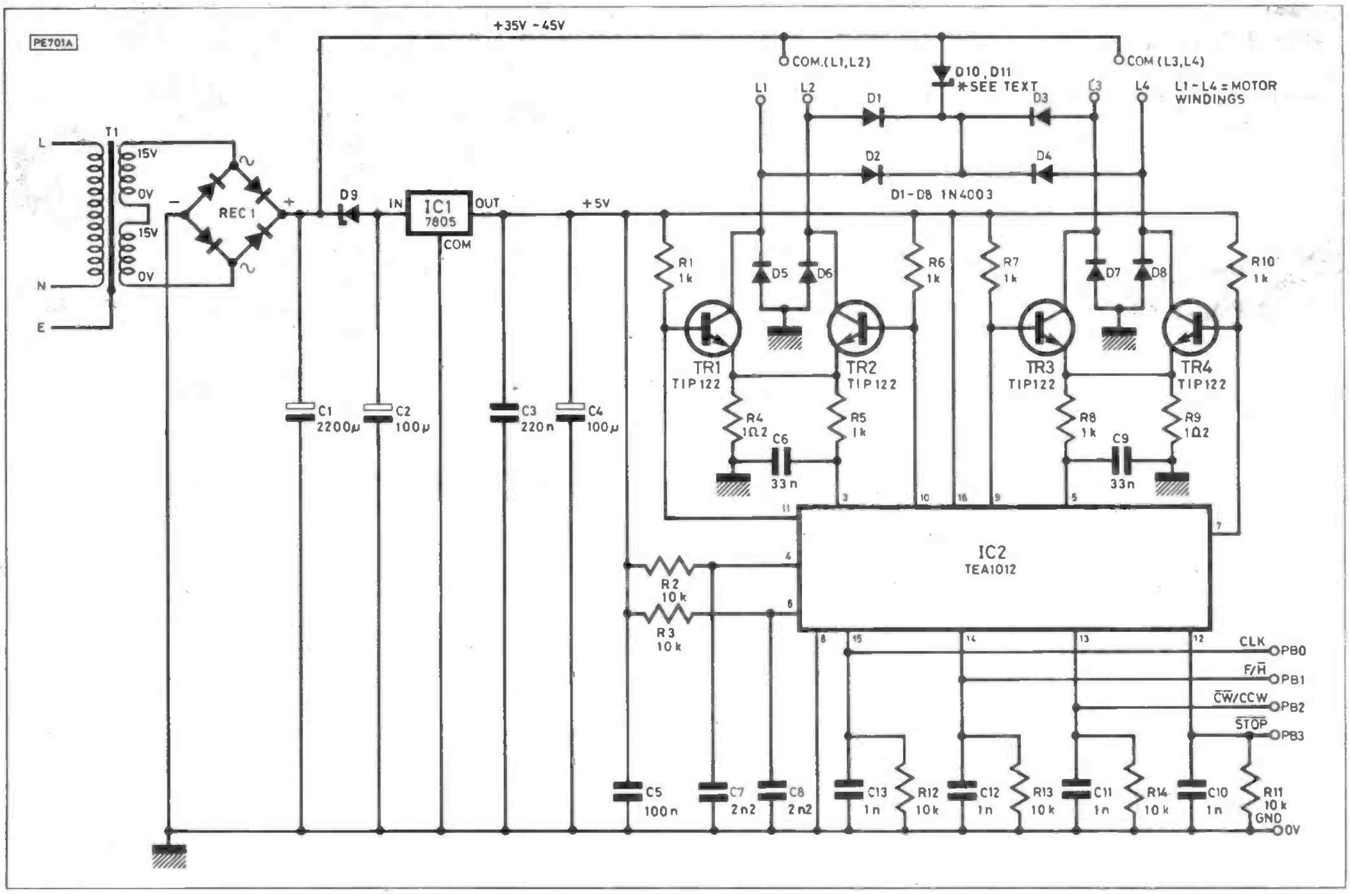


Fig. 2. Circuit diagram

The current in each motor winding is sensed, and when the required maximum current is reached the transistor driving the winding is switched off and on at a high frequency. The mark space ratio of the switching is set so that the average motor current stays at the required maximum level.

Power dissipation in the driving transistor stays low because it is either fully on or fully off, and so the circuit is very efficient.

This method provides full power to the motor at all times and so is suitable for all applications. As with BI-LEVEL VOLTAGE DRIVE the motor current rises rapidly because of the high applied voltage, and equally good high speed performance results.

PRACTICAL CIRCUIT

A circuit using the TEA1012 in the constant current chopper mode is shown in Fig. 2. This circuit uses a 35 to 45 volt supply. Its effect on stepping motors rated between 5 and 12 volts is quite spectacular. Maximum stepping rates exceeding 3000 steps per second are possible with excellent high speed torque.

The circuit has been evaluated using a BBC computer user port to provide the drive signals, but any computer port will do and programming is quite straightforward.

The four input lines are fitted with pull down resistors R11–14 and small decoupling capacitors C10–13 to prevent spurious pick up of the motor switching pulses from affecting operation.

Four outputs from the i.c. on pins 7, 9, 10 and 11 are used to drive power switching transistors which handle the full motor winding voltage and current. These outputs are 'open collector' types and so pull up resistors R1, 6, 7 and 10 are needed to provide the transistors with base current.

The coils of four phase unipolar stepping motors are wound in pairs and only one winding of a pair is energised at a time. This means that only one current sensing resistor is required for the two transistors feeding each pair of windings. R4 is connected in the emitters of TR1 and TR2 and senses the current for motor windings L1 and L2. Similarly R9 senses the current for L3 and L4.

The voltage across the sensing resistors passes to the i.c. via simple low pass filters consisting of R5 and C6 for L1 and L2, and R8 and C9 for L3 and L4.

These filters are there to remove switching transients from the feedback signal.

The i.c. compares the feedback signal with an internal 0·4 volt reference. As each winding is switched on the current rises steadily from zero at a rate determined by the inductance and resistance of the motor coil. As the current rises so the voltage across the sensing resistor rises. When this voltage reaches 0·4 volts a monostable circuit in the i.c. is triggered which turns off the supply to the winding by removing the base drive from the associated power switching transistor.

The current in the winding does not fall to zero instantly because of the inductance of the winding. Instead it continues to flow, finding an alternative path via D2 (for L1) and D10–D11, and decays steadily. This decaying current also induces a current in the other winding of its pair (which is wound in the opposite direction on the same core). The induced current flows via D6 (for L2) and is in such a direction that it aids the current in the other winding, thereby adding to the efficiency of the circuit. After a time, set by the period of the monostable components, the winding is again switched on. The current rises again until the feedback voltage reaches 0·4V, the monostable is then triggered and the cycle repeats.

Fig. 3 shows the saw tooth waveform of the current in the winding which results from the switching action. The frequency of the switching action is set by the current rise time and the monostable off time. The upper level of the current is that which

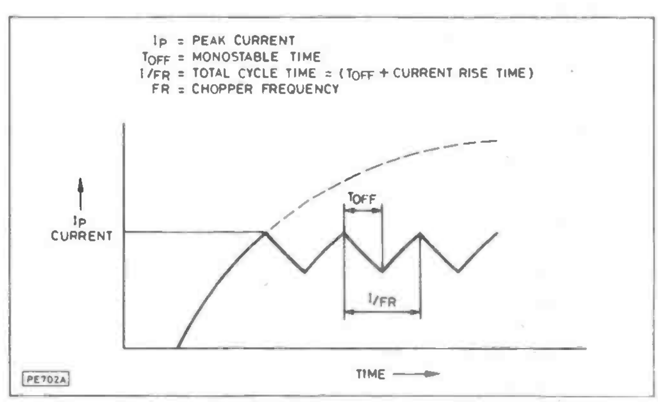


Fig. 3. Current waveform: Constant current chopper mode

produces a 400mV drop across the sensing resistor. A 1 ohm sensing resistor give 400mA and so on. The monostable off time is set by R2 and C7 for L1 and L2, and R3 and C8 for L3 and L4. The time is equal to 0·8 R.C., or 18 microseconds with the values given. The current rise time depends upon the motor inductance and resistance, and the supply voltage.

Ideally the switching frequency should be set just above the audible range ie 16–20kHz.

Note that this current regulation system is completely independent from the stepping action of the circuit. At sufficiently high stepping rates the current never rises high enough to trigger the monostable and so chopper action does not take place at all.

When the motor is stationary the chopper action operates continuously. The power supply is quite straightforward. A bridge rectifier and smoothing capacitor provide the main supply to the motor. D9 drops the voltage so that it is within the input rating of IC1, a standard 5 volt regulator i.c. which feeds IC2.

Zener diode D10–D11 limits the voltage to which the back EMF rises as each winding is switched off by the chopper control. Its value is selected to be just above the maximum operating supply voltage—in this case 45 volts. It is made up from two low voltage devices connected in series so that more readily available parts can be used.

Darlington power switching transistors have been used to keep the base current requirements down. As the collectors can swing up to twice the supply voltage 100 volt types are specified.

STEP SEQUENCE

Fig. 4 shows the state of the four switching transistors for each step in full and half step mode.

In full step mode two windings are energised at a time and the sequence repeats every four steps.

In half step mode the windings are energised individually as well as two at a time to produce an eight step sequence. There are two main advantages in using the half step mode. The motor resolution is doubled and resonance effects are greatly reduced.

Double resolution means that a motor which has 48 steps per revolution in full step mode will give 96 steps per revolution in half step mode.

Resonance is a problem affecting stepping motors which are driving loads that have low friction and high inertia. At certain speeds the inertia of the load causes the motor to overshoot after each step to such an extent that steps are lost and the motor 'dithers' out of control.

In practice resonance can be overcome by adding frictional resistance to the load and avoiding operation at the critical speeds. By operating the motor in half step mode these measures are usually unnecessary.

	L1	L2	L3	L4	FULL STEP
1	ON	OFF	OFF	ON	
2	ON	OFF	ON	OFF	
3	OFF	ON	ON	OFF	▲
4	OFF	ON	OFF	ON	▼
1	ON	OFF	OFF	ON	CW CCW
1	ON	OFF	OFF	ON	HALF STEP
2	ON	OFF	OFF	OFF	
3	ON	OFF	ON	OFF	
4	OFF	OFF	ON	OFF	▲
5	OFF	ON	ON	OFF	▼
6	OFF	ON	OFF	ON	CW CCW
7	OFF	ON	OFF	ON	
8	OFF	OFF	OFF	ON	
1	ON	OFF	OFF	ON	

Fig. 4. Switching sequences for full-step and half-step modes

One minor disadvantage of half step operation is that on alternate steps when only one winding is energised the torque is halved.

CONSTRUCTION

The circuit is built on a single printed circuit board which has been carefully designed to prevent interaction between the high motor voltages and currents, and the sensitive signal circuits around IC2. The four transistors are lined up so that a single heatsink may be fitted if high output currents are required. As the transistors are operated as switches the dissipation is small and heatsinks were not considered necessary in the prototype.

Fig. 5 shows the board foil pattern and the component layout. To simplify motor connections a 6 way terminal block is used for the output.

Input connections are shown labelled for a BBC micro user port, however, the circuit is suitable for use with any computer with at least 4 output port lines. A transformer rated at 18VA and 30 volts provides sufficient power for motors operating at up to 400mA per winding.

COMPONENT VARIATIONS

Different stepping motors require different operating currents and have different values of winding resistance and inductance. The motor current is set by the values of R4 and R9 which determine the peak current at which the monostable circuits are triggered. The chopper frequency depends on the monostable time, the motor inductance and resistance, and the motor supply voltage.

COMPONENTS . . .

RESISTORS

R1,R5–R8,R10	1k (6 off)
R2,R3,R11–R14	10k (6 off)
R4,R9	1Ω2 (2 off)

all ¼ Watt 5% carbon film

CAPACITORS

C1	2200μ 63V axial electrolytic
C2	100μ 25V axial electrolytic
C3	220n C280 polyester
C4	100μ 25V radial electrolytic
C5	100n C280 polyester
C6,C9	33n C280 polyester (2 off)
C7,C8	2n2 polystyrene (2 off)
C10–C13	1n ceramic (4 off)

SEMICONDUCTORS

IC1	7805 regulator
IC2	TEA1012
REC1	WO4 bridge rectifier
D9	13V 1·3 watt Zener diode
D10,D11	30V and 15V 1·3 watt Zener diodes
D1–D8	1N4003 diodes (8 off)
TR1–TR4	TIP122 transistors (4 off)

MISCELLANEOUS

P.c.b. mounting terminal blocks 3 way (2 off); 16 pin i.c. socket; tinned copper wire 22 swg approx; ½ metre, Veropins; printed circuit board; transformer—30V 18VA mains transformer; etc.

Constructors' Note

A full kit of parts is available from **Magenta Electronics Ltd., 135 Hunter St., Burton-on-Trent, Staffs., DE14 2ST. ☎ 0283 65435.** Price £20.98 excluding transformer. Transformer £5.98 extra, case for p.c.b. £2.95, BBC lead and plug £1.98, ID35 stepper-motor £14.50. All prices include VAT. P&P 60p extra per order. A cassette of the software is also available for £2 inclusive of VAT, etc.

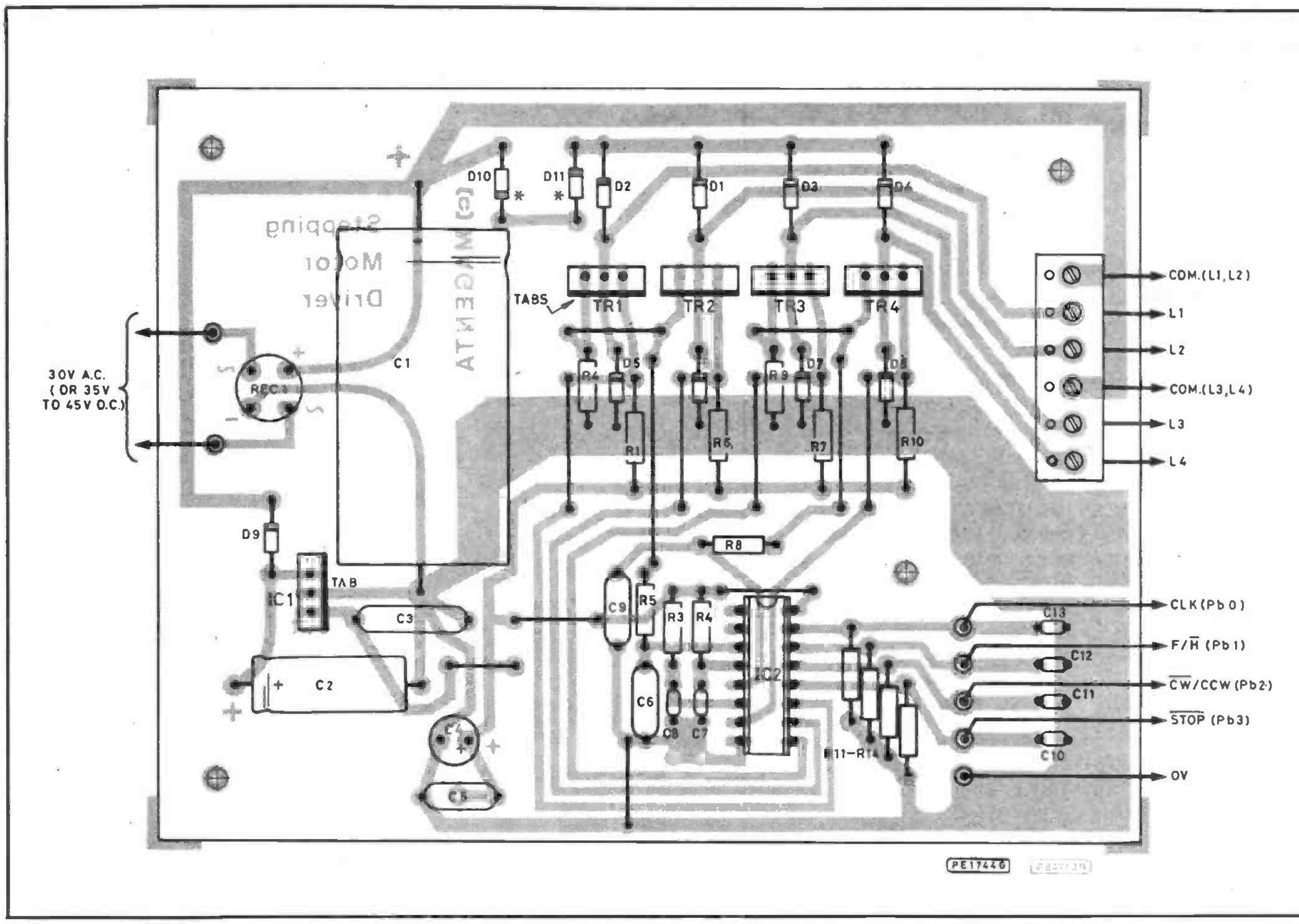
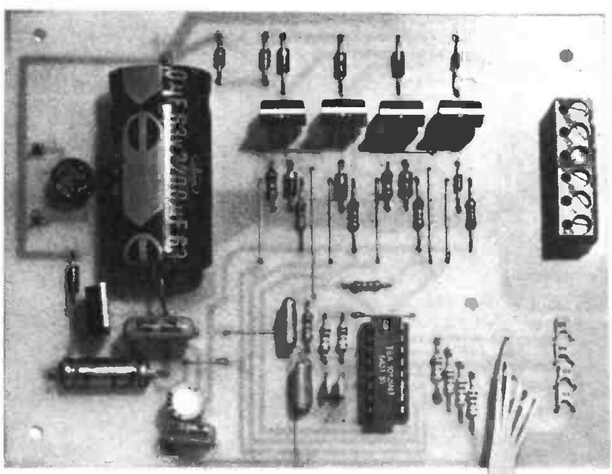
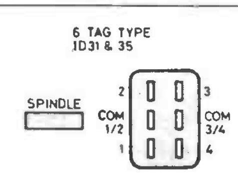


Fig. 5. Component layout of the Stepping Motor Driver





6 WIRE TYPE
HR23

SPINDLE END	REAR
YELLOW – 3 RED – 3/4 COM GREY – 4	YELLOW – 1 RED – 1/2 COM GREY – 2

Fig. 6. Standard stepper-motor connections

FISCHER TECHNIK

In Part Two of *Experimenting With Robots* (Oct. 85) we gave the address of Fischer Technik for the benefit of those wishing to obtain components of this construction medium. We have since been informed that all small orders from the general public should be addressed to: **Economatics (Education) Ltd.,** Epic House, Orgreave Road, Hansworth, Sheffield S13 9LQ. ☎ 0704 690801.

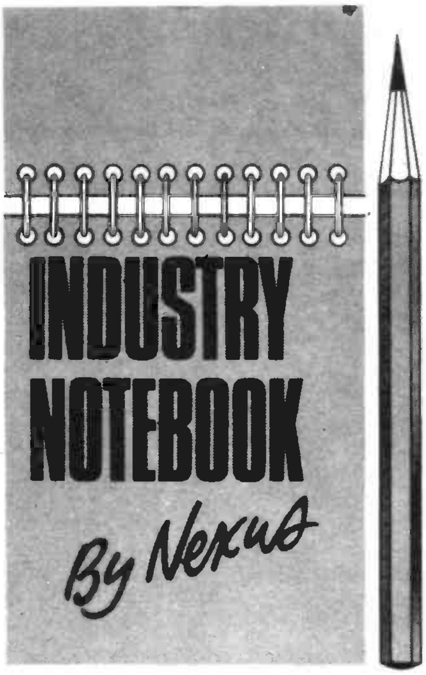
The values specified should work with most small motors, the ideal values for a particular set up can be found by experiment. It is worth noting that a stepping motor running at full power will run very hot. This is quite normal, the manufacturer's specifications allow a maximum operating temperature of 120°C.

PROGRAMMING

The functions of the four input lines have already been explained. It is a fairly simple matter to set up the necessary code for direction, and step mode, and to inhibit the 'stop' line.

The motor will step on each negative to positive (low to high) transition of the 'clock' line.

A simple BASIC program can be used for low stepping rates, but for the highest speeds a clock rate of 3,000 steps per second means machine code will need to be used. The motor and load inertia will limit the maximum speed at which the motor can be clocked from a stationary start. To run above this speed the motor must be accelerated by gradually increasing the clock rate. Similarly it must be decelerated in a controlled manner. The maximum acceleration and deceleration can be determined by experiment for the particular motor and load. One way to produce the ideal acceleration and deceleration from a computer program is to use a look up table to store a range of ever decreasng values which are used in succession by a timing loop. There are more elaborate (and compact) ways than this, but the programming skills needed are greater. ★



Graduate Demand

Last month I noted the shifting pattern of employment in the electronics industry in Scotland. Since then I have seen the figures for the whole of the UK published by the Engineering Industry Training Board. In round figures there were 21,000 scientists and technologists in the electronics industry in 1978. By 1984 the figure had grown to 34,500 although the total labour force had increased only moderately.

Today no less than 10 percent of all people in the electronics industry are of degree or equivalent status and this compares with only four percent for the engineering industry as a whole.

Looking at individual sectors of the industry the most startling increases have been in data processing and radio and electrical capital goods where the numbers of scientists and technologists have virtually doubled. Lowest increases were in office machinery and consumer electronics.

But while the ratio of skilled to unskilled employed has changed dramatically the geographical distribution of the industry has shown little change. The south-east is still dominant with 48.1 percent of employment, marginally up since 1978 while many of the less-favoured areas suffered small percentage losses. Scotland increased its share of the total from 9.3 percent to 11 percent and Wales came up from 3.3 percent to 4.5 percent. So even if you add Wales and Scotland together they are still dwarfed by the massive concentration in the south-east.

The message is plain. The greatest choice for a career in electronics is found in the south-east and the best chance of employment anywhere is to become well qualified though not necessarily in a narrow specialisation in the first instance. This will possibly come later.

The chronic shortage of well-trained people persists. Professor Richard Bishop, vice-chancellor and principal of Brunel University, reported recently that in design technology each graduate this year has had on average five offers of employment. Over the whole range of disciplines 95 percent of Brunel graduates are employed within six months of graduation.

Professor Bishop, a professional engineer, attributes much of the success of Brunel to the practice of every student spending three six-month periods working in industry during the four-year degree course. The newly graduated is thus anything but raw when entering full-time employment. From the employer's point of view the new recruit may still have much to learn but at least he has first-hand industrial experience and doesn't need six months to acclimatise in a new environment.

Education

PE Editor Mike Kenward is to be praised for expressing a view and inviting correspondence on electronics instruction (more generally lack of it) in schools. May I add my pennyworth by quoting Sir Kenneth Corfield, recent Chairman of STC.

In an interview published in the IEE journal *Electronics and Power* Sir Kenneth told of his own experience on leaving school. 'I remember very well the awful look on my headmaster's face when I told him I was going to become an engineer. And what he actually said to me was: "I am surprised Kenneth; we had you down at least to become a bank manager" '.

Well, that was the attitude 50 years ago and it doesn't seem to have changed much although some teachers would no doubt prefer the goal of trendy sociology to that of respectable bank manager, but even that in preference to science and engineering!

However, my somewhat jaundiced view of the teaching trade, brought about by over-exposure via TV to months of industrial action, has now been modified by the correspondence in PE. I am reassured that all is not yet lost and there is a silent majority of teachers who deserve to be regarded as professionals, the more so for decently doing their best in often difficult circumstances and encouraging their students by example to do the same. *(Here, here. Ed.)*

Industry Year

The Royal Society of Arts has designated 1986 as Industry Year. Apropos of the previous paragraphs I note that one of the RSA objectives is the establishment of links between schools and industry to promote mutual understanding, having recognised that we are an industrial country with an anti-industrial culture.

I hope that the special Industry Weeks to be organised in schools and colleges will point out to teachers and pupils that there is no such thing as free education. It is paid for from money generated in industry and other profitable enterprises—a brutal fact too often overlooked.

Partnership

A New Partnership: A New Britain. Such is the brave title of the joint TUC-Labour Party document published last August. Packed with bright ideas I believe it has a major flaw. The strategy outlined is based on the romantic concept of the brotherhood of man, of universal love, an ideal never yet achieved anywhere, least of all in the politics of the British left.

Although politics clearly has some influence on industry I often wonder whether that influence is not often overrated. I am reminded of Mr Ronald Ferguson who died this year at the age of 91 and spent 60 years in electronics. A school-leaver at 14 he taught himself telegraphy and went to sea in 1909 at the age 16 as the Marconi Company's youngest wireless operator and retired as managing director of Marconi Marine in 1961.

His active life spanned every development in electronics from the earliest spark transmitter to satellite communications. And this majestic progress from electronic infancy to our present maturity was virtually unimpeded by the policies of various governments. It mattered not who was in power or when because all the principal advances came about through scientific progress, private enterprise and an expanding and eager market.

