

