Nonetheless we have to bear politics in mind and the TUC-Labour document deserves a fair scrutiny if only for the remarkable omission of any reference to renationalisation or even socialism.

Investment

Good news for Scotland is the £82 million investment by Digital Equipment Corporation in a new microchip plant at Edinburgh. Most of its output will go to the nearby DEC plant at Ayr for assembly into ICs. DEC's present workforce in the UK is about 4,300 expanding in the next 12 months to over 5,500. DEC's UK operation is second in size only to that in the United States.

An interesting development is the expansion at Telford of Tatung Co where a new factory (a refurbished aluminium factory) has been officially opened by Mr Norman Lamont, formerly Minister for Industry. Tatung is Taiwan-based but has a labour force in the UK of some 700 people producing colour TV and sub-assemblies under contract. It was Tatung who bought the Decca TV business from Racal after Racal's acquisition of the Decca group of companies.

It is a tantalising question why Far Eastern companies manage to be successful in consumer electronics production in the UK whereas wholly UK companies consistently fail. This despite the fact that the workforce and the economic environment are the same. The answer has to be motivation and better management.

Among the largest investment programmes this year has been that in cellular radio which has easily surpassed its initial targets in user take-up. The only pity is that so much of the equipment has been imported. Happily the situation is now changing with Technophone Ltd receiving full approval of the Excell pocket phone for use in the Vodafone network. Transportable Vodafones are also being manufactured under licence from the Finnish Mobira Company at Racal's Seaton factory and base station equipment at Carlton, Notts.

Cellular radio has certainly been the growth success story of 1985 and promises to provide steady growth for many years ahead.

Introduction to MICRO SYSTEMS

MICHAEL TOOLEY BA   DAVID WHITFIELD MA MSc CEng MIEE   PART 3

A POINT which usually occurs to most people sooner or later in their introduction to micros is: "How does a micro system actually start operating?". It is all very well to look at how the CPU is able to fetch and execute its instructions from memory, and the different ways in which it can manipulate data when up and running. However—and remembering the frequently-repeated point that there is *no* inherent difference between code and data—the question arises as to how the CPU knows where to start running this program when it is switched on. To put it another way, what prevents the CPU just starting to execute bytes in memory (from a random start address) as if they were instructions?

GETTING STARTED

The preoccupation with running systems just mentioned can obscure this type of consideration. It can also result in the situation whereby so much time is spent in looking at the way in which the system functions when it is running, that the problem of how to get it started up properly can easily be skipped over quickly, or even ignored altogether.

If this is the case, it can lead to significant problems when you come to actually design and develop a system. Indeed, it very quickly becomes apparent that one of the first milestones in developing a working system is to be able to get the system to *start* running through the main part of the program that has been written to control it. Only then do you need to start worrying about whether the program is actually designed correctly.

In some ways, the problem just described is somewhat analogous to worrying about the performance of a new racing car engine before you even know whether it is going to start for the race. Once started, it may function beautifully, but as every motorist will testify, starting can be a very big "if"!

SWITCH ON

The exact details of what happens at switch-on vary from one micro to another. The general principles, however, are very much the same and apply to almost all micros. With most, the start-up sequence can also be initiated even when the system has been running for some time by activating the "reset" input on the micro.

This is typically an active low input, and the micro restarts as the signal changes from low to high. This type of reset is often provided to allow recovery of the system from a "lock-up", or error, and is a facility which is usually very well exercised during debugging! A simple manual reset circuit for a 6800 system is shown in Fig. 3.1.

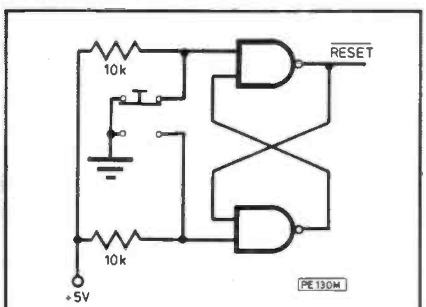


Fig. 3.1. 6800 manual reset circuit

IN PRACTICE

In practical systems, the power-on state is usually arranged to cause a reset to the system automatically to guarantee that the micro behaves in a predictable fashion. This usually means that after power is switched on, the reset input is held low for long enough to guarantee that the power supply has reached the required minimum operating voltage (typically +4·75V), and for long enough thereafter to allow the micro to complete the reset sequence. Fig. 3.2 shows a typical such reset circuit for a 6800-based system, whose timing relationships for the reset pulse and power supply start-up are shown in Fig. 3.3.

If required, the circuits of Fig. 3.1 and Fig. 3.2 can be combined by following the inverter in Fig. 3.2 with a 2-input AND gate, with its inputs fed from the two different reset signal circuits. The reset signal generated by this circuit can also be used to reset any other circuitry in the system.

As mentioned, there is usually a minimum time for which the reset input must be active to allow the internal operations involved to be completed. For example, the Z80 requires a minimum of 3 full clock cycles for the reset to operate correctly. The 6800, on the other hand, requires 8 cycles to elapse. The combined actions which are performed during the reset period or immediately afterwards are usually very similar for most micros. Only the order and the details tend to vary between different types. The reset pulse then, has a specified minimum duration, and after the pulse ends the next action is usually a delay for a small number of clock cycles before the processor starts/resumes processing.

Rather than continue the discussion in abstract, we will instead put these general concepts into more practical terms by looking a little more closely at the behaviour of the 6800 during and following a reset.

6800 RESET

While the reset input on the 6800 is low, and assuming that at least 8 clock cycles have passed, the CPU's output signals will be in the following states:

VMA	Low
BA	Low
Data Bus	High Impedance
R/$\overline{W}$	Read
Address Bus	FFFE

A timing diagram for the complete switch-on sequence is shown in Fig. 3.4. This shows the way that the conditions above are established.

Following the detection of a rising edge on the reset input, the reset sequence is executed by the CPU. During the reset sequence, the interrupt bit in the CCR is set to prevent any user interrupts (IRQs) from occurring too soon, and thereby throwing the CPU out of sequence before it has been set up to handle them. The contents of the last two memory locations (FFFE and FFFF) are then loaded into the program counter (PC).

The CPU then starts executing instructions, starting at the address just loaded into the PC (which points to the address of the *next* instruction to be executed). Thus, for example, to cause the CPU to start running its program from an address of (say) C000 after start up, the following would need to be set up in permanent memory:

FFFE:	C0	(start address high byte)
FFFF:	00	(start address low byte)

On a practical note, it should be noted that it is the memory addresses which *respond* when values of FFFE and FFFF are put out on the address bus which matter here. This can be a useful fact to bear in mind when designing the address decoding for the system's memory. This is essentially of academic interest, since a program normally only ever refers to a particular location by means of a single address. However, it does mean that it is possible to arrange that locations other than FFFE and FFFF are accessed when the reset sequence is executed.

It is quite usual for the reset *vector* (that is, the address which the CPU always accesses after a reset) to be located within the program

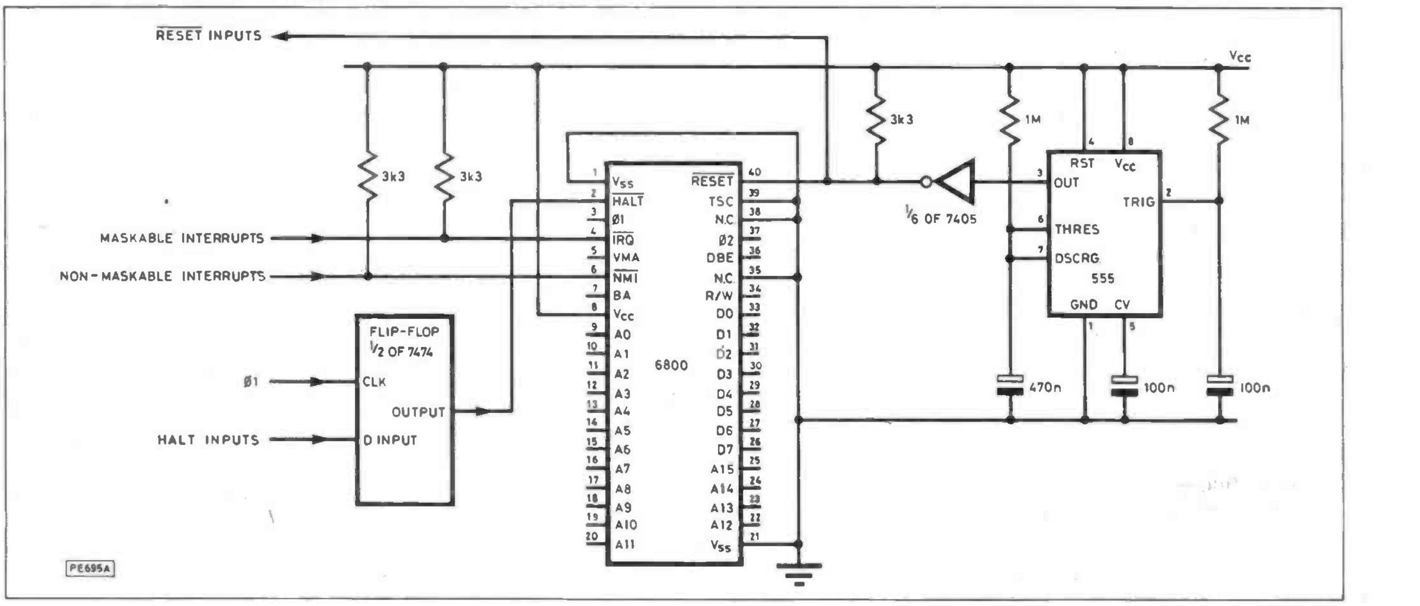


Fig. 3.2. Practical power-on reset circuit, ensuring that the micro starts up in a known state

ROM, right at the highest addresses. If we look back at the system described in Part One, the ROM represents addresses C000 to C3FF. However, if FFFF is put out on the address bus, this will actually access the ROM location at C3FF, due to only a partial decode being performed on the address bus for addressing the ROM. This is a very useful way of avoiding the need for special additional ROMs just to hold the reset (and other) vectors.

So, we have seen that in order to get a 6800 CPU to start up correctly, it is necessary to arrange for the reset line to be held low until at least 8 cycles after the supply rail reaches +4·75V. Thereafter, the line may be released to return to its normal high state at any convenient time. This will then cause the program *whose start address* is contained in FFFE and FFFF to be executed. This is summarised in the flowchart shown in Fig. 3.5.

What happens then is totally up to the programmer, so we now move on to look at the sort of actions which need to be taken to control a typical micro system *after* it starts up if it is to continue running as required. This section of the control program is usually referred to as initialisation.

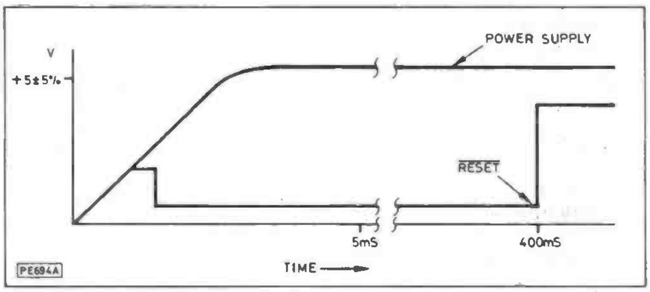


Fig. 3.3. Timing for power-on reset

INITIALISATION

Once again, the exact details of the initialisation routine will depend on the CPU and the configuration of the micro system itself. There are, however, a number of basic steps which are common to all systems.

The state of the CPU following the reset is that interrupts have been masked out. The basic steps which need to be followed are then:

1) set up the stack
2) configure any peripheral devices
3) enable interrupts

Of these operations, enabling of interrupts is certainly best left until the first two operations have been completed. If this is not done, the CPU may well be caught "on the hop" as it were, since an interrupt could occur (automatically performing a series of stack pushes) before the stack has been initialised. It is as well, therefore, to work through each of these stages in the order given above.

It may be occurring to some readers at this point that these issues are almost incidental to the workings of a micro system. However,

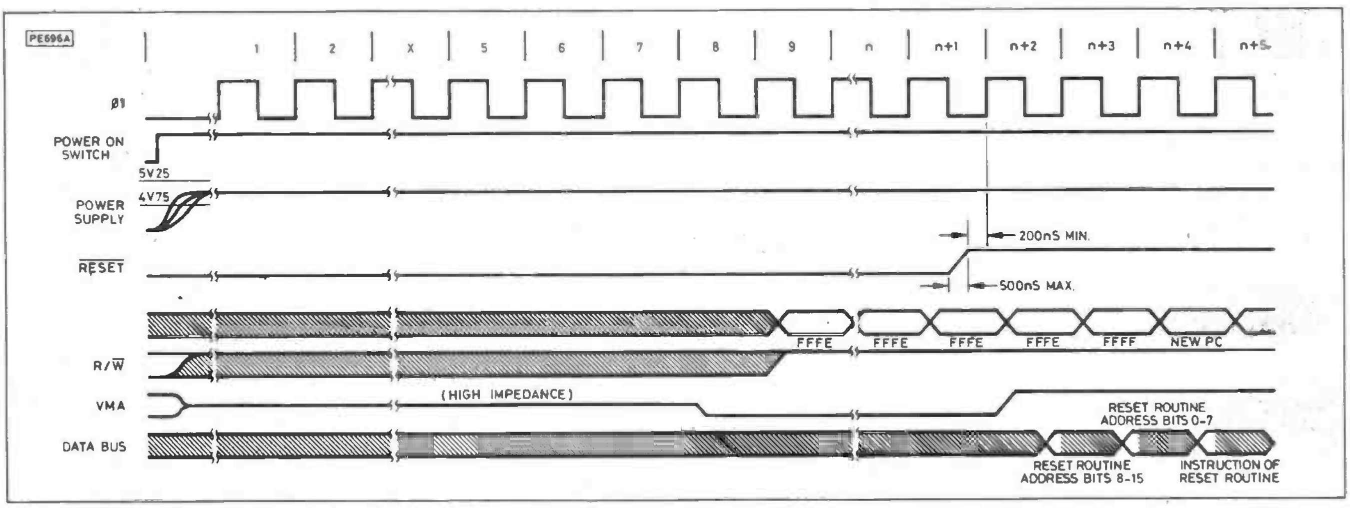


Fig. 3.4. Timing diagram showing the sequence of events after the micro is first switched on

experience shows that the majority of time spent in debugging a micro system can often be traced back to problems skipped over at initialisation. Thus, a properly set up stack is all but invisible in a working system and can be taken for granted, but a stack of inadequate length or with improperly matched push and pop operations can cause some *very* strange problems. Worse still, this type of error may only occur very occasionally, and to say that this type of bug can be hard to track down is something which does not need repeating to anyone who has tried.

The other point in discussing these topics in some detail is that they give a much better practical insight into how a micro system actually works. At the end of the day, writing the inner loops of the application code (e.g. the admittedly often complex routines to perform exotic mathematical functions or signal processing of data) is a relatively straightforward matter of using the available instructions in the most effective manner to achieve the required results.

The instructions themselves are well explained in the data books for the individual micros, and it is just(!) a question of selecting the appropriate ones for the particular task. At the worst, the answers produced are wrong, but there is usually something to indicate the nature of the problem, thus providing a starting point for tracking down the "bug".

However, getting the system to the point where the data is available to be manipulated, and being able to communicate with the outside world, usually involves more than two-thirds of the overall work required to complete the system.

The difficulty which causes the greatest delay at this point is that the usual response from the system prior to completing this stage is a stubborn silence. A major objective of this discussion, therefore, is to try to avoid or minimise the problems by covering the necessary ground rules for getting a system up and, if not exactly "running", not hanging up immediately after switch-on due to potentially avoidable reasons.

SETTING UP THE STACK

The stack needs to be set up in an area of RAM which is large enough to allow for the expected usage. Locating the stack is a straightforward matter of loading the stack pointer (SP) with the address in memory (RAM) where *top* of the stack is located. This is done by means of a special instruction, LDS, which loads two bytes from the specified memory locations (or which immediately follow the opcode) into the SP register. Thus, to load the value of 007F (i.e. the top of the RAM in our example system) into the SP, one way would be to load it as an immediate value with the following instruction:

```
LDS #007F
```

This would actually be coded as:

```
8E 00 7F
```

However, any of the other addressing modes available with LDS could be used to suit the particular application.

It should be noted that most micros do not include facilities for specifying a limit for the length of the stack, or detecting when stack space is exhausted. It is necessary, therefore, to make sure that sufficient memory is reserved for use by the stack. The space reserved (i.e. the unused area of RAM below the top of the stack) should take account of the number and type of stack operations that can be current at any time. System operations which make use of the stack are:

1) subroutine calls (BSR or JSR): 2 bytes each
2) interrupts (caused by external IRQ events): 7 bytes each
3) wait for an interrupt (WAI, same as an interrupt but saves time): 7 bytes each
4) push accumulator data onto stack (PSHA or PSHB): 1 byte each

Within a program, the use of the stack should be kept under careful control by the programmer. For example, the programmer should know how deep the subroutines will be nested, and allow sufficient stack space. Similarly, if the stack is to be used for temporary data storage, this must be taken into account when allocating space.

The only area of uncertainty here may be in the use of the stack by interrupts. This will be covered more fully later in the series, but essentially, the amount of space reserved for this purpose needs to take into account the maximum number of interrupts which can be pending at any given time, and 7 bytes must then be allowed for each. Overall, the golden rules to remember in using the stack are:

1) initialise the stack pointer *before* using the stack or enabling interrupts
2) allocate sufficient stack space to take account of the maximum expected usage (plus some extra space)
3) make sure that all stack pushes have corresponding stack pops (otherwise the stack will just continue to grow, and grow, . . .)
4) use RTS to return from a subroutine; *never* just jump out directly (subsequent nested subroutines will otherwise return to the wrong place, and the stack will grow)
5) use RTI to return from interrupt service routines (to prevent the stack just growing, as for RTS)

One point worthy of repetition is to remember that the 6800's stack pointer must be set up during initialisation to point to the *top* of the stack area, i.e. the highest address. Other CPUs have stacks which may work differently, and the details should be checked carefully before use.

Many of the points listed above are arguably simply examples of "good programming practice". They are nevertheless worth reiterating, if only to indicate *why* they must be observed. If the rules for stack usage are followed, the stack can usually be forgotten once set up, since it will automatically be maintained by the CPU, with the address in SP always pointing to the next free location on the stack.

CONFIGURING PERIPHERALS

In most micro systems, the setting up of peripheral hardware is usually a great deal more complicated than the setting up required for the CPU itself. As time has passed, peripheral control devices (such as floppy disc controllers and CRT controllers) have become ever more sophisticated.

The benefit of these powerful controllers is that they relieve the CPU of much of the detailed operations required to control the peripheral equipment. One consequence of this trend, however, is that peripheral controllers are rapidly becoming as complex and "intelligent" as the CPUs themselves.

Indeed, anyone who has struggled over the finer points of some of these controllers will probably lend their support to the theory that the controllers have already overtaken many CPUs in terms of complexity.

A good example of this trend is in the field of controlling floppy disc drives. With simple peripheral controllers, each CPU instruction which affects the controller has an effect on its own. In a floppy disc controller (FDC), the CPU must perform a sequence of operations (usually a mixture of read and write operations). It is these operations *combined* which represent what the FDC is being asked to do.

Once a sequence has been initiated, the FDC carries out whatever operation has been specified and, when complete, returns a result to the CPU.

One consequence of this method of interfacing with a peripheral controller is that the initialisation requirements are correspondingly more complex. While the simpler peripheral devices are relatively straightforward to initialise, it is a rather more involved matter for these "intelligent" peripheral devices. The 8271 is an FDC which was developed for use with the 8080 CPU, but which has since been much used with other CPUs, for example, in the 6502-based BBC Micro. It uses a control sequence, shown in Fig. 3.6, of the type described above. To give an idea of the practical initialisation requirements for such controllers, the flowchart in Fig. 3.7 illustrates the steps required to initialise the 8271 before it is ready for use.

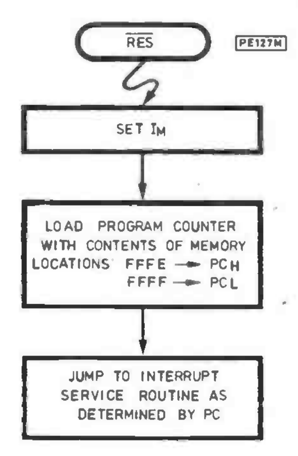


Fig. 3.5. Start-up routine

In contrast to the complexity of an FDC, the simplest of all

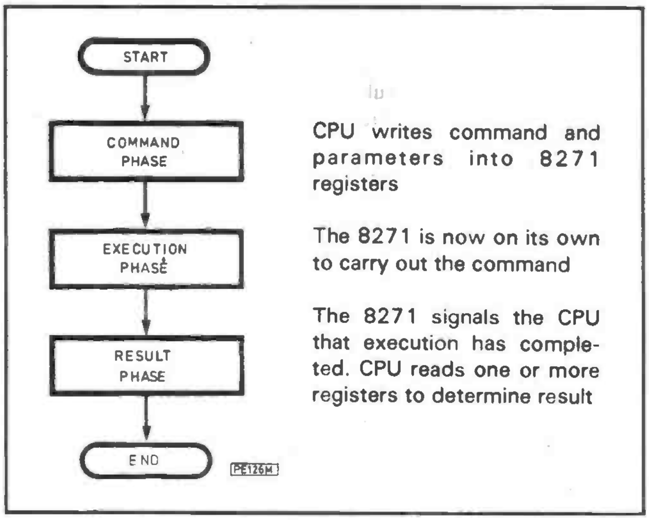


Fig. 3.6. Sequence of operations for an 8271 floppy disc controller. The CPU initiates action by sending a sequence of commands to the 8271; the 8271 then carries out the action independently, and returns the result to the CPU

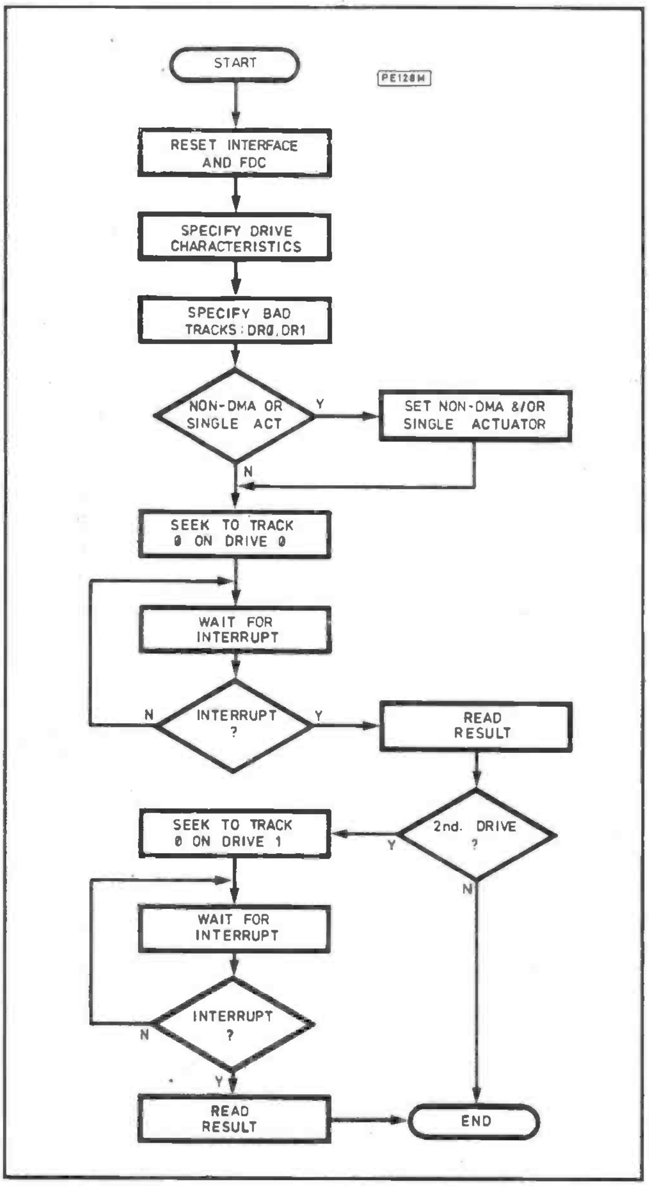


Fig. 3.7. Initialisation includes a reset to the interface hardware between FDC and CPU, and indication of whether or not this is a Direct Memory Access (DMA). The DMA facility allows the CPU to continue with other tasks while the FDC is finding the required data

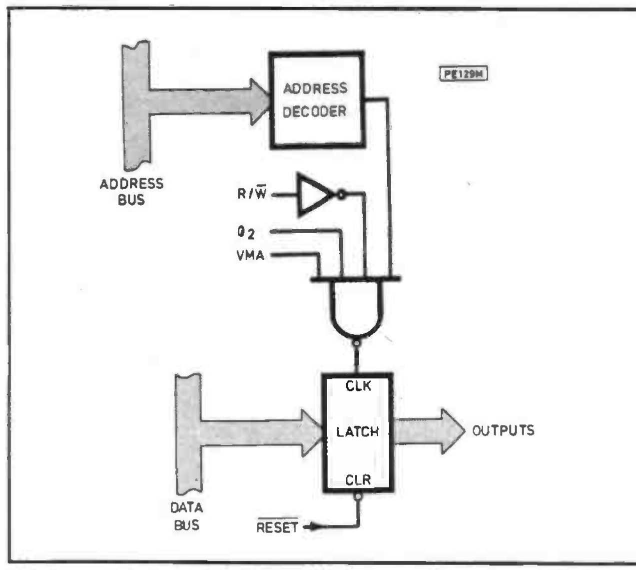


Fig. 3.8. Simple output port schematic

peripheral interfaces is probably an output port. A block schematic for such an interface is shown in Fig. 3.8. The output from the interface is set to the current value of the data bus whenever the CPU writes to the address it is set up to represent (as governed by the address decoder). This requires no initialisation at all before it can be *used* as an output port; the only consideration is to decide whether the output value at reset needs to be set to a particular value. If not, and as long as the port has been arranged to be reset automatically by the "system reset" to the CPU, there is no initialisation sequence required at all.

The basic point which comes out of all of this discussion is that, although the system reset will usually cause peripheral controllers to power up in a known state, they may well require further setting up before they are ready to be used in a particular application.

The more powerful and flexible the controller, the more likely it is that this will be so. The rules to follow for designing the peripheral initialisation sequence, therefore, are as follows:

1) Check that the system is designed so that the "system reset" signal also resets the peripheral hardware.
2) Check the states which inputs, outputs and any internal registers start up in after a reset.
3) Decide what initial conditions the system or external hardware requires.
4) Design the initialisation routine to make sure that any required conditions are set up.
5) If there is any doubt about any condition which will affect the operation of the system, set it specifically during initialisation.

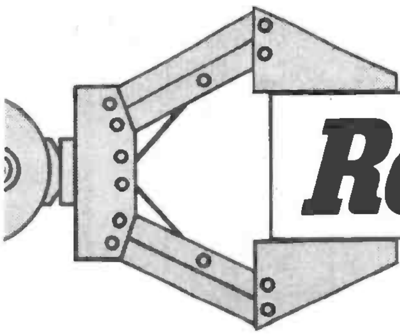
We shall be starting to look at peripheral hardware in micro systems a little later. For the moment, however, let us finish looking at the problem of starting the system up and getting it running properly.

ENABLING INTERRUPTS

The 6800 is typical of most micros by starting up with user interrupts disabled. This allows the CPU to set up any peripheral hardware which will give rise to these interrupts, as well as the stack, before having to worry about handling an IRQ. If the system is not using interrupts, however, they can be left masked out. Otherwise it is a question of simply clearing the interrupt mask once the CPU is ready to respond.

The interrupt mask in the 6800 is *one* of the bits in the condition code register (CCR). Special instructions are provided to allow the interrupt mask (the "I" bit, or bit 4 in the CCR) to be manipulated. The instructions SEI and CLI (op codes 0F and 0E, respectively), set the "I" bit to 1 and 0 to disable and enable IRQ interrupts, respectively. The action of enabling interrupts is thus simply a matter of issuing a CLI instruction when ready to respond. We will start to cover the subject of interrupts in much greater detail next month.

NEXT MONTH: A review of the start-up process, and then we move on to look at peripheral devices in more detail, and the workings of interrupts.



Robotics Review

Nigel Clark

BRITISH robats lead the world. However, our previous pre-eminence in the micro-mouse field is being strongly challenged by the Japanese.

Those have been the results of much travelling throughout the world during the late summer by enthusiasts from this country. Dr John Marr, winner of the British heat of robat, travelled to San Francisco for IPRC '85 to find no challengers from the States despite a great deal of interest and some rumoured attempts to build a robot ping pong machine. While in Belgium, for the European finals, Britain provided all five entries.

In Japan, however, the home country took the top six places in what was billed as the World Micro-mouse Final with the top British competitor coming seventh with a time almost double that of the winner.

The originator of the contest, John Billingsley of Portsmouth Polytechnic, was there to witness the Japanese triumph but was not completely happy with the way it was achieved. Although they had been within the letter of the rules he did not think they had been within the spirit.

All the entries came from one club and used the same basic hardware which the individual entrants then adapted, without having to think out the complete mouse from scratch.

Billingsley was full of praise however for the way the Japanese had organised the event and the resources which had been made available by the Government to pay for the travel and accommodation of the competitors from Britain, Korea and the U.S.

Charlie, complete with bowler hat and large flapping ears, was a far more sophisticated attempt . . .

The one major development from all the activity was a much improved robat machine from John Knight and David Lowery of Fareham, Hampshire. They have substantially rebuilt Kung Fu which came second in the British heats and with Charlie have a device which was able to hit the ping pong ball every time in the main test with considerable force. It was not as successful when the direction from which the ball came was deliberately altered but Billingsley said it was a great advance and did not think it would be long before a recognisable game could be played.

The vision system was much the same as for Kung Fu with three spinning cylindrical lenses which focussed the light from the ball onto a photo cell. The spinning lenses created pulses and the ball's position was judged by the time it took the pulses to reach the cell.

The ball was tracked by the bat on an XY plotter arrangement driven by servos. The hitting mechanism was activated by the ball crossing a light beam but it was too enthusiastic and the ball travelled much too far.

An Electron computer controlled the whole apparatus.

Charlie, complete with bowler hat and large flapping ears, was a far more sophisticated attempt at solving the problems than Kung Fu. That needed a Dragon and Atom and the bat was attached to some plastic drainpiping and powered by springs which were rewound between strokes. When released the bat was halted in the required position by magnetic clutches.

John Knight took Charlie to Strasbourg in October. It was part of an exhibition to show the European Parliament what was happening in new technology in Europe before they debated the subject. After that they and their competitors have until next summer to work on their machines before the next round of the contest, which is still seeking a venue.

A new company to the robot world is **HCCS Associates** of Gateshead. It is in the final stages of developing an arm which will be in the mid-range of prices at about £700. No firm figure can be given as the final design and manufacturing system for the gripper has not yet been decided but Jim Golightly said it would not be more than £1,000.

The design is the usual articulated arm with five axes plus gripper and will be able to lift 2kgs. It will be driven by servos with potentiometers providing feedback, though it will be possible to add optical encoders.

It has an on-board processor and can be connected to micros via RS232 and Centronics ports. Software will be available for the BBC B.

No launch date has been fixed but Golightly is hoping that it will be before the end of the year.

. . . MAX I—now to be called the ERIC . . .

Flight Electronics has changed its mind about its Ogre lookalike, the MAX 1. It is now to be called the ERIC, Educational Robot Incorporating Cybernetics. As revealed in the October issue it is a three axis arm driven by servos through worm gears and costs about £400. To that must be added £130 for the control board and power supply. The board allows connection to any of Flight's Three Microprofessor micros and has l.e.d. indicators to show the status of the motors and optical encoders and five spare inputs to allow customised sensors to be interfaced.

To complete the package there are experimental packs for each of the micros, including a manual and control ROM giving a number of routines.

Cybernetic Applications has added a work cell to its range. It consists of a conveyor and indexing table and unusually the conveyor is driven by stepper motors under the control of the computer. Further pieces will be added later.

The Mentor, from the same company, has been improved so that it can lift 1kg instead of its original 300 grams and can be given routines by lead-by-the-nose. Unlike Neptune, which uses touch sensors, the Mentor system works by simply disabling the motors and then moving the arm to the required positions. The Serpent system is operated by a button which when pressed allows the arm to be moved.

A full price list has been worked out for the Naiad with a complete built system, including a simulator and BBC B interface for £975 +VAT. The arm on its own in kit form costs £595 + VAT.

In addition IBM PC interfaces are now available for all Cybernetic machines.

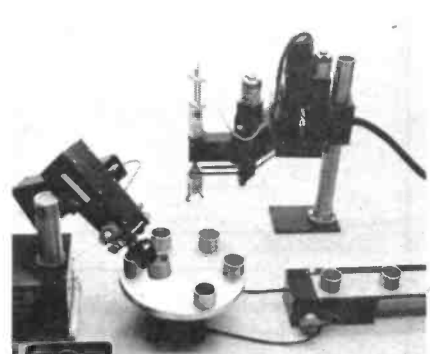
. . . electronic pets called Petsters . . .

It appears that Nolan Bushnell, founder of the now ailing **Androbot** company in the U.S., has finally persuaded Americans that robots do not have to do anything particularly useful other than "enhance the personality of the owner". After leaving Androbot he re-entered the personal robot market with electronic pets called Petsters.

With Catsters, Dogsters and more simply Petster Jnrs they are activated by hand claps and perform various routines such as coming when called and making noises in response to voice detection.

They have proved very successful. Can it be long before we see them in the shops in Britain?

John Knight and Charlie in Strasbourg. Is the name due to the hat or ears?



Mentor, Serpent I, indexing table and conveyor belt

NEW STUDIES

The Leonid meteor shower is at its maximum on the night of November 17. Occasionally the Leonids can be magnificent, as they last were in 1966; usually the shower is very sparse—but one never knows, and it is worth keeping a watch just in case we are treated to another major display.

New studies have been made of what is termed "galactic cirrus", material detected by the highly successful *IRAS* (Infra-Red Astronomical Satellite). Dutch investigators, headed by F. Boulanger of Gröningen, have produced evidence that the cirrus is made up of graphite or silicate grains embedded inside clouds of hydrogen. The temperature is too high to be explained by heating from local interstellar radiation, and it may be that the grains are very tiny—no more than a dozen Ångströms in diameter—and are briefly heated to high temperatures each time a grain absorbs a photon of light.

IMPOSSIBLE GALAXIES

In the constellation of Pisces there are two galaxies, NGC 7603 and NGC 7603B, which have come under recent scrutiny and which seem to present problems which are exceptionally puzzling.

The larger of the two is NGC 7603. It is linked to its companion by a luminous "bridge" made up of stars, dust and gas, and since 7603B lies at the end of the bridge there seems no obvious doubt that the two galaxies are genuine companions.

Yet—and this is a real puzzle!—the spectral red shifts are different. They indicate that the large system is moving away at about 5,000 mile per second, and the small system at about twice this speed. According to present theory, this would push NGC 7603B far into the background.

For many years there have been arguments about the significance of the red shifts in the spectra of external systems. If they are pure Doppler effects, they give a reliable key to the distances of the object concerned. Quasars, for example, have very large red shifts, and on the conventional interpretation they are the most remote systems known; some of them must be well over 10,000 million light-years away.

On the other hand, a few eminent astronomers have serious doubts. In America, H. C. Arp has listed many cases of apparently aligned galaxies and quasars which have different red shifts, and Sir Fred Hoyle, in particular, is firmly of the opinion that the quasar red shifts are misleading, so that the quasars themselves are relatively local to our Galaxy.

If NGC 7603 and 7603B really are companion systems, with different red shifts, the effect upon cosmological theory will be profound indeed. So what does the evidence show us?

Dr. Nigel Sharp, of the Kitt Peak Observatory in Arizona, has made a new examination of the pair, and believes that the luminous "bridge" does not end exactly at the smaller galaxy, but extends past it. If so, then the main argument in favour of real association is removed, and NGC 7603B could really be in the background, so that we would be dealing with a line of sight effect.

Yet there are some other considerations to be taken into account. The total luminosity of NGC 7603B seems to match that of a dwarf elliptical *companion* galaxy, and the spread of velocities of its individual stars seems to be only about 100 miles per second, which is much lower than one would expect at the indicated cosmological distance.

The Sky This Month

The planets are, in general, not particularly well placed this month. Mercury is theoretically an evening object, but it is so far south of the celestial equator that it is not likely to be seen from Britain. Venus is visible in the eastern sky for a brief period before sunrise, but it rises later and later each morning, and after the middle of next month it will be lost in the dawn brightness.

Jupiter continues to be a splendid object in the south-west after dark: telescopically it has been of great interest lately, because there has been great activity in the planet's south equatorial belt, which has been the darkest and broadest belt on the disc—though normally it is less pronounced than the north equatorial belt. Saturn is in conjunction with the Sun on 23 November, and is therefore out of view.

Mars is coming back into the morning sky as it moves through Virgo. It is still a long way away, and its magnitude is only 1·9, so that it is little brighter than the Pole Star, but it will increase steadily until it next comes to opposition in July next year. Its present apparent diameter is a mere four seconds of arc, so that no telescope will show much upon it.

The Moon is new on 12 November, and full on the 27. There will be a total solar eclipse on the 12 November, but not even the partial phase will be visible from Britain; the track of totality begins in the South Pacific Ocean and ends in Antarctica, but the length of totality is less than two minutes.

Of course, the most-studied member of the Solar System at the moment is Halley's Comet (see special feature on page 28), which is on view throughout the month and still moving in the Tauraus area, well north of the celestial equator. By now it is within binocular range, and the magnitude may increase from about 8 at the start of November to above 7 at the end, though exact forecasts are always difficult to make; comets—even Halley's—are notoriously unreliable, and we cannot even tell whether there will be much in the way of a tail or tails.

On 12 November the comet will pass between the stars 65 and 67 Tauri, magnitudes 4·4 and 5·4 respectively, and on the night of 16 November the position will be two degrees south of the Pleiades star-cluster—a good opportunity for celestial photographers. On 27 November the comet makes its first approach to Earth, at just under 60,000,000, miles by which time it will have moved into Aries and will be just south of the famous telescopic double star Mesartim or Gamma Arietis.

At the time when I write these words (September 7) all the five comet probes — two Russian, two Japanese and one European—are on course, and performing well. All will make their rendezvous with the comet during the second week of March next year.

Comet Giacobini-Zinner, which has a period of $6\frac{1}{2}$ years and which has been well seen during the late autumn, has now faded to below the tenth magnitude, and has moved so far south in the sky that British observers have lost it.

VOYAGER

The concentration upon Halley's Comet must not make us forget the other important probe of the moment: Voyager 2, *which is on its way to an encounter with Uranus at the end of January. There have been problems with* Voyager, *but there is every reason to hope that the Uranus mission will be successful—and no doubt Uranus, like the other giant planets, will provide plenty of surprises!*

With the onset of winter, Orion and its retinue are coming back into view; Orion itself rises in the east during late evenings, and is always unmistakable with its two brilliant leaders, the red supergiant Betelgeux and the glittering white Rigel. The Square of Pegasus remains prominent in the western part of the sky, while much of the southern aspect is occupied by the large, dim constellation of Cetus, the Whale.

Dr. Sharp himself has come down on the conventional interpretation—that is to say, the red shift really is a Doppler effect, and NGC 7603B is a system in the far background. But it does look more like a dwarf elliptical, and certainly the "bridge" seems significant even if it does not end abruptly at the smaller system.

If the association between the two is real, we may have to re-think many of our current theories about the red shifts as keys to the distances of galaxies—and quasars. It may be unlikely, but it is certainly not impossible, and astronomers will eagerly await the results of future investigations.

ERNST ÖPIK

Astronomers the world over will be saddened at the death of Ernst Öpik, at the age of 92; he died in September at his home in Northern Ireland. Öpik had an eventful career. He was Estonian by birth, but was strongly anti-Communist, and eventually made his escape to arrive in Britain penniless. Luckily he was invited to Armagh Observatory by the Director, Dr. Eric Lindsay, and remained there for the rest of his life. Öpik was very much of an "all-rounder", who made major contributions to both stellar and Solar System astronomy; he was also a prolific writer.

It is fair to say that some of his opinions were unconventional—for example he believed that there was a link between sunspot activity and political revolutions, and I do not think he ever believed that the Russians had sent men into space! But certainly he was a major figure, and he will be greatly missed.

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PE BAZAAR DECEMBER '85

DISCO LIGHTS CONTROLLER

John M.H. Becker

PART TWO

IN THE FIRST part of this project last month, the theory of the main unit of the controller was explained. This month, the project is completed by showing how a "chaser" circuit can be added. The components for the "Auxiliary Units" are those for the chaser, and also for the ALC and computer interface (see last month).

CHASER CIRCUIT

Many DJ's like to have their lights flashing even when music is not being played, and so some sort of sequential control is also desirable, though not necessary to the operation of the rest of the circuit. The method of sequential, or chasing control used here is to feed a variable audio frequency from a VCO to the filter circuit, and to vary the way in which the frequency is automatically changed.

Refer to Fig. 2.1: the VCO is formed around IC7b, IC8a and IC8b. Its output waveform at C19 is triangular and has an amplitude of about 4V p-p. The frequency is set by C18 in conjunction with the current at IC8 pin 1. This is derived from the voltage seen across R36 and VR7, the latter presetting the optimum range.

The circuit around IC7a produces the varying voltage, and four output waveforms are available. The circuit is basically a square wave oscillator with its rate set by C17 and the feedback resistance of VR6 and R34, and variable between 200ms and 1·5 minutes, depending on the mode selected. The rate of charge or discharge of C17 controls the rate at which the comparator trip point set by the voltage on IC7 pin 5 is passed, at which point the comparator output changes state.

The waveform seen at C17 is normally an approximation of a triangle wave that is slightly distorted due to the charging characteristics of C17. By switching D12 in parallel with VR6, C17 now charges slowly via VR6, and discharges rapidly via D12, producing a rising ramp. With D13 in parallel instead, a falling ramp results. Although all three waveforms at C17 are non-linear, they can be used to control the VCO by tapping them via the high impedance buffer IC8c. Fourthly, the squarewave output can itself be tapped directly. The modulation mode by which the VCO has its frequency varied is selected by S4. (Photos 2.1, 2.2, 2.3, 2.4.)

As the frequency shifts across the filter spectrum, so the different filter bands will be operated and the relevant lights will come on and off. Different chaser patterns can thus be generated by selecting the desired controlling waveform. Additional variations to the pattern can also be achieved by altering the levels at which VR1 to VR3 are set. In the chaser mode the filter control pot VR4 is out of circuit and has no effect, the control node of IC2 being held at a midway level via S3b. S3a is ganged with S3b and in switching to chase mode, the input music socket is removed from circuit.

ASSEMBLY

The full unit just nicely fits into the box size shown—230 x 133 x 63·5mm. The drilling should be carried out after adequate pre-planning, which should also take into account that any mains connections must not come into contact with other parts. Particularly ensure that if using bayonet lampholders, their terminals cannot contact the triac flanges when the lamps or plugs are inserted. It is preferable from a safety point of view that the mains neons should be omitted until the rest of the circuit has been completed and tested. This ensures that at this stage all mains connections are confined to the rear of the box. Where feasible, cover any exposed mains contacts with adequate insulating tape. Full interwiring details are shown in Fig. 2.3.

Except when adjusting the presets VR5 (main board) and VR7, or checking voltages, the unit should never be worked on unless unplugged from the mains. If you are in doubt or inexperienced, seek authoritative advice.

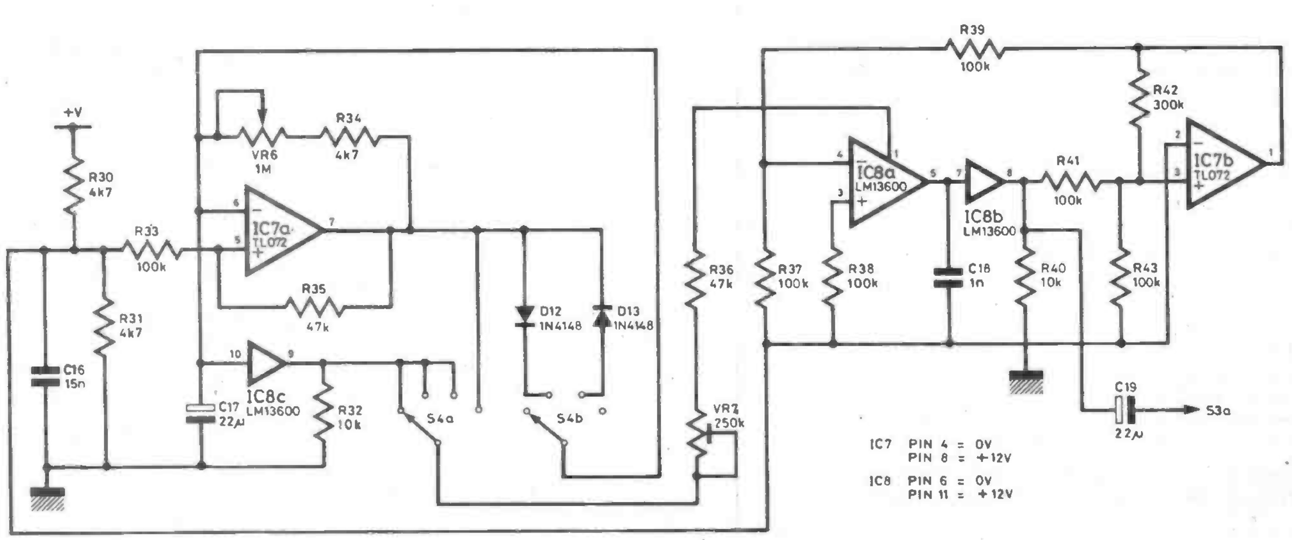


Fig. 2.1. Circuit diagram for the "chaser" sequential control option

PE682A

Below, chaser VCO modulation by LFO. Upper trace VCO, lower trace LFO. The VCO frequency is shown lower than actual amplitude for illustrative clarity

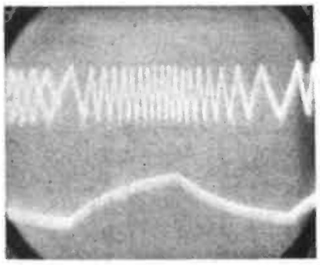


Photo 2.1: S4 position 1

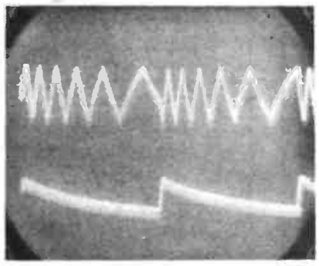


Photo 2.2: S4 position 2

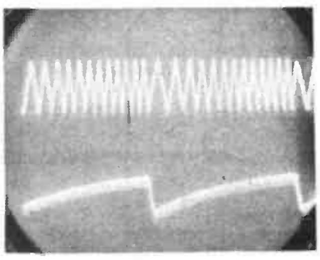


Photo 2.3: S4 position 3

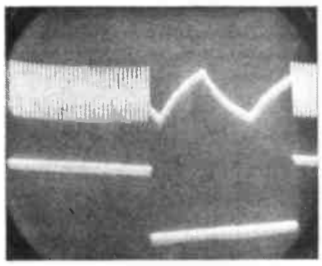
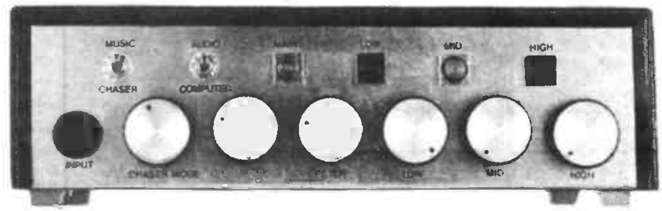


Photo 2.4: S4 position 4



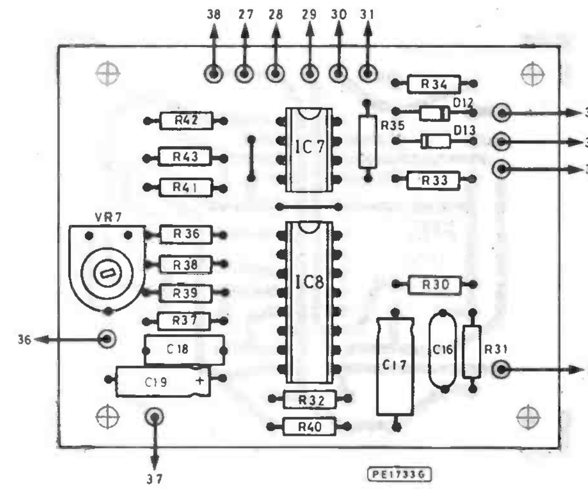


Fig. 2.2. Component layout and p.c.b. design. The off-board numbered lines refer to numbered lines on the main board, and on the interwiring diagram

CHECKING OUT

Setting up simply consists of adjusting the two presets VR5 and VR7 and can easily be done while watching the output lamps. First though, it is best that correct operation of the various circuit stages is checked methodically.

Before inserting any of IC1 to IC8 in their sockets, plug into the mains and check that a d.c. voltage of about 18V is present at the input of IC9, and 12V at its output. If either voltage is significantly different, recheck your assembly. Next insert IC1 and IC2 together with IC6 if it is being used. Operation of the filter can be checked with the meter on a 12V d.c. setting. Whilst playing a music recording into the unit, monitor the signal side of VR1 to VR3, and a small variation in the meter reading should be seen. Now adjust VR5 around its midway point until, with VR1 to VR3 fully up, full scale deflection of the meter occurs roughly in time with the music when looking at pins 1, 7 and 8 of IC1. If using the chaser extension, check also that a varying voltage is seen at the pole of S4a.

The frequency output of IC8 will be too fast to be seen by the meter, but can be monitored indirectly by referring again to the signal ends of VR1 to VR3, with S2 and S3 in the correct position.

When satisfied, IC3 to IC5 can be inserted, and low power lamps connected to the output sockets. Set switches S2 and S3 back to music input mode, but remove music from the input. VR5 can now be more accurately set. First adjust it until all three lights are on, then turn it back again slightly until the lights are just off. When applying music, as VR1 to VR3 are brought up, so the lights should flash as required, and turning VR6 will vary the emphasis of the frequency range.

If the response of the lights is a bit too edgy with regard to the low settings of the control pots VR1 to VR3, slightly back off VR5, so setting the comparator threshold point a bit further away. VR7 of the chaser circuit should be adjusted from the best observed response of the sequences when VR1 to VR3 are at about one quarter rotation.

COMPUTER CONTROL

Control of the three lamps by the computer requires probably one of the simplest control programs that will ever be needed. A low output bit from the computer turns a light on and a high bit turns it off. This control can be carried out quite readily from the normal IEEE output, or from the User Port socket possessed by many computers. Below the code required for the Commodore Pet series is given, for other machines your manual should give the

COMPONENTS . . .

AUXILIARY UNITS

Resistors

R1	560k
R2, R3	30k (2 off)
R26	1k
R27–R29, R35, R36	47k (5 off)
R30, R31, R34	4k7 (3 off)
R32, R40	10k (2 off)
R33, R37–R39, R41, R43	100k (6 off)
R42	300k
All ¼W ±5% carbon film	

Capacitors

C1–3, C19	1µ 63V electrolytic (4 off)
C4	4µ7 63V electrolytic
C5	56p polystyrene
C6, C17	22µ 16V electrolytic (2 off)
C16	15n polyester
C18	1n polystyrene

Potentiometers

VR6	1M mono rotary
VR7	250k skeleton

Semiconductors

D5	7V5 400mW zener
D6–D13	1N4148 (8 off)
IC6	571
IC7	TL072
IC8	LM13600

Switches

S2, S3	min. d.p.d.t. (2 off)
S4	3-pole, 4-way

Miscellaneous

p.c.b. clips (4 off); knobs (2 off); mains neon (4 off); PCB245B; 8-pin i.c. socket; 16-pin i.c. socket (2 off).

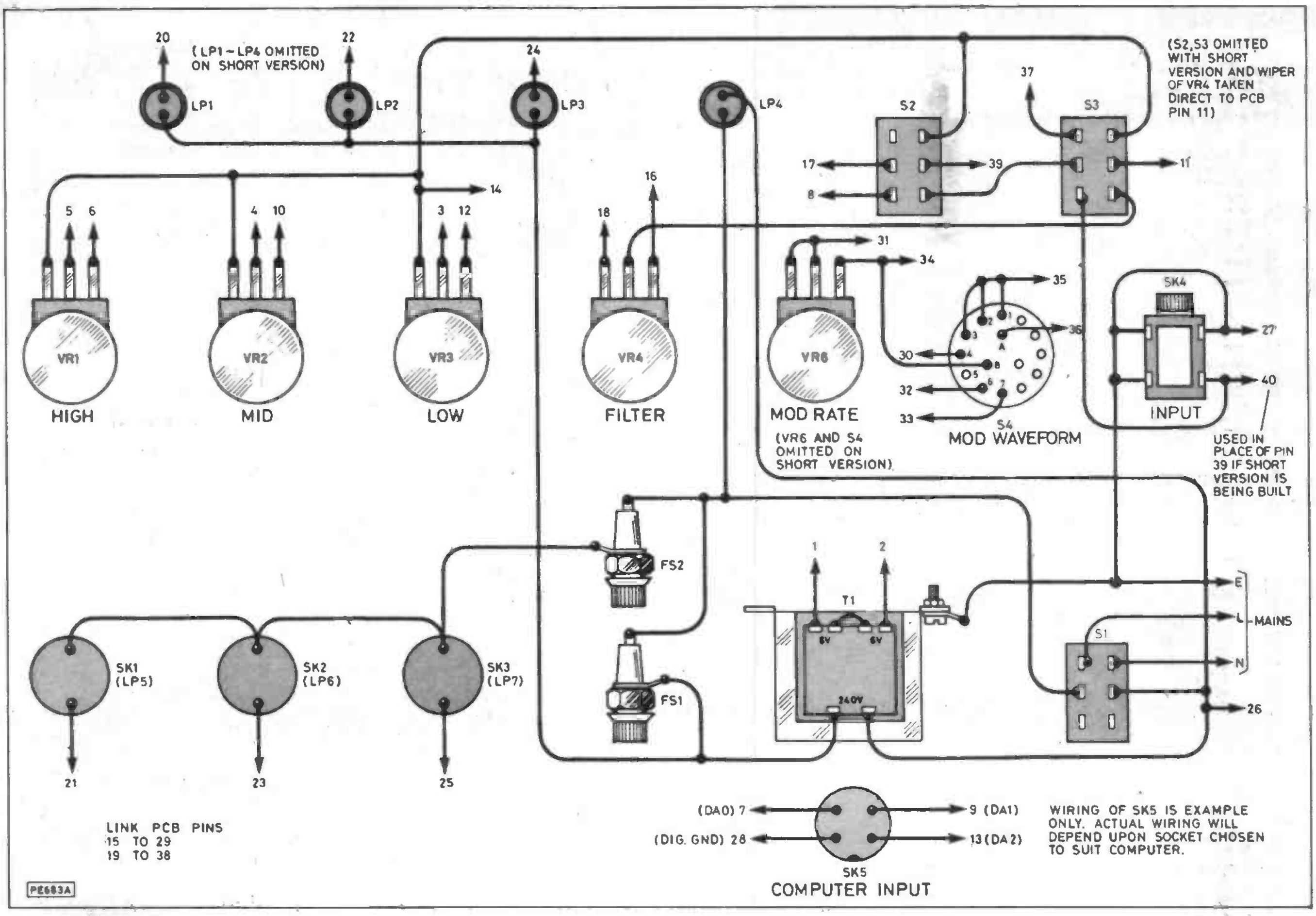


Fig. 2.3. Complete interwiring diagram for the Disco Lights Controller. The numbered lead-out wires relate to numbered lines on the main p.c.b., published in Part One, and to the optional "chaser" board. If the simplest version of this project is being built, many components can be omitted, as noted above, and the input taken direct from line 40 to the main p.c.b. In the full version, line 40 is omitted, and the input taken from line 39

simple equivalent codes. (C64 equivalents are 56579 and 56577 respectively.)

First open the port as an output for the first three data bit lines by:

POKE 59459,7 (7 = binary 00000111)

POKE 59459,255 would do equally well, this opening all eight bits as outputs, (255 = binary 11111111). Once having POKED this number there is no need to change it during the rest of the program. To turn on the particular lights required all you do then is POKE 59471 (the output port), with one of the following numbers.

Lamp 1	= 254 (binary 11111110)
Lamp 2	= 253 (binary 11111101)
Lamp 3	= 251 (binary 11111011)
Lamp 1 and 2	= 252 (binary 11111100)
Lamp 1 and 3	= 250 (binary 11111010)
Lamp 2 and 3	= 249 (binary 11111001)
Lamps 1, 2 and 3	= 248 (binary 11111000)
No lamps	= 255 (binary 11111111)

In each case where a "0" occurs the lamp associated with that bit will be turned on. Examination of a decimal to binary chart will show that other numbers, such as 0 to 7, will also produce a similar response with the 3 lamps.

Holding loops can be inserted in between each program step so that the length of time between lamps changing can be varied. Such a loop can be written as:

FOR Z = 1 TO T : NEXT Z

where T is the delay factor. On my Commodore 3032 with T at 4000 a delay of approximately 5 seconds occurs. This may vary between machines depending on their internal clocking rate, and any auxiliary editing aids.

A random lighting sequence can also be run from a sub-routine such as:

```
10 T = 100
20 R = INT(RND(1) x 256)
30 POKE 59471,R
40 FOR Z = 1 TO T
50 NEXT Z
60 POKE 59471,255
70 GOTO 20
```

In this fashion random or specified sequences with delays from fractions of a second up to several days can be program controlled. ★

Constructors' Note

Send a large SAE for full details and prices for this project to: **Becker Phonosonics,** Dept. DLC, 8 Finucane Drive, Orpington, Kent BR5 4ED.

HALLEY'S COMET

Dr Patrick Moore OBE

On July the second this year I flew to French Guiana. I went there at the invitation of British Aerospace, and for a very special reason: the launching of the Giotto probe to what is probably our most famous celestial visitor, Halley's Comet.

I am quite sure that a great many people know what a comet is, and by now there can be few who have not heard about the return of Halley's Comet; but it may be as well to clear up a few points at the outset. I still have letters from writers who say, in effect, "Last night I saw something crossing the sky; can it be a comet?" Of course the answer is 'no', because a comet is millions of miles away, and has to be watched for hours before any noticeable movement can be seen against the starry background. Secondly, any object which moves perceptibly must be in our air, or close to it. It will be either an artificial satellite or a meteor—unless, of course, it is something more mundane, such as a high-altitude weather balloon or a distant aircraft.

DIRECT HIT IN 1908

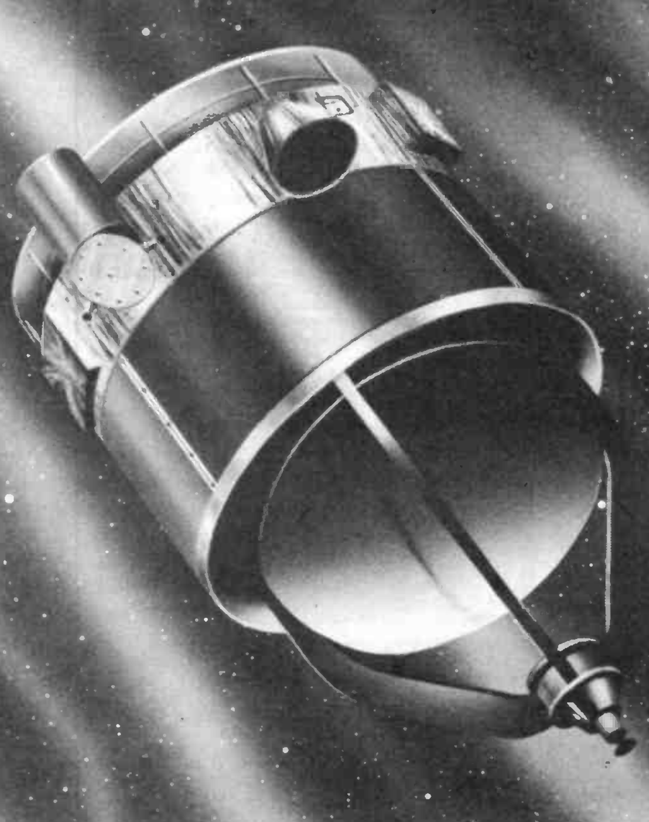
The other point to be made at once is that comets are very insubstantial, and even a direct hit on Earth could do no more than local damage. (There is good evidence that a part of a comet did land in Siberia, in 1908, and although it blew pine trees flat over a wide area there were no human casualties.) And though the gases in a comet's tail would be dangerous if dense, they are in fact so rarefied—millions of times less dense than the air you and I are breathing—that they are totally harmless. In 1910, at the last return of Halley's Comet, the Earth went right through the tail, and nothing could be noticed. This time the comet will not come within 30 million miles of us.

A comet has been described as "the nearest approach to nothing that can still be anything". The only part which is reasonably massive is the nucleus, no more than a few miles in diameter, and presumably made up of ices, mainly water ice, together with rocky fragments. Surrounding this is the head or coma, which may be extremely large (the coma of the Great Comet of 1843 was larger than the Sun), and extending away from the coma is the tail—or, rather, tails; a large comet may have both a gas tail (the 'ion' tail) and 'dusty' tail. Many smaller comets, however, never produce tails, and look like nothing more than tiny patches of luminous haze in the sky. Basically, a comet depends upon reflected sunlight, though when close to the Sun its gases may fluoresce and emit a certain amount of light on their own account.

HEAD IN THE CLOUDS

As yet we do not know a great deal about the nucleus of a comet. As the distance from the Sun grows less, as the comet draws in toward its perihelion or closest approach, the ices in the nucleus start to 'boil off', and the resulting coma hides the nucleus completely. Generally we are not even sure just where the nucleus is. This is where we hope that Halley's Comet will help us in March next year.

Comets are believed to come from the 'Oort Cloud', a whole collection of comets orbiting the Sun at a distance of at least a light-year (nearly 6 million million miles). They are, naturally, quite invisible from Earth; if a member of the cloud is perturbed for any reason, it may swing inward toward the Sun. Its journey will take a very long time indeed, because not until it is reasonably close-in will it start to move quickly, but eventually it will enter the observable part of the Solar System. One of several things may then happen.



If the comet is not affected by the pull of a planet, it will simply swing past the Sun and return to the Oort Cloud, not to come back for many centuries. If it is perturbed by a massive planet (usually Jupiter, which is more massive than all the other planets combined), the comet will either be thrown into an open orbit, and expelled from the Solar System altogether, or else put into a small orbit with a short period, in which case it will pass through perihelion every few years.

PERIODICAL COMETS

Apart from Halley's, all these so-called periodical comets are faint; very few of them become visible with the naked eye, and few develop tails. We know when and where to expect them; Encke's Comet has the shortest period of all (3·3 years), and there are many others with periods of from 5 years to a few tens of years.

The brilliant comets seen throughout history—for example in 1811, 1843, 1858, 1861, 1882 and 1910—are regarded as non-periodical. This is not completely true, becausee they will return eventually (unless they have been thrown into open orbits), but they are visible only at one return in many lifetimes, and there is no way in which we can predict them.

BYGONE SIGHTINGS

The exception is Halley's Comet. It has a mean period of 76 years, and it has been seen regularly since well before the time of Christ. Records of it—mainly Chinese—go back to the year BC 1059, and every return since that of BC 240 has been observed.

It "shone down" in 12 BC—much too early to be associated with the Star of Bethlehem. It was visible in 1066, just before William of Normandy launched his invasion of England; in the famous Bayeux Tapestry it is shown, with King Harold toppling from his throne and the Saxon courtiers looking on aghast. In 837 it was magnificent, with a nucleus and coma as bright as the planet Venus, and a tail stretching for more than 90 degrees across the sky.

In 1301 it was seen by the Florentine artist Giotto di Bondone, who represented it in his picture "The Adoration of the Magi". In 1456 there is a story that it was excommunicated by the Pope, Calixtus III, as an agent of the Devil; this is certainly not true, but the Pope does seem to have had some unkind things to say about it.

In 1682 it was seen by Edmond Halley, friend of Isaac Newton and the future Astronomer Royal, who worked out its path and realized that it was identical with comets previously seen in 1607 and 1531; he predicted its return for 1758—and on Christmas Night of that year it was duly picked up by the Saxon amateur Palitzsch, passing perihelion in 1759. It returned in 1835 and again in 1910, after which it was lost once more until it was recovered in 1982. The date of the next perihelion passage is 9 February 1986.

Until Halley's time, the movements of comets were not known; it was generally believed that they travelled in straight lines, by-passing the Sun only once. Therefore, it is only just that the comet should have been named in Halley's honour.

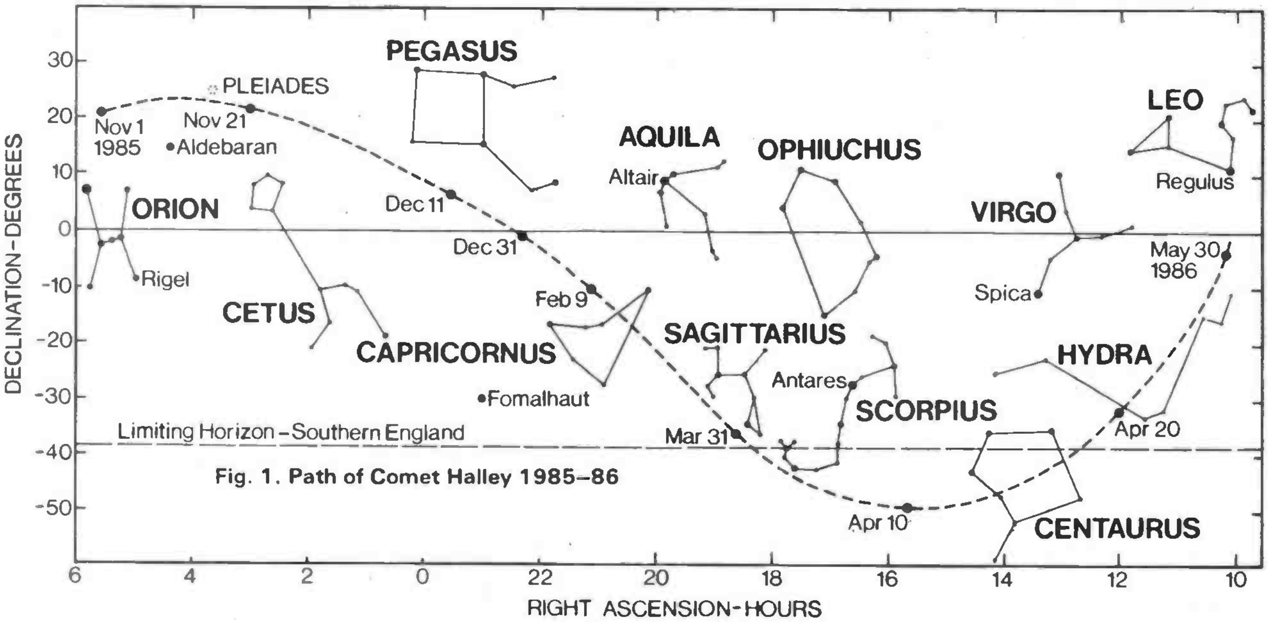


Fig. 1. Path of Comet Halley 1985–86

CLUE TO ORIGIN

Comets are important because they are very ancient. They date back to the very early days of the Solar System; we know that the Earth is over 4,500 million years old, and if we could find out more about the make-up of comets we would be adding to our knowledge of the past history of the entire planetary system. We are learning all the time.

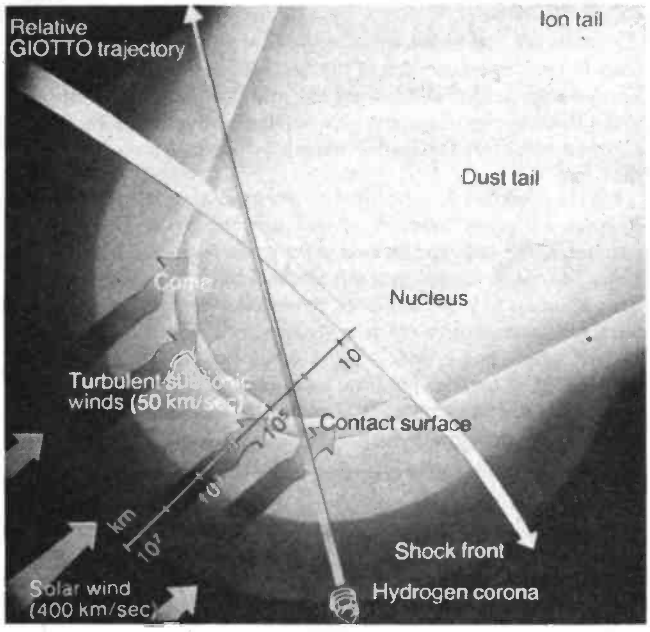
On the other hand, every time a comet passes through perihelion it loses a certain amount of its material by evaporation; in particular, the tails are formed from material in the nucleus and coma. No comet can tolerate this loss indefinitely, so that the short-period comets have limited lives. Several last-century comets which were regular visitors have now disappeared; for example, Biela's Comet, which had a period of $6\frac{3}{4}$ years, but broke in two at the return of 1845 and has not been seen since 1852, though a brilliant meteor shower was seen in 1872 radiating from the position where the comet ought to have been.

There is, in fact, a close association between comets and meteors. As a comet moves along, it leaves a 'dusty' trail behind it; when the Earth passes through such a trail, the particles enter our atmosphere and burn away by friction, producing the familiar shooting-star appearances. Many of the annual meteor showers have known parent comets, and Halley's Comet is associated with two showers, the Eta Aquarids of May and the Orionids of October. (Note, by the way, that there is no association between comets and meteorites. Meteorites are more closely related to the minor planets of asteroids; there may be no essential difference between a large meteorite and a small astroid.)

HARMFUL GASES

In 1910 Halley's Comet was a brilliant object, because at the time of perihelion it and the Earth were on the same side of the Sun. It attracted a great deal of attention, and even some alarm; people jumped to the conclusion that the gases in the tail would be harmful, and one enterprising American even made a large sum of money by selling anti-comet pills, though nobody seems to be sure just what they were meant to do! This time, alas, the situation is less favourable, and at the time of perihelion, in early February, the comet will be almost directly behind the Sun, so that it will be unobservable. Our only hope of recording it then will be from one of the space-craft now in orbit round the planet Venus.

It is unfortunately true to say that people in general may be disappointed at the appearance of the comet, but at least it will be visible, and of course we know exactly how it will move. During November it will pass through the constellation of Taurus, and as the magnitude will rise to 6 it will be an easy binocular object (Fig. 1). On the night of 16 November its position will be just south of the Pleiades star-cluster; by the 27th the distance from Earth will have been reduced to just under 60,000,000 miles, and the comet will be just south of the well-known telescopic double star Gamma Arietis.



On board experiments will include dust, plasma and nucleus make-up analysis. Good quality photographs are expected

NAKED EYE OBJECT

During December the comet should become a naked-eye object as it passes from Pisces into Aquarius; whether by that time it will have developed a definite tail remains to be seen. In early January it will 'set' soon after the Sun, and by the middle of the month it will disappear from view.

It will re-appear in late February, and the best chances of seeing it to advantage will be in March and April—*if you live in the southern hemisphere!* When at its best, in early April, the comet will be in Centaurus, which means that it will not rise at all in British latitudes, though from countries such as Australia and South Africa it will be almost overhead before dawn, and should be quite prominent, with a nucleus of at least the third magnitude and a tail which should extend for up to 30 degrees.

By the end of April it will have reached Hydra, and will again be visible from Britain, though it will fade quickly. Modest telescopes will be able to track it until August, but by the end of 1986 the main part of the return will be well and truly over.

On 24 April there will be a total eclipse of the Moon. This will be a great opportunity for spectacular photography—a chance which is unlikely to recur for many hundreds of years. Halley is bound to be the best-photographed comet of all time.

TAIL FIRST

It is never safe to forecast the development of a comet's tail or tails; in the case of Halley, records indicate that the main development takes place after perihelion. The ion tails are straight, the dust-tails curved; they always point more or less away from the Sun (due mainly to the effects of 'solar wind', a stream of atomic particles being sent out from the Sun constantly in all directions), so that when it has passed perihelion, and is moving outward, a comet actually travels tail-first.

Earth-based astronomers will be very busy throughout the apparition. There is full international co-operation, and the comet will be monitored as continuously as possible, so as to check phenomena such as short-term changes in the tails. Since 1910 new techniques have been developed, and spectroscopic investigations should tell us a great deal more about the comet's make-up. But the most exciting possibilities involve spacecraft.

Remember, Halley's is the only major comet which we can predict, and this is why it is of such importance. Smaller comets can be contacted by probes (as the periodical Giacobini-Zinner, in September last), but Halley is unique, and plans to by-pass it were laid many years ago. The Americans had a very ambitious programme, but abandoned it on the grounds of expense—a decision which they will no doubt regret for the next 70 years at least. So we are left with five probes: two Russian, two Japanese and one European.

HEART TO HEART

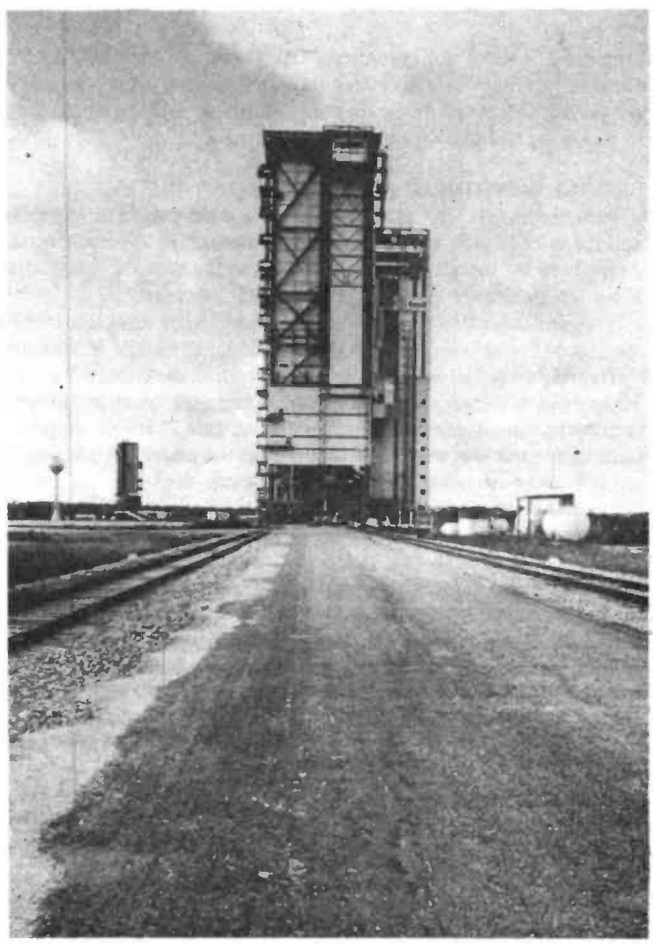
Because we do not know the size or the precise nature of the nucleus, or even just where it is, the only real hope of finding out is to send a spacecraft right into the comet's heart. This is the rôle of the European probe, named Giotto in honour of the Florentine painter. It is modest in size, but it is crammed with instruments of all kinds, and we hope that on the night of March 13–14 next year it will penetrate the coma and send back close-range pictures of the nucleus itself. The results will come through to the Parkes 210-foot radio telescope in New South Wales, and will be transmitted straight to Darmstädt in Germany, where the pictures will be electronically assembled. I will be at Darmstädt, hoping to show the results on BBC television immediately. If all goes well, it will be an exciting night.

Previously, the two Russian and two Japanese probes will have passed by the comet at a more respectful distance, and will have carried out surveys of all kinds—including radar determinations of the position of the nucleus inside the coma, which should enable Giotto's trajectory to be corrected at the last moment. The Russian spacecraft, Vega 1 and Vega 2 (nothing to do with the star Vega) travelled to the comet by way of Venus, and as they passed by they dropped balloons and landing probes into the atmosphere of that decidedly peculiar and hostile world. The Japanese probes are much smaller, but they too have an important part to play, and so far all seems to be going well with them.

GIOTTO—MAIN HOPE

Yet it is fair to say that our main hopes rest with Giotto. Because Halley's Comet moves round the Sun in a retrograde direction (that is to say, in a sense opposite to that of the Earth) Giotto will meet it almost head-on, at a very high relative velocity, and this means that the mission is fraught with danger. We do not really know much about the conditions in space close to a comet, but there must be many solid pieces of material around—both rock and ice—and a collision between Giotto and a sizeable lump of solid matter can

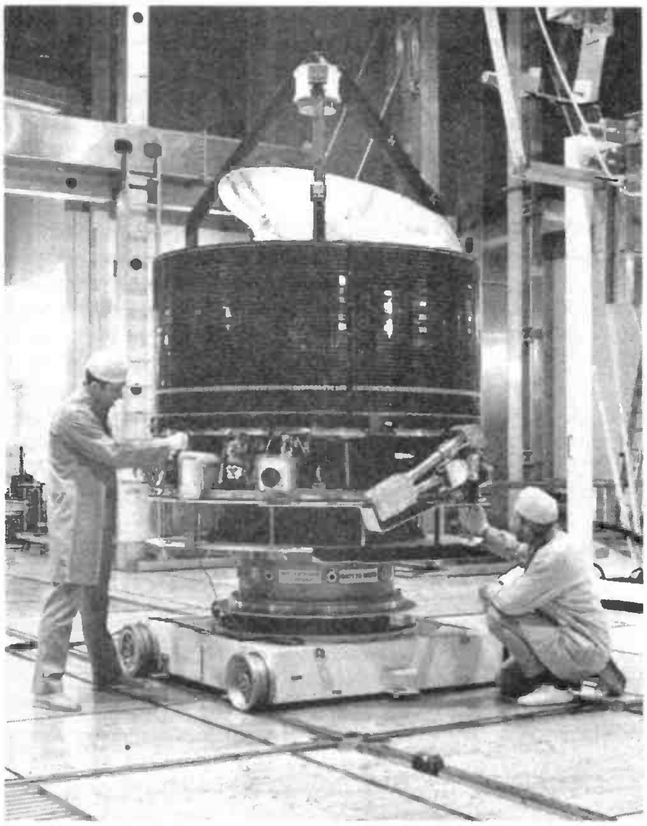
The launch pad at Kourou, French Guiana, where the successful launch took place in July this year. An Ariane rocket, a direct competitor with the space shuttle for satellite launches, was used



have only one result. Frankly, the chances that Giotto will pass through the coma and emerge unscathed are very slim indeed. What we hope is that the probe will survive for long enough to send back the data we so badly need.

What exactly will it show? We can at least speculate. As the comet is heated by the Sun, its nucleus will be in a state of constant agitation; there will be cracks, outbursts and small explosions as the ices evaporate, and the entire scene is likely to be one of chaos. There is no reason to doubt that the picture quality will be good—if Giotto survives for a sufficient length of time, but the whole climax of the mission will be over in a very short time, and there can be no second chance.

Even when the main excitement is over, there will still be much to do, as the comet makes its closest approach to Earth during its outward journey and is intensively studied from all major observatories. Amateurs also can play a useful rôle in helping to maintain a continuous watch. We can never tell just how the comet is going to behave.



Giotto under laboratory conditions at the British Aerospace facility at Bristol. The probe is almost 3 metres high and is 1·84 metres in diameter

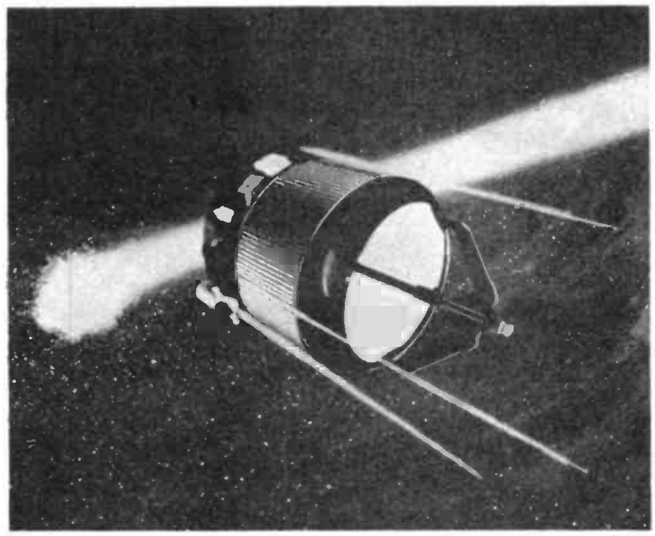
GLOBAL SCRUTINY

The International Halley Watch (IHW) was formed by Louise Friedman, then of the Jet Propulsion Laboratory in California, in 1979. The idea was to set up an organizing body which would co-ordinate worldwide ground-based observations of the comet throughout the apparition, and at the present time the IHW is in full swing; the organization has proved to be very effective indeed.

The main investigations concern astrometry, infra-red spectroscopy and radiometry, large-scale phenomena, near-nucleus studies, photometry and polarimetry, radio science and spectroscopy.

The amateur network, co-ordinated by S. J. Edberg, involves visual observations, photometry, spectroscopy and photoelectric photometry, plus data on the two associated meteor streams, the Eta Aquarids and the Orionids. There is a regular IHW Newsletter, prepared by the Jet Propulsion Laboratory together with NASA, and at the end of the apparition all the results will be summarised in the official Halley Archive.

How long will we be able to follow Halley after perihelion? Certainly for some years; the Hubble Space Telescope, a 94-inch reflector due to be launched in the near future, should be able to track it until it passes out into the remoter parts of the Solar System. We intend to learn all we can, and no effort is being spared. But for



When Giotto finally encounters the comet, around midnight of March 13/14th 1986, it will have travelled some 435 million miles and will be around 93 million miles from Earth

most of us, this coming period is our sole chance of seeing Halley's Comet. It will not be bright again until the year 2061; so let us make the most of our current opportunities. It is comforting, too, to remember that Giotto, though a full-scale European project, had a British firm—British Aerospace—as its main contractor, and that the probe was built in Bristol. This is fitting, particularly as when Edmond Halley forecast that the comet would return in 1758, he modestly added that if he were proved right, then 'posterity will not refuse to acknowledge that this was first discovered by an Englishman'.

ACKNOWLEDGEMENT

Thanks to British Aerospace for kindly supplying photographs used in this article.

MODEL RAILWAY TRACK CONTROL

J. MILNE

PART TWO

LAST MONTH, we described the circuit operation of the Model Railway Track Control project in full detail. The p.c.b. layout and construction of the main control unit was also covered and this month, the final part, deals with receiver boards, construction and testing.

CONSTRUCTION AND TESTING (TYPE A RECEIVER)

The circuit board and the component layout for the Type A receiver are shown in Fig. 12. When the components are assembled on the board, but before inserting IC1 into its socket, some checks can be carried out. Connect a d.c. power supply to the board line terminals. Switch on, and gradually increase the voltage up to 28V. When the supply current has stabilised, it should settle at about 2mA. Check the voltage at C1 is 15V, and TR1 collector at 0V. Using a 10Ω or similar value resistor, discharge capacitor C4, when the supply current should fall to 1·5mA for about 1s, and then increase to around 25mA, while C4 is recharging. The recharging time will be about 1s for each 1000μ.

The receiver i.c.s are of MOS construction, so the usual handling precautions should be taken. After switching off, and the capacitors have discharged, the chosen IC1 can be plugged in. Switch on the power supply, and the current, when stable, should be about 6mA.

If an oscilloscope is available, the decoding oscillator can be seen to be running, producing a 3V peak to peak sawtooth at pin 2.

SETTING UP (TYPE A RECEIVER)

Connect the receiver (Type A) line terminals to the control unit output. On the control unit, select the appropriate positions on the rate and word switching for the board. From the fourth column in Table 2, select which output pin on IC1 will be energised when the word is recognised, and connect it to a voltmeter to read 15V. Transmit the code word while adjusting VR1 over its full travel. Note the two positions of VR1 where a steady high reading is just obtained, and then adjust it midway between them.

CONSTRUCTION AND TESTING (TYPE B RECEIVER)

The circuit board and component layout for the Type B receiver is shown in Fig. 13, and for the extension board in Fig. 14. Three links are required, one of which connects either D or $\overline{D}$ to IC2 input, and must select D when an extension board is used. Where $\overline{D}$ is not required, TR5 and R16 can be omitted, and R15 replaced with a link.

The board should be assembled as normal, taking care to ensure there are no dry joints or solder splashes.

When the components are fitted to the board, the initial testing procedure is the same as that for the A type receiver, and similar readings should be obtained.

SETTING UP (TYPE B RECEIVER)

Connect the receiver (Type B) to the control unit output terminals, and select the appropriate rate and word switch positions. Connect a voltmeter to read 15V between V– and IC1, C-bit output, both easily accessible at the edge connections for the extension board. Rotate VR1 fully anticlockwise, and on the control unit hold switch S5 in position A. Rotate VR1 slowly clockwise until the meter reading becomes erratic, and note its position. Rotate VR1 fully clockwise, hold S5 in position B, and rotate slowly anticlockwise. Again a position should be found where the voltage reading is unsteady. Position VR1 midway between the two points, and check that the voltage is high after an A signal, and low after a B signal.

Change the voltmeter connection to check $\overline{D}$, again at the edge connection. From Table 3, select the switch positions that will cause IC1, D output to be high. This will cause $\overline{D}$ to become low, but the actual voltage reading will depend on both the gain of the transistor used for the inversion, and on the impedance of the meter used. To reduce the time taken for a change of state, TR5 should not be driven into saturation, and a collector voltage of 0·2V to 2·0V should confirm this. This voltage must not exceed 4·0V, and the value of R16 can be altered to correct it.

TYPE A AND B RECEIVER, FINAL TESTING

Before the boards are screwed down under some inaccessible corner of the layout, it is advisable to see that they really work. For this, all the receivers that operate at a particular data rate should be checked at the same time. Connect the boards to the control unit and to the appropriate number of spare motors, if you have them. As an alternative, the test circuit, shown in Fig. 15, can be used. I found this useful during the development of the system, as it is easier to spot the flash of an l.e.d. in the wrong place, rather than trying to trace where the noise came from.

Whichever method is used, the checking procedure is the same. With VR1 on the control unit set so that the l.e.d. is just out, try each of the code words in turn, checking that the correct operation occurs. The control unit l.e.d. should be illuminated after each operation, showing that the storage capacitor is recharging, and the next operation should not be attempted until this is complete. Also check that code words at higher and lower data rates do not cause an operation.

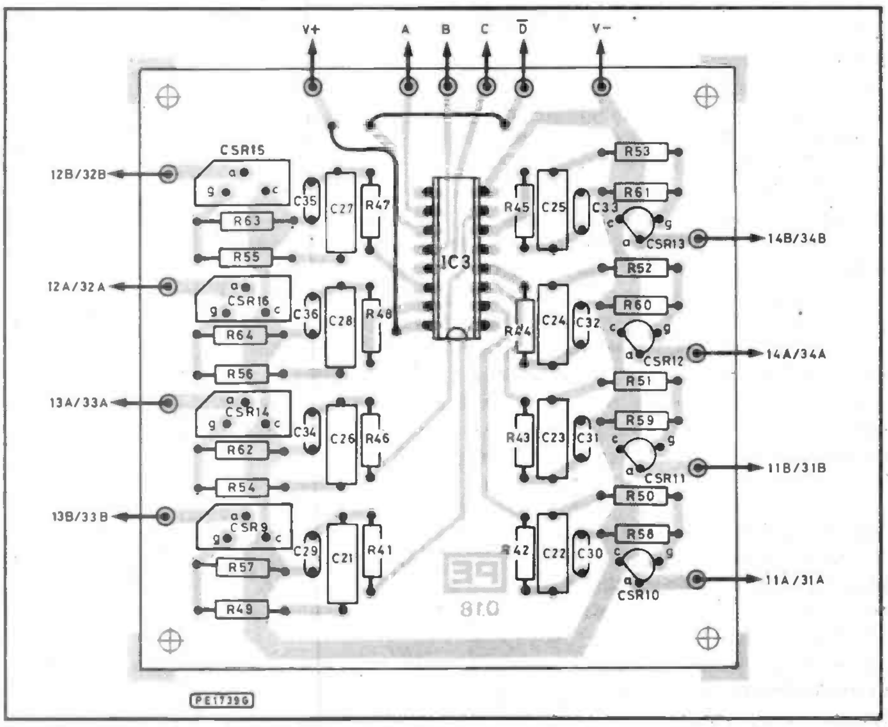


Fig. 12. Type A receiver board constructional details

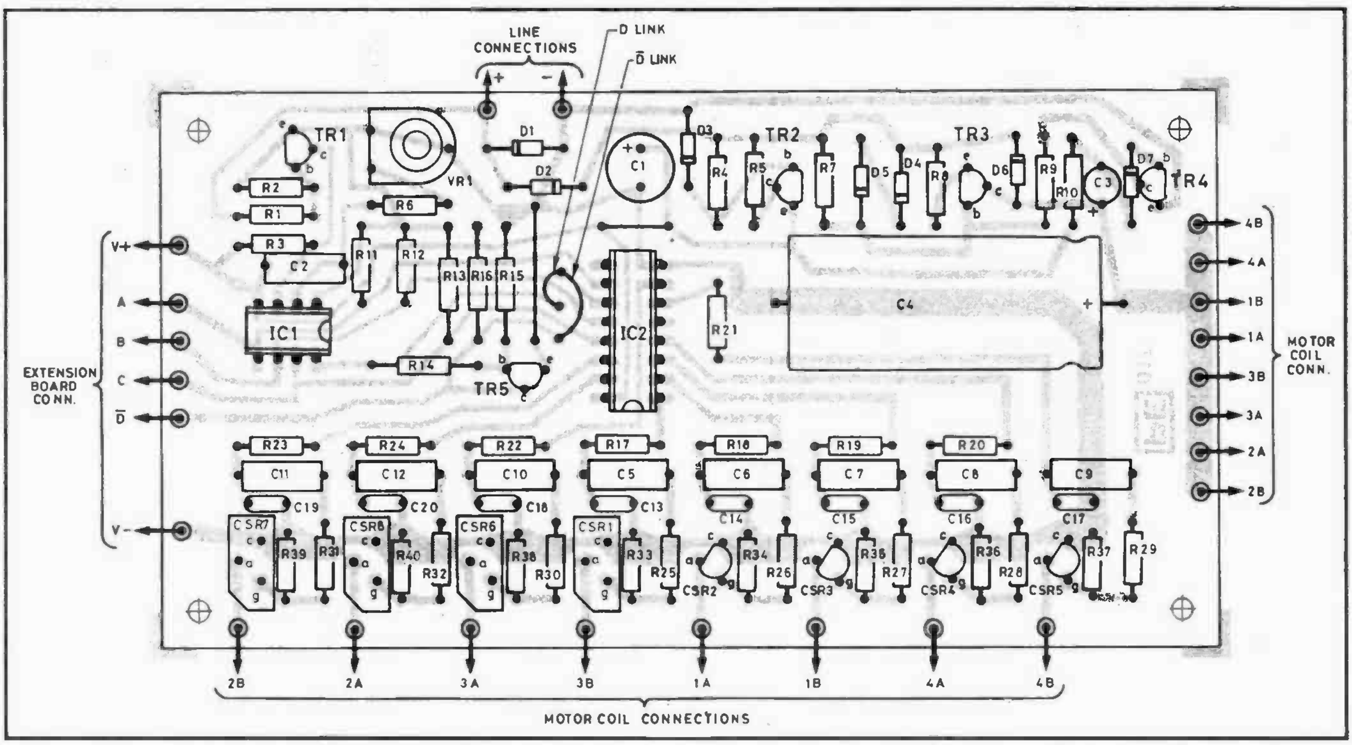


Fig. 13. Type B receiver board constructional details

CONNECTING UP

The receiver boards can be fitted under the layout unprotected, except for a thin coating of suitable lacquer, providing there is no danger of them becoming wet, or of physical damage. The wiring from the control unit to the receivers will depend on layout, but a basic ring supplying a series of connector blocks, with spurs to each receiver, is probably the most flexible. When connecting motors similar to the Peco and "H and M", the common coil connection should be made to terminals on the same side of the motor. This ensures that the small induced pulse in the unused winding is negative at the thyristor anode, which is particularly important when 30V devices are used.

When all the connections are made, switch on the control unit and allow all the storage capacitors to charge. When conditions have stabilised, the control unit line voltage l.e.d. should be at normal brightness, and by adjustment of VR1, the line current l.e.d. should be just off. If this is not so, there is a fault on the wiring, or connections, which must be corrected. If the indications are satisfactory, check the operation of every point, in both directions.

If a second operation is attempted on the same receiver during the recharging cycle, it is possible for a thyristor to latch, so preventing the cycle completing. The cure for this is to switch off the control unit, count to twenty slowly, and switch on again, when all should be well.

MOTOR RATINGS

Measurement of a motor minimum operating current can be difficult with the equipment found in the average workshop, and it is also too easy to accidentally burn out a coil. An alternative method is to establish the required value of the storage capacitor empirically.

This may be achieved using a d.c. power supply, capacitor and a 1k resistor.

Connect a variable d.c. power supply to the capacitor with a 1k resistor. Connect the point motor and switch, and find the lowest capacitor charge voltage which will operate the motor, in both directions, when the switch is closed. A capacitor of suitable value should operate the motor at a voltage of 15V to 20V.

To calculate a realistic value for the maximum motor current, the coil resistance has to be measured with a reasonable degree of accuracy, but the figure for coil inductance can be less precise.

The average test meter is not noted for accuracy when measuring low values of resistance, but the d.c. voltage indication can be good, particularly when comparing voltages on the same

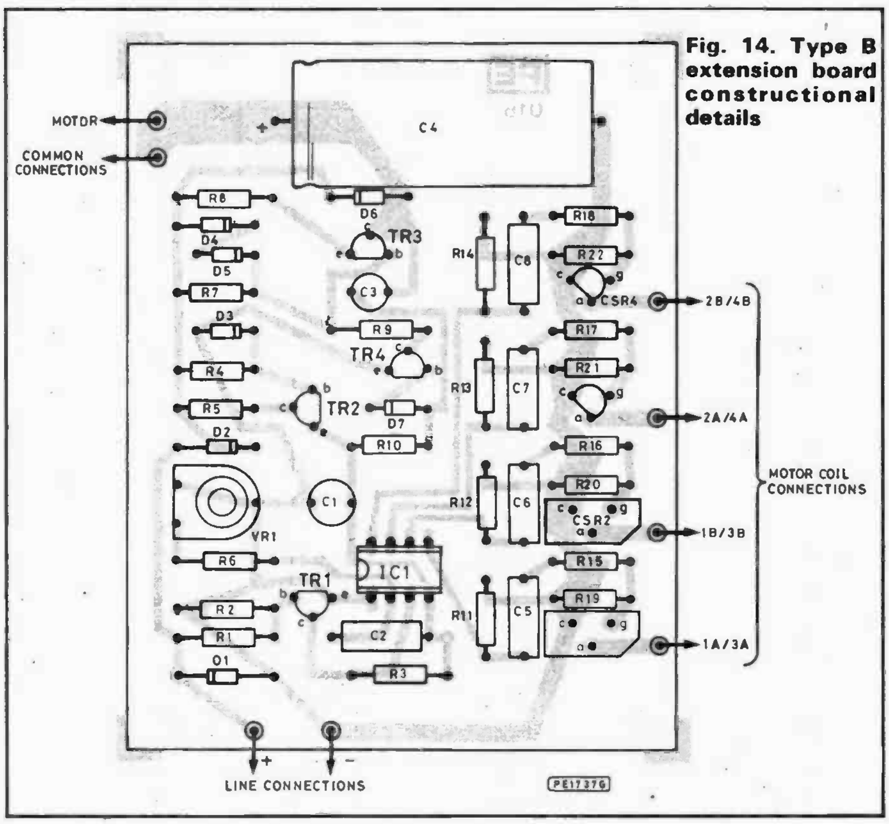


Fig. 14. Type B extension board constructional details

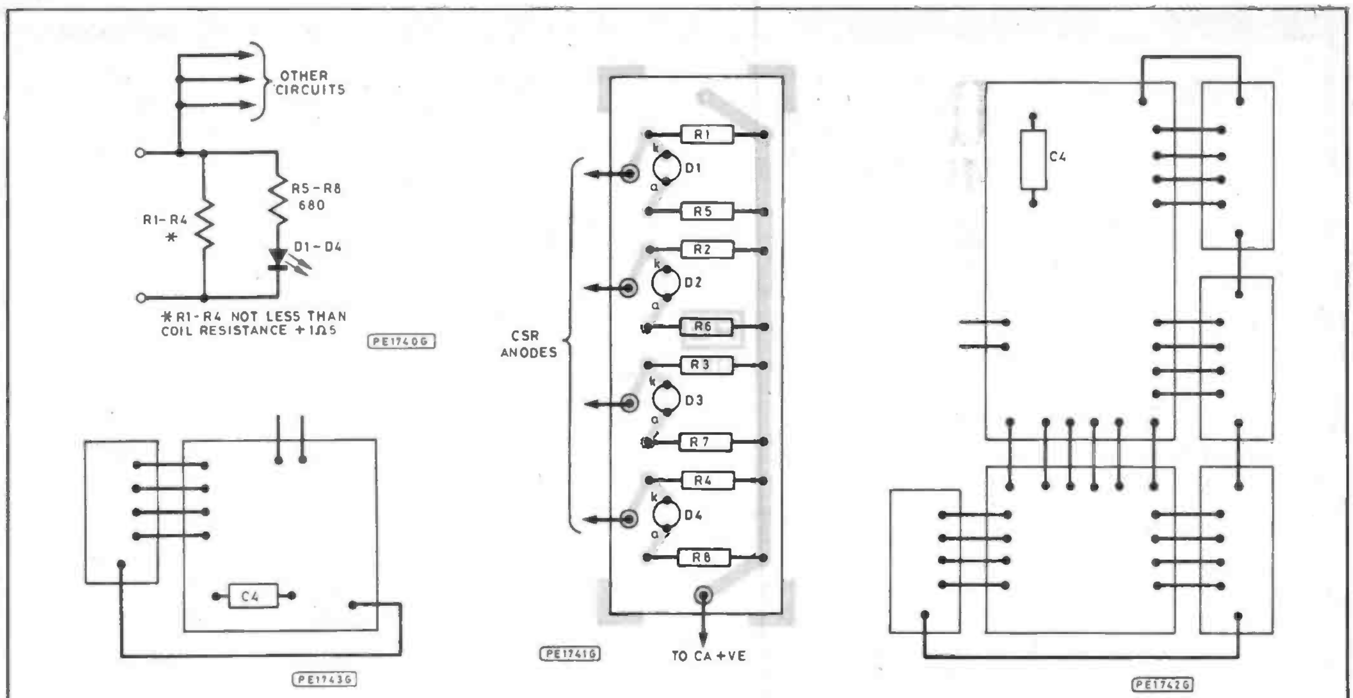
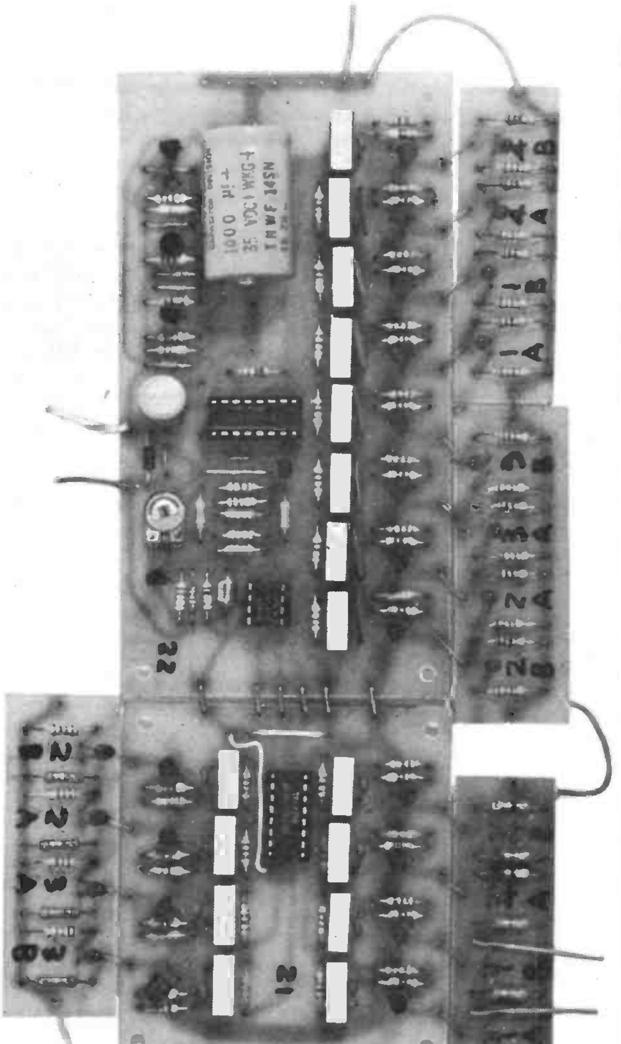


Fig. 15. Circuit diagram and p.c.b. layout of the test circuit together with schematic diagram of the connection details of the test set-up



Photograph illustrating the Type B receiver and extension board connected to the test boards

range setting. Connect a resistor of similar value to that of the coil, and 5% or better tolerance, in series with the coil. Connect to a d.c. power supply, at about 2V, or full scale on the nearest voltmeter range. Take readings of the supply voltage, V, and the voltage drop through the coil V_c, then:

Coil resistance $$R_c = \frac{R \times V_c}{V - V_c}\,\Omega$$

In a similar way, the coil inductance can be found, but this time using an a.c. supply of around 2V. The measurements must be taken with the motor armature in the ready to operate position.

Coil inductance:

$$L_c = \frac{V \times R}{V_r \times 100n} \times \sqrt{1 - \frac{(V_r^2 + V^2 - V_c^2)}{2.V_r.V}}\,H.$$

The theoretical circuit for the motor and storage capacitor relies on a perfect switch for correct operation. For the circuit to operate as designed, it should be over damped, and not tend to oscillate, that is:—

$$R_c^2 > \frac{4.L_c}{C}\ .$$

At any time t secs, after the switch is closed, the instantaneous current

$$i = \frac{V}{\sqrt{R_c^2 - \frac{4.L_c}{C}}}\,.\,(e^{-(\alpha - \beta)t} - e^{-(\alpha + \beta)t})\ A.$$

where

$$\alpha = \frac{R_c}{2L_c},\ \text{and}\ \beta = \sqrt{\frac{(R_c)^2}{(2L_c)} - \frac{1}{L_cC}}$$

The maximum current will occur at a time:—

$$t = -\frac{1}{2\beta}.\log_e\frac{(\alpha - \beta)}{(\alpha + \beta)}\ \text{secs.}$$

The thyristor is an imperfect switch, and so modifies the current in the circuit. An approximation to the forward characteristic of most thyristors can be made by assuming a voltage drop of 0·9V, and by increasing the motor coil resistance by 0·4Ω. The capacitor charging voltage is also reduced by the receiver diode D2, which should be taken as 1 volt. This reduces the effective charging voltage, in the above equation, to 26·1V, with a line voltage of 28V.

The result given by the above calculations will give a guide to the choice of a suitable thyristor, and should not exceed 50% of the surge rating of the device. ★

BBC Micro Forum...

David Whitfield MA MSc CEng MIEE

THIS month we continue to look at applications for the lightpen whose construction was described last month. As users of the lightpen with the simple test program will have noticed, the results are far from ideal. To begin, therefore, I shall be offering an improved program which makes rather more use of the capabilities of both the lightpen and the BBC Micro.

DRAWING ON THE SCREEN

The most natural medium for drawing is surely with coloured pens on a sheet of white paper. The graphics capabilities of the BBC Micro theoretically make this type of drawing quite a feasible proposition. The usual problem encountered by users, however, is the difficulty of programming the computer to perform as required. What is really required is the natural hand-to-eye coordination which is present in conventional freehand drawing, rather than wrestling with streams of PLOT commands.

The use of a lightpen on the screen is probably the most natural currently feasible method of interacting with a computer, since it involves so little change to the human operator's normal method of working. Just for once the computer is adapted to the needs of the operator, rather than vice versa.

The program in Listing 1 provides one example of using the lightpen in just the manner described. This is by no means representative of the best that can be achieved with the BBC Micro/lightpen combination; instead it illustrates the type of facilities which can be provided by programs of quite modest length. The program is still a little longer than is usual in this column, so a few notes of explanation as to the way it works, as well as how it is used, are appropriate.

PROGRAM DESCRIPTION

The program is effectively split into four major sections: setting up (lines 10-180), the main loop (lines 190-310), exit (lines 320-360), and subroutines (lines 380-580).

An assembler routine is provided in lines 50-70 to read the current value of the lightpen register from the CRTC. The characteristics of the standard 'beep' are then redefined in lines 90-120, and various parameters set up for controlling the operation and characteristics of the program. User defined character definitions, and the format of the screen windows are established in lines 130-180.

The main program loop starts by allowing the user to select a pen colour from the palette displayed on the left edge of the screen. This selection is performed using the lightpen. Once selected, a bar of the chosen colour replaces the palette, and a short 'beep' is also emitted. There is then a delay (set in line 100) to allow the pen to be moved to the required start position for drawing on the white sheet area provided. This should be done before the second beep sounds to show that the pen is now active; otherwise an unwanted smear may well result. Thereafter the pen's position on the screen is followed by the program, which prints the character defined as ASCII 254 (line 150). This character may be redefined to be larger or smaller as required; see page 384 in the User Guide to see how this is done. To produce a smooth response, a software filter is included in lines 250-270. Readers will have noticed with the demonstration last month that the pen produces a very jittery response unless some form of filtering is introduced. The smoothing factor for the filter is adjustable, and is set in line 110; larger values increase the time constant.

Listing 1: Drawing Tablet Program

```
 10 REM Lightpen Drawing Tablet
 20 REM -----------------------
 30 :
 40 ON ERROR GOTO 330
 50 DIM P% 30
 60 [.pen LDX #16:STX &FE00:LDX &FE01
 70 LDA #17:STA &FE00:LDA &FE01:RTS:]
 80 :
 90 Corr%=1542: *FX210,0
100 Delay%=200: *FX212,136
110 Smooth%=8:  *FX213,200
120 MODE 2:     *FX214,3
130 GCOL 0,135: COLOUR 135: CLS
140 A=24: B=60: C=126: D=60
150 VDU 23,254,A,B,C,C,C,C,B,A
160 VDU 23,255,D,D,D,D,D,D,D,D
170 VDU 28,0,31,0,0
180 VDU 23,1,0;0;0;0;: VDU 5
190 :
200 REPEAT PROCselect_colour
210  Temp=INKEY(Delay%): VDU 7
220  PROCpen_position
230  CurrX%=X%: CurrY%=Y%
240  REPEAT PROCpen_position
250   dX%=X%-CurrX%: dY%=Y%-CurrY%
260   CurrX%=CurrX%+(dX% DIV Smooth%)
270   CurrY%=CurrY%+(dY% DIV Smooth%)
280   MOVE CurrX%,CurrY%: VDU 254
290   Temp=INKEY(0)
300   UNTIL Temp=32
310  UNTIL FALSE
320 :
330 VDU 23,1,1;0;0;0;: *FX212,144
340 MODE 7: *FX213,101
350 *FX214,7
360 END
370 :
380 DEF PROCpen_position: *FX19
390 Pos%=(USR(pen)AND &FFFF)-Corr%
400 X%=16*(Pos% MOD 80)
410 Y%=1024-32*(Pos% DIV 80): ENDPROC
420 :
430 DEF PROCselect_colour
440 VDU4: COLOUR 135: CLS
450 FOR colour=0 TO 7
460  COLOUR colour+128
470  VDU 32,255,255
480  IF colour<>7 VDU 32
490  NEXT colour
500 *FX 21,0
510 REPEAT PROCpen_position
520  Key=INKEY(0)
530  UNTIL (X%<128) OR Key=33
540 IF Key=33 CLG: GOTO 440
550 VDU 7: colour=7-(Y% DIV 128)
560 GCOL 0,colour: COLOUR colour+128
570 CLS: VDU 5
580 ENDPROC
```

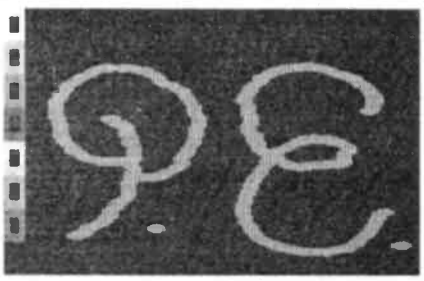


Fig. 1. Sample results from Listing 1

To change colour (or just lift the pen), the space bar is pressed. This stops the drawing process, and causes the palette to be re-displayed. The user may then select another colour (or re-select the same colour) using the lightpen as before, and the whole operation then repeats as just described. As an alternative to selecting another colour, the drawing sheet may be wiped clean by pressing the "!" key; the program then continues by displaying a blank sheet and the palette. Exit from the program is by pressing ESCAPE; the cursor and beep characteristics are reset to their normal values by the exit routine in lines 320-360.

The first of the two subroutines is for reading the X-Y coordinates of the lightpen, and for converting the CRTC values to graphics coordinates for use by the PLOT command. The second routine is for displaying the colour palette and allowing the user to select the pen colour. The palette is displayed using a one character wide text window.

RESULTS & ENHANCEMENTS

A simple example of the results which can be obtained using this program is shown in Fig. 1. In use, it will soon be found that many improvements may occur to you for incorporation into this basic program. The program just described is still relatively simple, but is offered here as a starting point for experimentation. One of the first improvements which could be considered is to add a facility to overcome the wrap-around effect that occurs when the pen approaches the right edge of the screen.

The next improvement could be to eliminate the need to use the keyboard at all during the operation of the program. One way of doing this would be to make use of a microswitch mounted on the pen barrel, and connected to one of the fire button inputs on the analogue port. This simply requires one extra wire to be brought to the pen, as shown in Fig. 2. Thus, the lightpen could be configured to draw only when this switch is held down. This means that the switch really needs to be mounted conveniently under the artist's finger as the pen is held, but this should not be too much of a problem. An alternative could be to consider touch pads connected to one of the ADC inputs to detect the resistance of a finger as the switching event.

As mentioned before, the uses to which a tool such as a lightpen may be put are limited mainly by the imagination of the programmer. Anyone looking for further ideas for directions in which to develop their lightpen applications may like to consider trying to emulate some of the capabilities of the Reekie Image Plotter as reviewed in September's PE. Another use for a lightpen is in applications where the user is not familiar with entering choices from the keyboard (e.g. with young children, who prefer to point). Here it is often much better if a menu of choices can be displayed, and the actual choice made by pointing at the appropriate symbol or coloured area on the screen. In this type of application, it should always be remembered that the lightpen responds best to white areas, and not at all to black areas of the screen.

Happy experimenting!

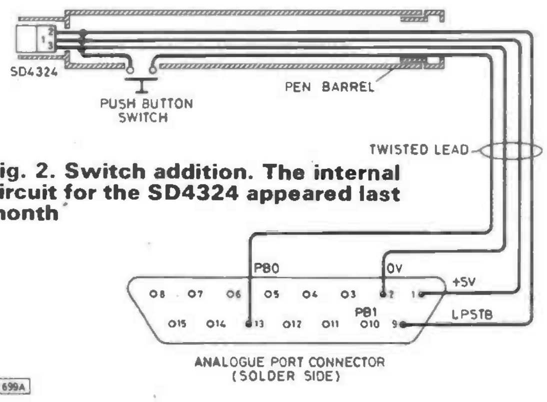


Fig. 2. Switch addition. The internal circuit for the SD4324 appeared last month

Book Corner

After two month's absence, *Book Corner* returns to look at what could perhaps be described as a programmer's atlas to the BBC Micro's built-in software. **Within the BBC Microcomputer** by *Roger Cullis* is published by Losco Ltd., PO Box 4, Cranleigh, Surrey GU6 8BQ at £11.95 plus £1.80 P&P. A spiral bound book of around 260 pages, this is a reference manual for the serious assembler programmer and hardware designer. It contains descriptions and explanations of the principal ROM routines, memory maps, tables of RAM usage, ROM routine entry points, page zero locations, and JMP/JSR and lookup reference origins. It covers OS 1.2, Basic 1&2, DFS 0.90, NFS 3.34, 6502 2nd processor OS 1.1, and DNFS/Econet Tube communications.

It must be said that this is not for the most part a book to be recommended for light reading, since it is more of a reference book in the true sense of the word. That said, however, there is much interesting material contained in the description which introduces each of the types of ROM. For example, there are 13 pages devoted to an outline description of the MOS in terms of its principle routines. This is the type of material which is not easily to be found elsewhere.

Each ROM is dealt with in a similar fashion, which considerably eases the task of finding your way around the book. A title page gives basic information about the ROM in question, such as the title string, the assembly address, relocation and workspace requirements. This is followed by a memory map of the ROM, giving the basic structure of the code, in typically just over half a page. After this is a map identifying which of the first 256 bytes of RAM (page zero) are used by the ROM. Descriptions of the main routines in the ROM then follow, accompanied by a gazetteer of their entry points. The areas of RAM used are then identified, and each section is concluded by tables giving the sources of subroutine calls, unconditional jumps and lookup references.

It must be said that these latter tables are likely to be of interest only to anyone who is actually trying to use the routines within the ROM. This section of each ROM's description would benefit fom a few words of explanation as to the significance and usefulness of the information presented. A few examples would also help to illustrate these parts of the book, which otherwise left your reviewer little the wiser. In general, the book would benefit from a few illustrations and hints as to how to use the data which is so carefully, clearly and thoroughly provided.

Verdict: *A useful reference guide, full of much valuable information, which may be the answer to many a prayer. However, you will need to know what you want to do with the information presented in order to make full use of it.*

NEXT MONTH:
The RS423 port is explored.

21 YEARS OF ELECTRONICS

MIKE KENWARD...PART TWO

At the end of 1977 PE and EE were separated and the editorial offices of PE moved to Poole in Dorset. I took over responsibility as Editor of PE with the January '78 issue—that month we had a mistake on the front cover, not the best start for a new Editor. Fortunately things could only get better!

MICROS

As microcomputers developed into the hobbyist area and prices started falling a number of designs were being produced by contributors and offered to the hobby magazines. Apart from the PE Champ which we published in Sept. '77 PE resisted the temptation to carry these designs while developments were racing ahead. However by mid '79 various realistic systems had been built around chips like the Z8 and 6502 and we took the plunge with Compukit UK101. This design was arguably the most successful kit to be published in a UK hobby magazine and while, as has often been the case with microcomputers, there were early supply problems the design took off in a big way. Success was mainly due to the use of Microsoft BASIC and a realistic specification for an all in price of around £200.

Interestingly we had published a microcomputer printer using electrosensitive foil paper and a 40 column, 5 × 7 dot matrix print head made by Mastsushita a full six months before UK101—the cost of constructing the printer was about £90. In Feb '79 we looked at "Home Computers . . . the Microprocessor Miracle!" and such machines as the Commodore PET, Tandy TRS80, Apple II, Research Machines 380Z and Nascom 1 were featured—it's surprising how long some designs have been around!

We reviewed bubble memories in April '79 and expected them to make an impact fairly quickly, the article said **"Already a 64K device has been passed in the laboratory by a 256K device which should enter production before 1980. In the USA chips as large as 1M have been made and operated and chips four times this capacity have been projected by the early 1980's . . . It is hoped that over the next few years circuit designers will come to regard magnetic bubble devices as just another integrated circuit package."**

Zilog were shouting about their new 16 bit micro the Z8000 around the end of '79 and we reported on their Captain Zilog comic:

"Now, one way to tackle the publicity task would be to commission some technical articles and advertisements extolling the virtues of the Z8000 architecture, but Zilog wanted to get all electronics engineers interested and there's only one way to do that, isn't there? Yes of course, they gave the Z8000 its very own comic book! Enter Captain Zilog, alias systems designer Nick Stacey, who is given the gift of "Zilog power" by an extra-terrestrial being who hauls him bodily through his VDU screen.

Moulded in the fine tradition of Superman and Captain America, Captain Zilog hurls himself into adventures such as "The doom of Doctor D" and "Battle beneath the architecture" in a desperate (and of course successful) attempt to foil the dastardly plans of Doctor Diabolicus who intends to conquer Earth with the aid of his super main-frame computer. Liberally laced with comments such as: "Stick it in your Index Register Diabolicus" or "Dancin' data" and "Leapin' logic", the new Zilog comic book is a must, if you can get one!"

We spent more than a year describing most of the available microprocessor chips during '83 in Micro-File written by Ray Coles. The work has proved to be well accepted and together makes an invaluable reference to microprocessors. The series which has now been updated will be available in a book from Newnes in the near future.

More recently we have turned our attention to explaining how to use microprocessors and the new series Introduction to Microprocessor Systems is an example of this policy.

ENTER ZX

Science of Cambridge was the company name, Clive Sinclair the driving force and the ZX80 the breakthrough product. It was available in kit form for £79.95, and PE's Mike Abbott reviewed it in July '80 with the following conclusion:

I see the ZX80 in the classroom, and in workshop control applications. Perhaps even hidden in the executive's top drawer, to be pulled out at lunch times to resume training. For these situations, the machine is excellent, and eminently suited to teaching children the art of computer programming. It is of little use scientifically at present, with only integer capability and no mathematical functions, and this to some extent wastes the boasted processing speed of the machine.

At the time of writing it seemed appropriate to advise that a firm delivery date be secured before purchasing the ZX80 microcomputer. Some things do not change much do they?

Of course the ZX80 soon gave way to the much more successful ZX81 and then the Spectrum. None of the later models were offered in kit form. Clive Sinclair—later Sir Clive—has come a long way since those early ads in 1980 but the Spectrum was to take him away from the electronics hobbyist and firmly into the new area of home computing.

The Compukit UK 101. A 6502 based single board computer. This 8K machine was published in August '79 and proved to be one of our most popular projects

The Jan '78 front cover, can you spot the mistake?—It wasn't deliberate!

PROJECTS

Over the years the editorial staff of the magazine have built up a general knowledge of what projects are likely to be the most popular and of course those which are often requested by readers. One such project was an Ultrasonic Cleaning Bath—a design which had often been requested but which had always eluded us because of transducer and stainless steel bath supply problems. A project was published in the Jan '80 issue and a kit was available for £68. With the help of a friendly component supplier the problems had been solved; a little ingenuity resulted in a canteen food dispensing dish being used as the bath.

About 20 kits were sold over the next few months—a very poor result especially when the design had often been requested. Later a fire destroyed the stock of components and the design information for the special coils used—truly a fated project and one which is occasionally requested by readers; even now we still have to disappoint them. (We cannot supply any information or assistance on projects that are more than five year old anyway.)

Other project landmarks in '79 were an Accoustically Coupled Modem, PE Magnum Metal Locator and PE Teletext. We published a sound board for Compukit and a Speech Synthesiser. Support for Compukit continued through Micro Prompt—the hardware and software exchange point for PE computer projects—and in the Interfacing Compukit series which ran in 1981.

CB was big at that time, PE allowed readers to listen to the illegal a.m. transmissions with a 27/28MHz converter for car radios. Of course it was illegal to even listen to those transmissions but that was up to you! Later the same year we published a booklet entitled Introduction to Legal CB and, at the same time, commenced a short series describing the construction of a rig designed to meet the newly introduced CB laws, the PE Ranger.

The Ranger design annoyed some established amateur radio magazines as they argued it could not be type approved by the Home Office. The kit was moderately successful but the CB bubble soon burst and readers could buy a ready-made full spec. rig for less than the £60 it cost to build the Ranger.

1981 was quite a year for projects and PE scored further hits with the Genesis Robots—designed by Richard Becker then a director of Powertran—and with the PE Car Computer—probably still an unsurpassed design capable of many in-car calculations. Both these projects went on to be marketed around the world, as have many other PE designs over the years.

A few projects never seem to die and the PE Scorpio Ignition System was one of these. In '82 we published a miniature version of the unit that was first introduced to readers in 1974; once again it proved to be very popular.

FAME

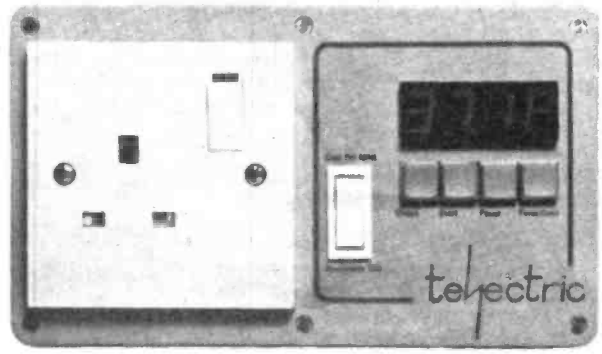
Just a couple of items we have described to readers have made it to BBC's Tomorrow's World. The first was XEE described last month; the other was the Telectric, an electricity cost monitor featured in March/April '82.

Telectric behaved itself perfectly well, though just what happened to the food being cooked in a conventional and a microwave oven is a mystery—my guess is the cameramen got there first.

One or two other projects have made it to various local radio programmes and some readers may have heard me describing them rather nervously to presenters; Micrograsp was one featured late in '82.

It would be easy to go on at length about various projects over the years but as we come more up to date readers will remember what has been done. Many projects had their associated problems, some gave us more than a few headaches—notably some of the various robots that have been featured.

Projects changed with the times; we published logic analysers, digital lighting effect units, a computer terminal and many add-ons for various computers—in fact just the subjects you will find in PE today. Where do we go next? What about surface mounted devices and are we moving towards an android type robot? Who knows, perhaps that is what makes it all so exciting.



HUMOUR

PE has not been the place for much humour. Right or wrong we have always felt that the serious matter of technology at a reasonable level of understanding does not readily mix with off the cuff remarks and the "cheap sell" approach. However we have "bent the rule" a little on various occasions and sometimes this has rebounded on us.

"I had the pleasure of spending a day with the Tomorrow's World team during '82, seeing how the programme is put together and watching Judith Hann fall off a pair of Japanese motorised roller skates that were also being featured."

In April 1980 we were pleased to find BBC Wales interested in doing a programme based on an item in Semiconductor Circuits, but imagine their red faces when we had to explain the whole page was an April Fool. Llyis Electronics exploits were reported such:

"ZMOS F.E.T. (X520, X530)

All the rage in UK discos later this year will be the new range of ZMOS f.e.t.s from the Welsh firm of Llyis Electronics. At last the unflagging research efforts of this energetic young company have come to fruition, and there will be no stopping them now. Working with only limited capital and outdated equipment, the back-room boys at Llyis have taken on the might of giants like Texas Instruments and Motorola, beating them at their own game with radical and innovative technology of the very highest standard. Llyis make their own silicon because they have found imported material to contain too many impurities, and with the confidence encouraged by a bulging order book, they have now found it possible to take up their option on a section of Prestatyn beach, thus ensuring a ready supply of raw material for years to come.

The new ZMOS power transistor family is typical of Llyis products. Designed primarily for high current, high power applications in disco power amplifiers, the new ZMOS family manages to combine the best of bipolar, MOSFET and valve technology in one easy to use "HEX-NUT" package. The ZMOS X520 for example, is very sensitive to static charges and requires a high current drive source, and yet it has the highest "on" resistance in the industry and runs from a 200V h.t. supply. All the ZMOS range feature industry-standard 6·3V a.c. heaters and unique "disco safety" circuits which render the amplifier harmless during transient musical passages which might otherwise lead to auditory damage. The 4kW per channel (typical using 4 × X520S) or 8kW per channel (typical using 4 × X530S) is higher than anything unleashed in discos before, and has forced Llyis to develop companion loudspeakers with leather cones. Every device carries a government health warning, but under extreme conditions the "disco safety" circuit will cause the output devices to self-destruct before the 160dB pain threshold is exceeded.

The novel ZMOS "HEX-NUT" package features ports for standard microbore central heating pipes, and for evaluation purposes a domestic radiator and central heating pump system topped up with ice water before a session will be about ready to brew coffee two mind blowing hours later. For serious applications a thirty gallon header tank will be needed, a full quadrophonic system can provide central heating for an average street if used just four hours per day. Nice one boyos!"

We presume BBC Wales were worried about the beach disappearing!

We have carried other April fool pieces over the years and '85 was no exception, the item shown was carried in News & Market Place, April issue.

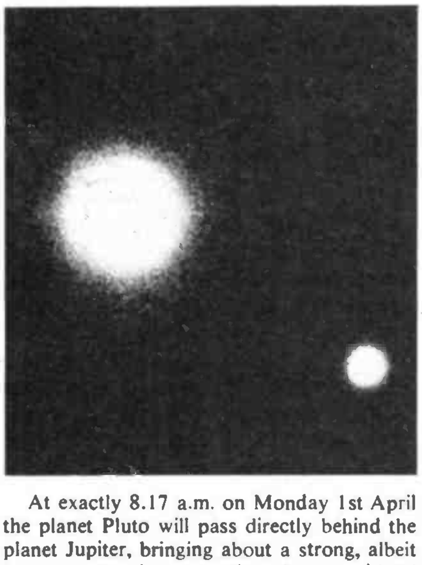
One reader suggested that with so many people in the UK jumping at once it might put the world off balance, but unfortunately our Australian readers must have been heavy enough to counteract the effect. Only a small tremor was felt in the editorial office and that mainly due to IPC staff trying to beat the record!

This tongue-in-cheek news piece appeared in the April issue this year

LAST CHANCE FOR 11 YEARS

In these times of regular space travel most of us know what weightlessness 'looks' like having witnessed much television coverage of the Space Shuttle crews.

It is a little known fact, however, that once in every eleven years we can actually experience a level of weightlessness right here on earth.



At exactly 8.17 a.m. on Monday 1st April the planet Pluto will pass directly behind the planet Jupiter, bringing about a strong, albeit momentary, increase in the combined gravitational pull. At the precise moment when the planets are in exact spacial alignment, a sense of elation can be felt. Indeed jumping into the air at this exact moment will bring about a real sensation of weightlessness.

This phenomenon was originally discovered in 1899 when a Mr. Y. S. Dilloss made an incredible high jump of 3·47 metres, a record incidentally that has never been broken.

As its title would signify, *Practical Electronics* was an addition to the famous family of periodicals created by publishers George Newnes.

A word of acknowledgement to the father of the "Practical Group" will not be out of place here. F. J. Camm is a name that will be remembered by thousands of readers, and certainly by those with radio interests. Founded in 1932, *Practical Wireless* became the largest selling publication of its kind.

Fred Bennett joined *Practical Wireless* in 1962, shortly after to become Assistant Editor. Two years later he was assigned to work on a new publication that would cater for all electronics enthusiasts. Early in 1964 the Practical Group moved from their original home in Tower House, just off the Strand, London to nearby Catherine St. (next door to Theatre Royal, Drury Lane) and this was to be the birthplace of PE and its home for the next few years. In 1970 the Practicals moved once again, this time into the City, to Fleetway House, Farringdon St.

During the launch period Roy Smith, then Advertisement Manager of PW took on similar responsibility for the new magazine. He was assisted by David Tilleard. Within a few months, David Tilleard was appointed ad. manager, a post he has held throughout to the present day.

The first recruit to the PE editorial team was David Barrington, an established member of the Practical Group, who commenced his early training with the Company under F. J. Camm. He now holds the position of Assistant Editor (Production) on PE and sister publication *Everyday Electronics*.

Gordon Godbold joined the editorial team in 1965 and with the establishment of the PE workshop he became responsible for testing and evaluating projects submitted by readers, as well as creating numerous designs himself. Gordon was Assistant Editor from 1977 to 1982.

Jack Pountney was appointed Art Editor and continued in this role until his retirement in August 1985. Jack was responsible for the design of last month's front cover, celebrating 21 years of PE—his last for PE.

MOVE TO POOLE

With the publication of the December '77 issue, an era closed. This was the last issue of PE to be produced in London and the last to be edited by Fred Bennett who had held this office throughout from the launch of the magazine in 1964.

The editorial department moved to a new location at Poole, Dorset and Mike Kenward was appointed editor. No newcomer to PE, Mike joined the staff of this magazine in 1968. When a sister publication *Everyday Electronics* was created in 1971 he was chosen to be Assistant Editor and held this post until leaving the company in early 1977, only to return six months later.

***Everyday Electronics* remained in London under Fred Bennett. The "sisters" had been separated and each publication went its own independent way. As was to be expected, some rivalry developed between PE and EE and the demarcation between areas of interest may have become a little less distinct than before, however, the original editorial policy laid down for each magazine was, in general, maintained.**

A further domestic upheaval took place in 1984, with the relocation of *Everyday Electronics* to Poole. Thus PE and EE were re-united once more under one editor, this time Mike Kenward. Fred Bennett remained in London, acting as Consultant Editor until his retirement in September 1985.

Fred's last published work for PE was the first part of this feature, a fitting end to 21 years involvement with PE.

Just for interest the idea was one that Dr Patrick Moore—now a PE contributor—tried out on a radio programme some years earlier, apparently with much success! Patrick was kind enough to let us use it in PE.

GIFTS

For many years PE produced and gave away a number of free plastic gifts. 1979 was no exception, with two excellent tools being cover mounted free with the May and October issues. The tools were an IC Insertion Tool and an IC Removal Tool which proved so popular with readers that both gifts were repeated a couple of years later.

Probably the most successful gift we have ever given was the Instrument Case presented free with the May '81 issue—a similar but improved case is now sold by Maplin for £1.25, but PE was responsible with Lascar Electronics for its inception. The case was cover mounted, it took up half the cover and was twice as thick as the magazine so it gave us a number of problems with distribution of the issue.

We published six projects designed by Lascar to go into the case and later other contributors used it to house their projects. The case was so popular it proved difficult to follow, and further gifts have been mainly of the paper variety—charts like the one in this issue, and data sheets for logic etc. Once again these have been very well received and we feel are of more value than a very simple plastic item. Of course if we can come up with something rather special again you will benefit—we are working on it!

COVERS

For many years PE covers were virtually always given over to depicting projects. A change was introduced in April '83 with more wording and a split photo-approach being adopted. This never worked to our entire satisfaction and we gradually moved back to the original ideas until a complete departure was instigated with the February issue this year.

Our covers are now mainly formed from abstract photos taken in the electronics industry, exciting covers that are in keeping with PE's standing and readership. We will continue to produce exceptions to these like this month's specially commissioned artwork of Halley's Comet which ties up with Patrick Moore's article.

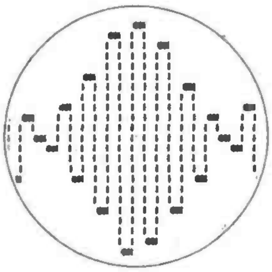
The Micrograsp robot with interface and ZX81—a very popular low-cost system introduced in Dec '82

THE NEXT SEVEN YEARS

Over the last few months there have been many changes in the market place. Magazines like *Electronics and Computing, Digital and Micro Electronics* and *Electronics Monthly* have changed, disappeared or been merged with others (*Electronics Monthly* has been bought by IPC and merged with our sister publication *Everyday Electronics*). Some companies have not withstood the recession and disappeared, with very few newcomers to replace them.

PE has weathered the storm well and recently we have been able to increase our page size while still introducing economies to keep the cover price at a reasonable level—we are still cheaper than our direct opposition and believe we represent better value for money.

From a firm base with many new ideas we will again move forward with the next generation of hobbyists and engineers who may well be designing and building with surface mounted components and more l.s.i. than ever before. Stay with us—it should be interesting.



Micro-Scope

John M.H. Becker Part 1

Computerised circuit tester for audio to visual display on Commodore PET or BBC

THERE are many readers who periodically build some of the published projects and who would ideally like to use an oscilloscope to give a visual display of circuit activities during testing. Although there are low cost oscilloscopes available, the expense is not necessarily justified if projects are only built infrequently. However, many people who take an interest in electronics, probably have a computer that can be quite readily used with an interface circuit and suitable program to give such a display at a considerably lower cost.

WHAT IT'S FOR

Principally this interface unit has been designed for use with the Commodore Pet series 2, 3 and 40-column 4, C64 and the BBC, but should be usable with any micro having an 8-bit parallel socket, with only minor modifications to the program given later.

The capabilities of this unit allow the sampling and display, in oscilloscope fashion (Photos G, I, J), of audio frequencies of less than 1Hz to greater than 70KHz, with an input amplitude range switchable from 1mV up to 25V in three steps. The program has been written so that in addition to waveform display, there is a read-out of peak to peak signal voltages, of the fundamental frequency being sampled, and also a bar graph display of a.c. or d.c. voltage levels so enabling the unit to act as a voltmeter (Photo H). The unit will not totally simulate equipment dedicated to these functions but the accuracy is sufficiently close to provide a realistic use of a computer as an electronic test aid. All figures quoted are subject to normal component tolerance variations.

A-D CONVERTER

Essentially the unit is no more than an analogue to digital converter with variable input gain, but the inclusion of panel controlled biasing, and switchable frequency division gives greater flexibility than with just an A-D on its own. IC2 is the business end of the unit and is a high speed successive approximation A-D chip which produces an 8-bit binary output number that is relative to the analogue voltage present at its input.

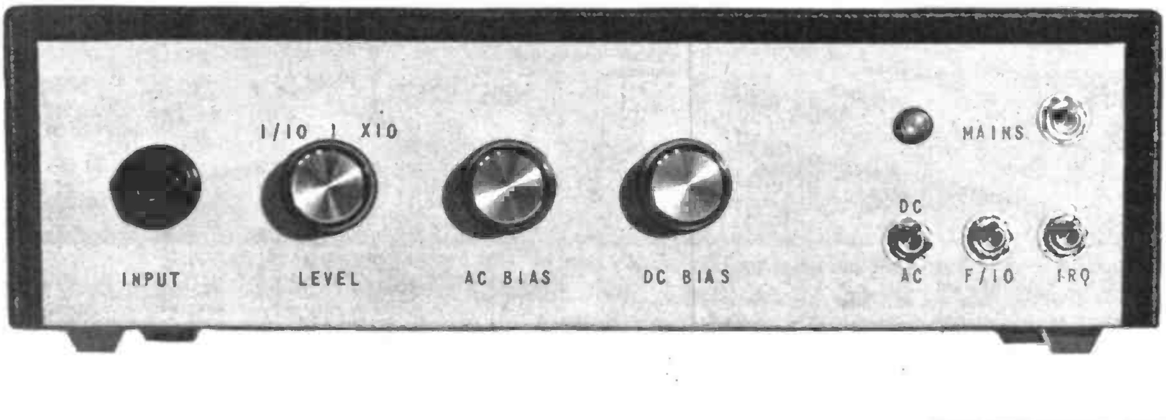
Upon receipt of a convert pulse from the computer, the chip samples the voltage level whereupon an internal oscillator, the frequency of which is set by C4 to about 1MHz, then clocks the chip through 8 cycles. During each cycle it assesses whether the binary bit associated with that cycle should be high or low. At the end of the eighth cycle the conversion approximation ceases and the DAV output goes high signalling that the chip has a satisfactory answer available. The computer is programmed to take note of the DAV signal, where upon it reads the output of IC2 via its eight data lines. After processing the sampled byte, the computer signals back to the chip to proceed with the next sampling.

SAMPLING PARAMETERS

It will be apparent that this sampling is not instantaneous. The maximum rate depends on the conversion clocking procedure which takes approximately 8 microseconds with a 1MHz clock, and the computer takes about another 50 microseconds to process the data. During this time the signal amplitude at the input to IC2 has probably changed its level by the time that the next sampling takes place. The result is that there is a step between the level of each sample, and so the read out display given by the computer will not be a smooth waveform slope as found with a normal oscilloscope, but a succession of cliffs and platforms, the platform representing the actual sampled voltage, and the cliff the graph line displayed linking each sample (Photo E).

This naturally places an upper limit upon the frequency that can be sampled. The minimum number of samples that can be used to represent a particular frequency is two, either the signal is low or it is high, resulting in binary 0 or greater than binary 0 (Photo F). For a better waveform approximation at least three samples per waveform are better so that intermediate points can be plotted, and so the clocking rate should preferably be at least three times the sampled frequency. Here, with the computer program running at about 15kHz sampling rate, 5kHz is about the maximum input frequency that will still show a resemblance to its actual waveform. (Photo B). As the more dominant audio frequencies lie below 5kHz this limit is quite adequate for most signal tracing tests. For input frequencies of less than 5kHz the number of samples per cycle will increase and so a better waveform shape can be approximated. (Photo A). Frequencies greater than twice the sampling frequency will still be sampled, but each sampling will take place on different frequency cycles, and so the resulting display will effectively show harmonic waveforms related to the ratio of the input and sampling frequencies (Photos C, D).

The reference voltage at IC2 is set by an internal zener to about 2·5V and the total number of binary output variations from the 8-bit output is 256 (2^8), so each bit represents a 10mV step, up to



a maximum level of 2·5V. The amplitude of the input signal though can be increased or decreased before it reaches IC2, and so a wider input voltage range can thus be sampled.

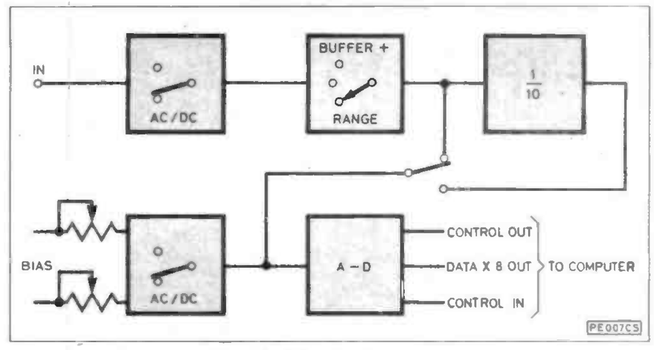


Fig. 1. Block diagram

FROM INPUT TO OUTPUT

The signal is brought in from JK1 and can be selected by S2a for either d.c. or a.c. coupling via C1. S1a then selects whether the signal comes direct from S2a with no attenuation, or via R1 and VR1 which are set for an attentuation to one tenth of the original level. The overall impedance at the input is about 100k, so that the unit will offer very little load to the circuit being examined.

IC1a is a high impedance buffer and gain stage, where the gain is switch selectable by S1b. In positions 1 and 2 the gain is set by VR3 for x1, and position 3 via R4 and VR2 for x10. The three positions of S1 thus allow for a gain range of x0·1, x1 and x10. From IC1a the signal is routed to IC2 directly, or via the frequency divider circuit, as selected by S4. On the latter route, the signal is given maximum gain by the open loop amplifier IC1b. With sufficient gain from the preceding IC1a, the output from IC1b will be a full line to line swing square wave of about 10 volts peak to peak. This is suitable for driving the decade counter IC3, which divides the frequency by ten and produces an equal mark-space square wave at its output. R2 and R6 attenuate the output swing to a level low enough not to embarrass IC2. It is not intended that waveform shape should be retained at IC3, and this part of the circuit is included primarily so that frequencies higher than 5kHz can be measured by the computer. A visual display will still take place, but of course it will only be a square waveform. (Photo F). In this mode the frequency readout should be multiplied by 10.

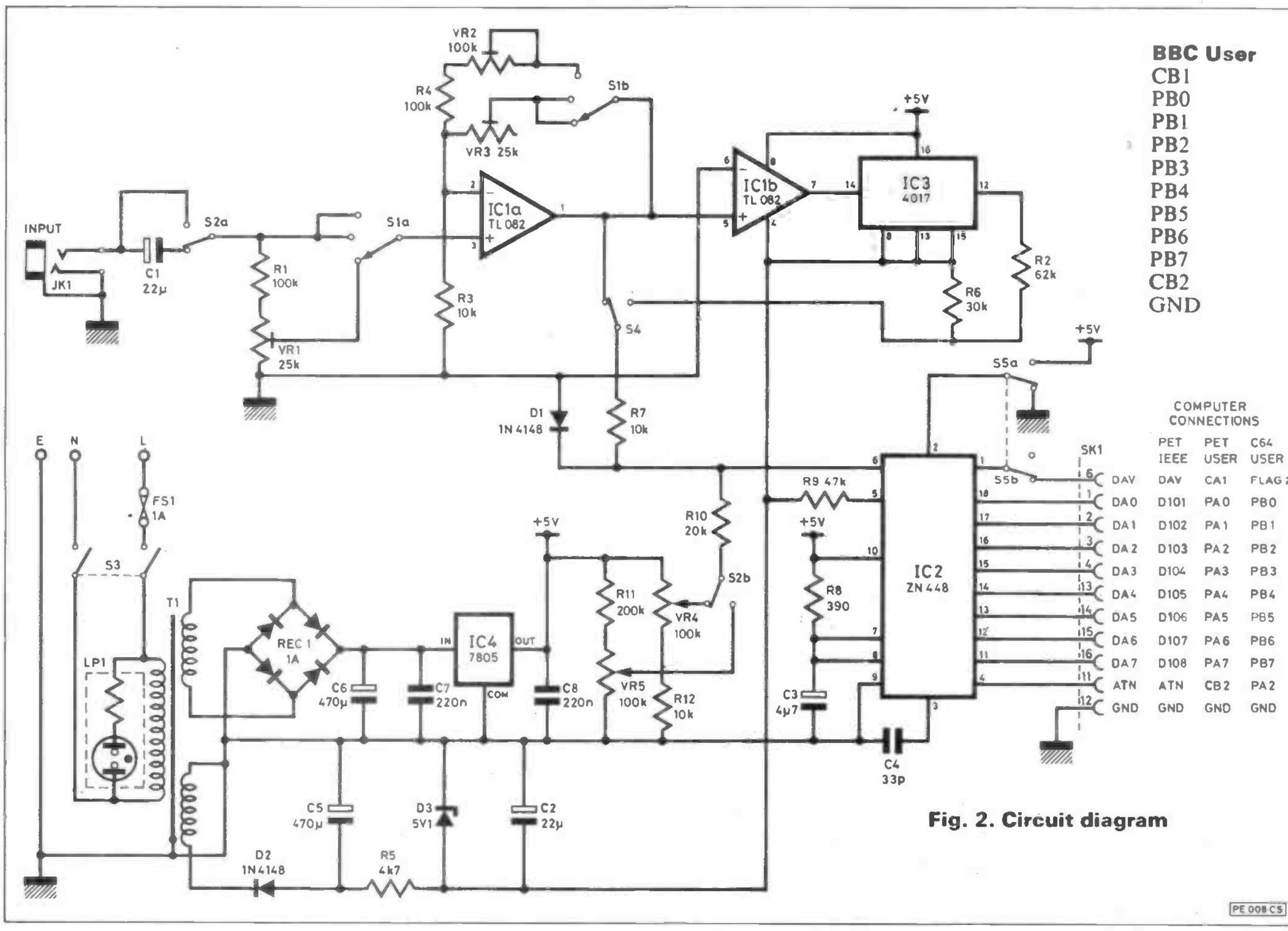
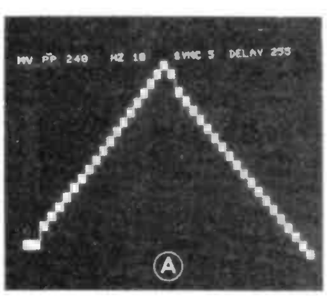
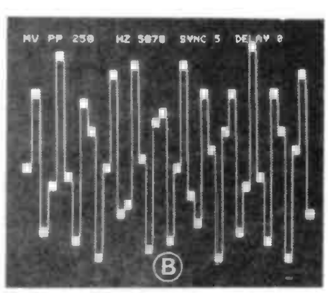
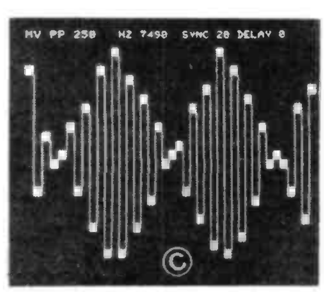
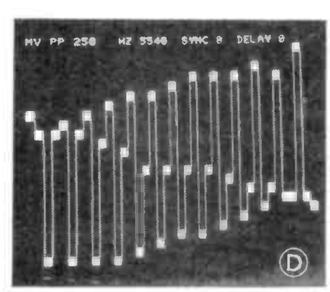


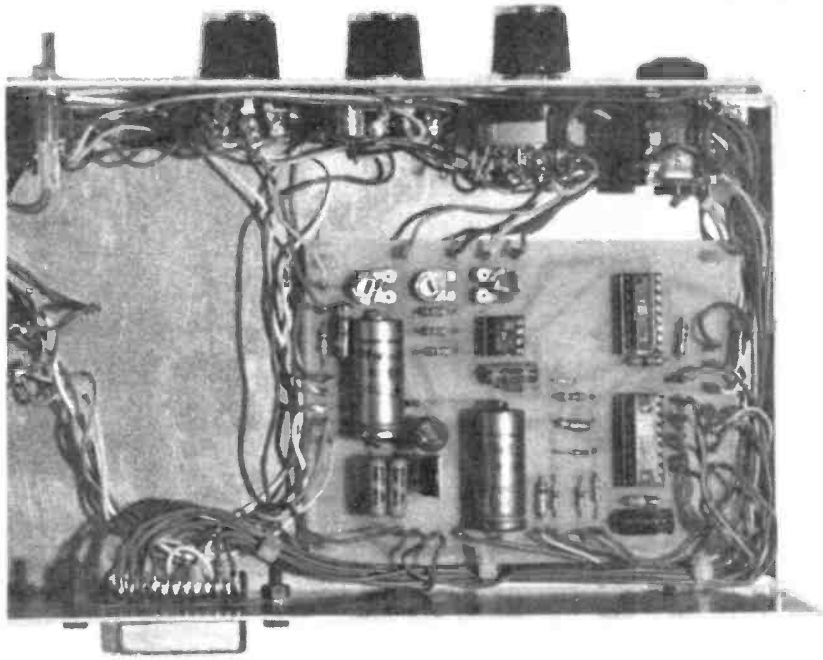
Fig. 2. Circuit diagram











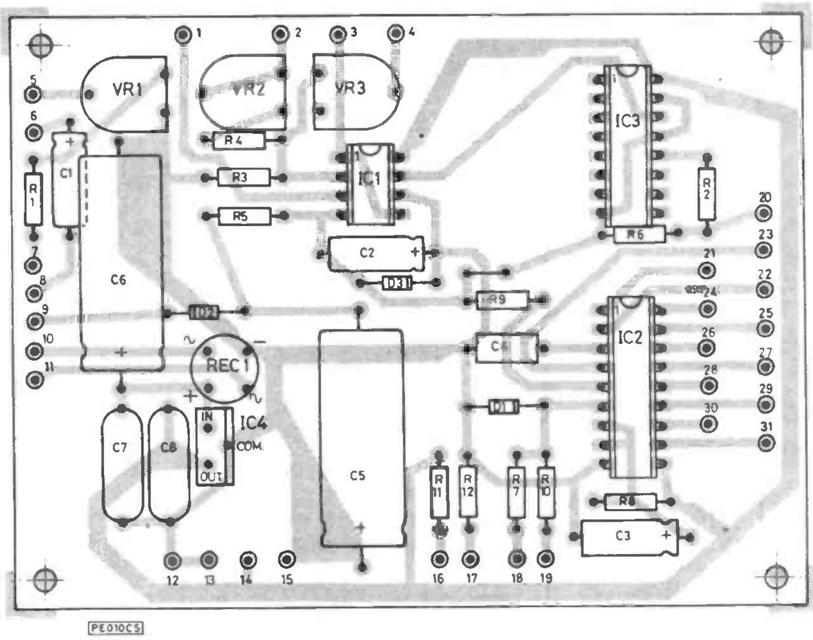


Fig. 4. Component layout

From S4 the signal goes to the input of IC2. Here the requirements for d.c. and a.c. voltage reading are different. For a.c. waveforms these need to swing evenly from either side of a midway point so that the computer sees approximately decimal 128 in the absence of a signal. For d.c. voltages, the computer needs to see decimal 0 for zero voltage. Consequently separate biasing panel controls are provided. VR4 is used in the a.c. mode to set a midway point, and VR5 is used in the d.c. mode to set a zero point. S2b selects between the two. Diode D1 ensures that only positive levels reach IC2.

POWER SUPPLY

IC2 requires about 25mA of current and so the unit has its own mains power supply to ensure stability. The positive rail uses a standard full wave rectifier circuit with the level regulated to +5V by IC4. The negative rail draws hardly any current and is produced from a half wave rectifier circuit coupled to the other winding of T1. D3 drops the rectified level to –5V, with C5 and C2 ensuring adequate smoothing.

PORTS AND PROGRAM LOCATION

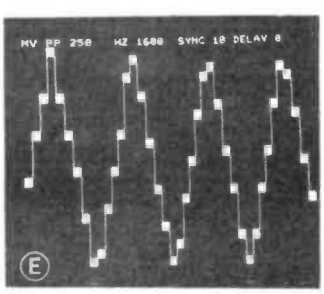
The computer program has been written to be automatically used anywhere in memory for a Commodore Pet, C64, or BBC2. On the Pet it can be used either with the IEEE 488 Port, or with the user Port. For the C64 and BBC it is only for use on the user Port. For use with other machines on their IEEE or user ports, sufficient information is given for the relevant memory codes to be readily changed. The program itself is totally relocatable, and will automatically place itself in the highest available RAM area and reset the memory pointers and its own branch codes accordingly. It can be used in the presence of Tool Kit and Super Chip, and probably with other programming aid chips. The data output socket should be selected and wired to suit the computer being used.

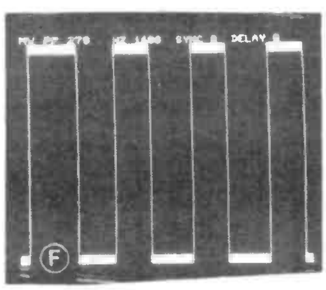
When typing in the program remember to change Line 150 give the computer type otherwise the wrong data statements will be read. Experienced programmers can omit data lines not related to their machine. Note that if the control unit is on the same control lines as other equipment such as disc drives or printer, S5 must be switched off if those other items need to be used otherwise IC2 will affect their correct operation. With S5 off IC2 is in high impedance.

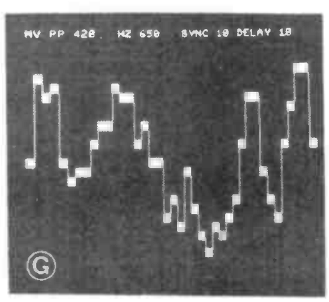
A full description of the program is beyond the nature of this article, and only brief function descriptions can be given. Closer examination of the program itself will reveal more of what happens.

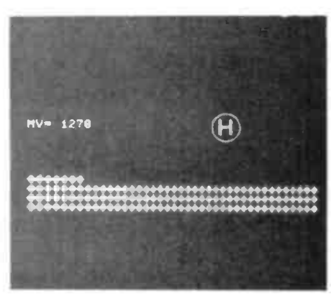
BASIC START

The BASIC program first checks to see if the existing top of memory pointers need to be reset, and if so resets them. It then loads the relevant data statements into the reserved area of memory. These data codes are the machine code routines that do the main sampling and display. When the data has been stored in memory, the program goes straight into the scope display routine

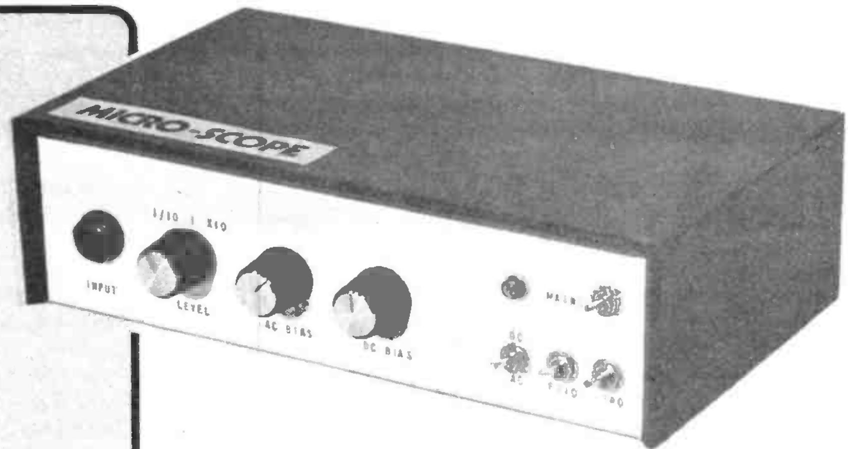


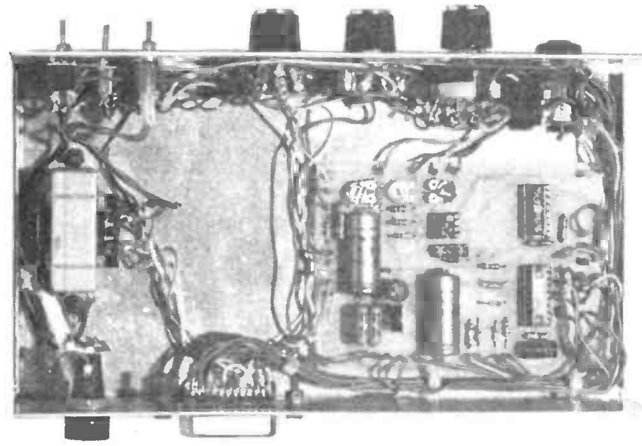






COMPONENTS . . .





Resistors

R1, R4	100k (2 off)
R2	62k
R3, R7, R12	10k (3 off)
R5	4k7
R6	30k
R8	390
R9	47k
R10	20k
R11	200k

All resistors $\frac{1}{4}$W 5%

Capacitors

C1, C2,	22μ 16V electrolytic (2 off)
C3	4μ7 63V electrolytic
C4	33p polystyrene
C5, C6	470μ 25V electrolytic (2 off)
C7, C8	220n polyester (2 off)

Potentiometers

VR1, VR3	25k skeleton (2 off)
VR2	100k skeleton
VR4, VR5	100k mono rotary (2 off)

Semiconductors

D1, D2	1N4148 (2 off)
D3	5V1 400mW Zener
REC1	1A bridge rectifier
IC1	4017
IC1	TL082
IC2	ZN448
IC4	7805

Switches

S1	3 pole-4 way
S2, S3, S5	min d.p.d.t. (3 off)
S4	min s.p.d.t.

Miscellaneous

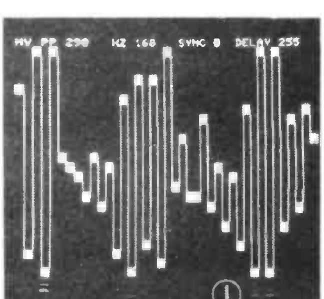
Fuseholder; p.c.b. clips (4 off); 1A fuse; knobs (2 off); MAINS NEON; PCB247A; 8-pin i.c. socket; 16-pin i.c. socket; 18-pin i.c. socket; mono jack socket; T' former 2 x 6VA secondaries.

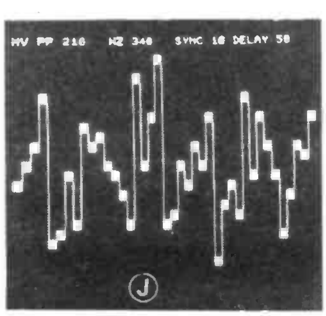
Constructors' Note

The full kit of parts is available from **Becker-Phonosonics, 8 Finucane Drive, Orpington, Kent BR5 4ED.** Price £44.50 + VAT. Postage and packing £1.50 extra. The p.c.b. on its own costs £3.33. ☎ 0689 37821.

Copies of the following software are available on request from *Practical Electronics* (Poole office). Please send SAE 230 x 300 mm.

1) Full Combined Program for PET, C64, BBC
2) Optional Assembler





without any synchronisation or sampling rate correction factors. A prompt is displayed if the computer thinks that the control unit is not fully switched on. If the prompt display remains on check that both power switch S3 and DAV switch S5 are switched on.

SAMPLING ROUTINE

As soon as the program goes to the machine code routine a pulse is sent out on the ATN line to IC2 triggering it into its conversion routine. Upon completion of the conversion a pulse is sent back to the computer on the DAV line. During the conversion the computer waits for this change, and upon its detection and for the next 255 samplings, the computer successively reads the incoming binary data, stores it in successive memory locations, each time sending back another convert pulse to IC2. When all 256 samplings have been stored, another routine is started in which any previous data on the screen is erased, and the correct sampling step points and their connecting lines are calculated and displayed. The maximum lines are limited to 24 vertically, 1 less than the maximum screen height, and 40 columns across, the maximum screen width. The remaining stored bytes are ignored by the screen. They are, however, used in the next routine to which the program then jumps.

FREQUENCY COUNTING

In this routine the progam counts the number of times that the stored number goes above and below the midway decimal 128 mark. The answer is stored and becomes the base for calculating the main dominant frequency. The number of crossovers within the 256 byte block will be related to both the input and sampling frequency rates. The latter may vary between computers and the actual position in memory. The timing factor "T" in line 230 has been given a nominal value of 59, representing the 59 microseconds for the computer to acquire and store one byte of data. If the screen readout shows a frequency that is significantly out when checked against a signal generator, this factor can be reset accordingly. Do not expect precision and the figures should only be treated as a guide line.

NEXT MONTH: More information on the use of the Micro-scope. How to wire it up, and computer connector details.

THE LEADING EDGE

PERILS OF PATENTING

In a separate item (see August issue) I looked at how the public records of the British Patent Office tell an interesting story about the history of Sir Clive Sinclair's plans for wafer scale integration. The patent records also tell something interesting about Sir Clive's work on the C5 car.

Under current British patent law (since the late 70s) patent applications are published while still pending. Before the 1977 Act, pending applications stayed secret. They still do remain secret in America.

Many inventors, and firms, still have not woken up to what the new British law means to them. They get hot under the collar when people who know the patent system do a simple patent search, and read technical details of an invention which the firm would prefer to remain secret.

Sir Clive Sinclair is well aware of the perils of patenting. He got caught early on when a French language patent application on his flat TV tube was published earlier than he expected. Suddenly his secret was public knowledge. Since then Sinclair has been wary about filing patent applications unless he is sure that the product will be ready to launch by the time the application is published.

For a while it looked as if Sir Clive had slipped up on his electric car. In May 1983 he filed a patent application on a motor vehicle. This was due to be published on November 6, 1984, but even by the end of the year there was still no sign of the document. There was also still no sign of any official launch of the vehicle.

Advance publicity from Sinclair then promised an unveiling of "The Sinclair electric vehicle" on January 12. The publicity showed a "top secret" wrapping on a box, which we now know contained the C5 trike. Even by the day of the launch, there was still no sign of any published Sinclair patent.

UNEARTHING THE SECRETS

Mysteriously the Official Register of the Patent Office gave no clue as to why the application was still unpublished. The full answer, which I can assure you has taken quite a bit of digging to unearth, is as follows. It's important, especially to anyone who keeps an eye on the patent records, to see what a competitor is doing.

The Patent Office routinely publishes all pending applications unless there are special circumstances. These special circumstances could be routine print delays, but slippage is usually only a few weeks. If the Government thinks that an invention touches on national security then it can prohibit publication. The Sinclair C5 is unlikely to be in this category! More often, non-publication is because an inventor has withdrawn the patent application, to prevent it being seen.

Until Spring 1984 the Patent Office published lists of patents that had been withdrawn (or refused by the Office) and it entered this information in a public register. But on 26 April 1984 a brief note in the Official Patent Office Journal said bluntly that this practice had stopped.

Only those who are closely in touch with Patent Office matters will have seen and noted the importance of this notice. When I questioned the Department of Trade Press Office (which acts as spokesbody for the Patent Office) they knew nothing about it.

The nitty-gritty is that the Patent Office is now interpreting the British laws as forbidding it to give any information on patent applications until they are published. In catch-22 fashion they can't say why a patent application hasn't been published!

In the case of the Sinclair patent, all the signs are that Sir Clive filed an application on an electric vehicle and then withdrew it, either because the technology claimed turned out to be old or because his launch schedule was delayed and he did not want the press to be able to read his secrets before the official January unveiling.

So the patent application was never published and the Patent Office is not able to say why. A casual searcher, looking through the Patent Office records could be trapped into thinking the case is still pending, because there is no mark in the public register to say it is dead.

Anyone who uses the patent system, for instance to keep an eye on what competitors are doing, should note this well. They may also like to note that there is one remaining loophole. If you wait until a patent application should have been published and then file a form called a caveat (official fee £7) you can ask the Patent Office to tell you whether or not it has been published. If the case has been withdrawn (rather than held up) the Patent Office will state the simple fact that it has not been published. This tells an astute searcher all he or she needs to know.

ENDOCRINOLOGY

Everyone knows how easy it is to start feeling drowsy at the wheel of a car, on a long journey. Sadly we all know, if only from press reports, what can then happen.

Over the years there have been several ideas put forward for waking people up before they have a chance to go to sleep. For instance, a mercury switch can be attached to the head of the driver. It will bridge contacts and sound an alarm when the head nods down. But obviously it is better to alert the driver before the head starts dipping. The key to this, is skin resistance.

For a long time people have known that human skin on the volar surfaces (that's the palms of hands and soles of the feet) exhibit a curious characteristic. Their electrical resistance falls as we become more alert, and rises as we become drowsy. The obvious thing then is to monitor this resistance and use any sudden rise to trigger an alarm.

At first sight, this looks easy. You just strap an electrode to a finger or toe, and connect it to a resistance-measuring circuit. When the resistance rises above a pre-set threshold, it closes the circuit to a bleeper.

Recently a doctor, who specialises in endocrinology (the science of glands) showed the press a prototype of a circuit, which he calls Dormalert. Dr. Gerald Swyer reckons that it overcomes the kind of practical problems which people encounter when they try to build a volar alarm.

The first problem is that different humans have a different nominal skin resistance. It can be as high as 4 megohms or as low as 5 kilohm. So it's obviously impractical to use the same alarm sensor threshold for everyone.

Also there is a settling-in period. When the electrode is first attached, the resistance starts high, and then falls, over a period of 10 minutes, before bottoming out. To be reliable, the alarm must have a 10 minute delay and then self-adjust to nominal skin resistance. On Swyer's prototype, a knob then sets the alarm threshold at anything between 50 per cent and 32 per cent above the nominal resistance after settling in and self-adjustment.

Swyer is now trying to sell the idea to any electronics firm who will manufacture it. Reading between the lines he hasn't yet had too much success, and the press conference was obviously called to stimulate publicity. As a gadget for car owners, it's surely a lot more useful than nodding dogs for the back seat and stickers for the window to obscure the driver's view.

JUDGEMENT TIME

Hats off to Swyer for suggesting some other novel uses. The volar alarm would keep sonar and radar operators awake, for instance in air traffic control. It would also stop people in charge of oil and chemical plant process controls from dozing off.

I particularly like Swyer's suggestion that it would be useful to keep audiences and committee members awake during boring meetings. When the House of Lords is televised, half of them seem to be asleep.

Judges, too, might be interested. Former Lord Chancellor, Lord Elwyn-Jones, said recently, *"One of the dangers of sitting on the woolsack is falling asleep."* Quite how people will react to the sound and sight of a judge in court suddenly bleeping and sitting bolt upright remains to be seen.

BARRY FOX

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JANUARY

issue!

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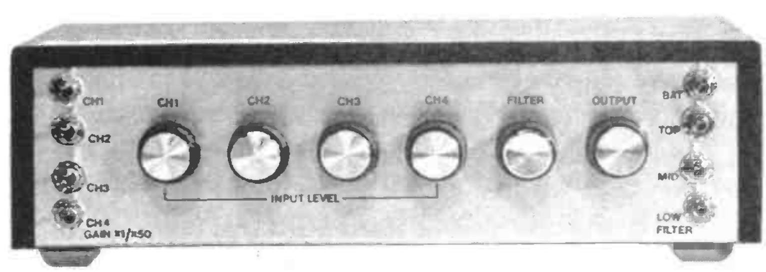

Microelectronics Education Programme

The MEP was established in 1980 to assist education to prepare children for life in an era of microelectronics. We take a look at MEP—what it is doing, why and how.

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JANUARY 1986 ISSUE ON SALE FRIDAY, DECEMBER 6

PRINTED CIRCUIT BOARD SERVICE

Printed circuit boards for certain PE constructional projects are now available from the PE PCB Service, see list. They are fully drilled and roller tinned. All prices include VAT and postage and packing. Add £1 per board for overseas airmail. Remittances should be sent to: ***PE PCB Service, Practical Electronics Editorial Offices, Westover House, West Quay Road, Poole, Dorset BH15 1JG.*** Cheques should be crossed and made payable to IPC Magazines Ltd.

Please note that when ordering it is important to give project title, order code and the quantity. Please print name and address in Block Capitals. Do not send any other correspondence with your order.

Readers are advised to check with prices appearing in the current issue before ordering.
NOTE: Please allow 28 days for delivery. We can only supply boards listed here.

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,,		405–04	£2.90
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Oscilloscope Calibrator		407–04	£4.23
Comm. 64 RS232C Interface		408–01	£3.02
Field Measurement	AUG '84	408–02	£3.19
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Simple Logic Analyser II		408–05	£2.93
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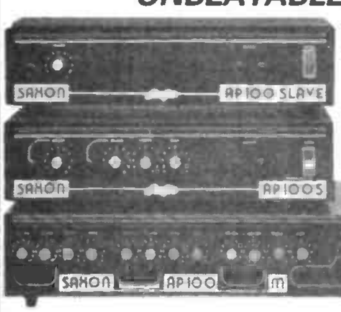

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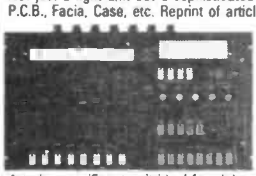

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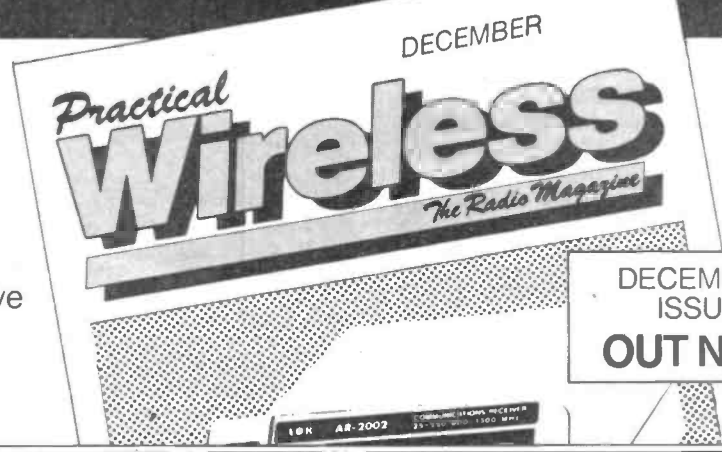

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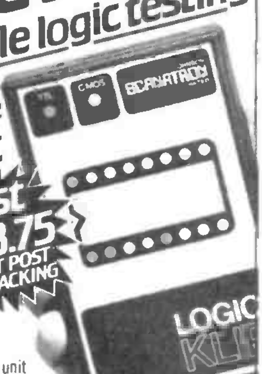

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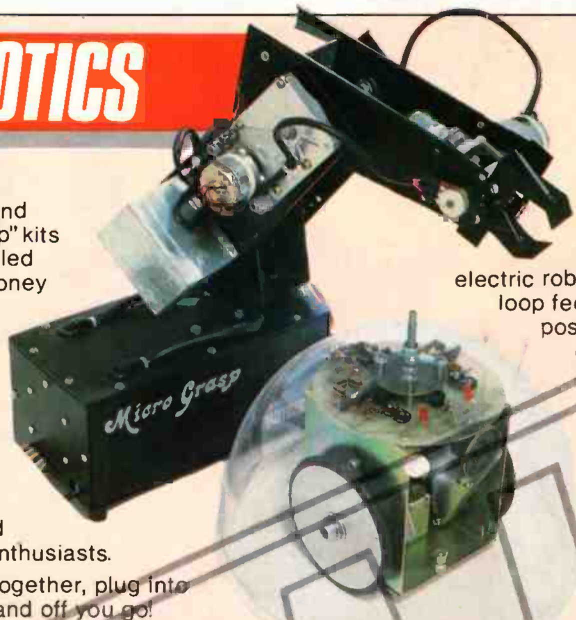

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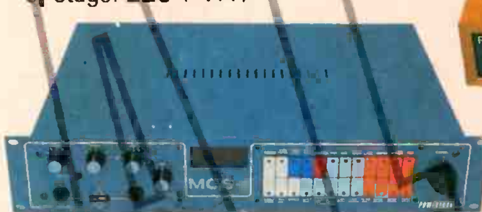

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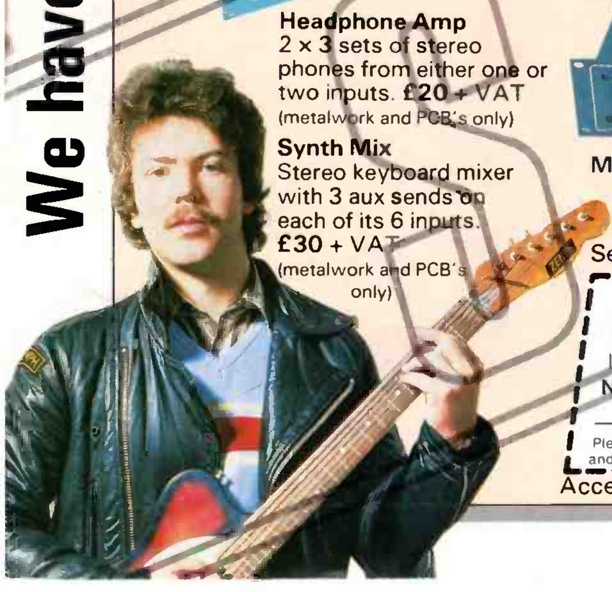

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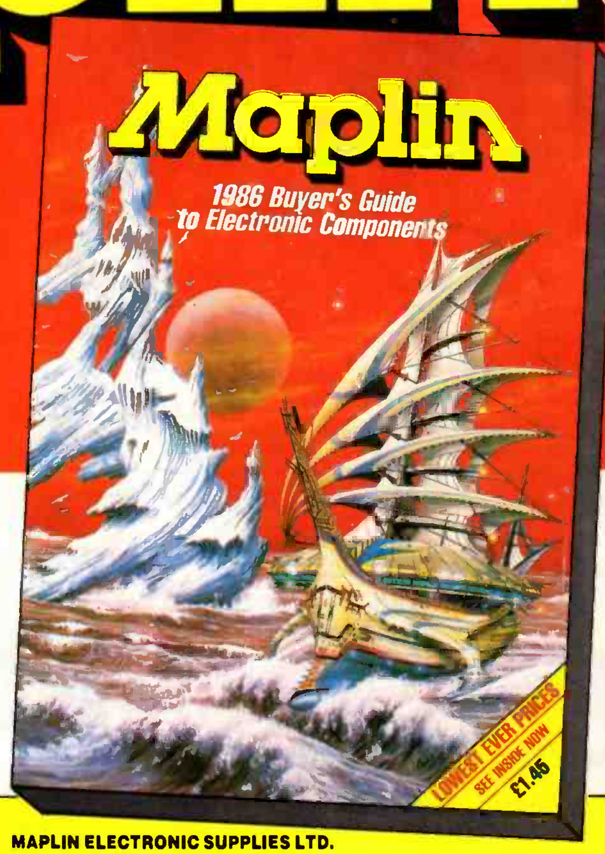

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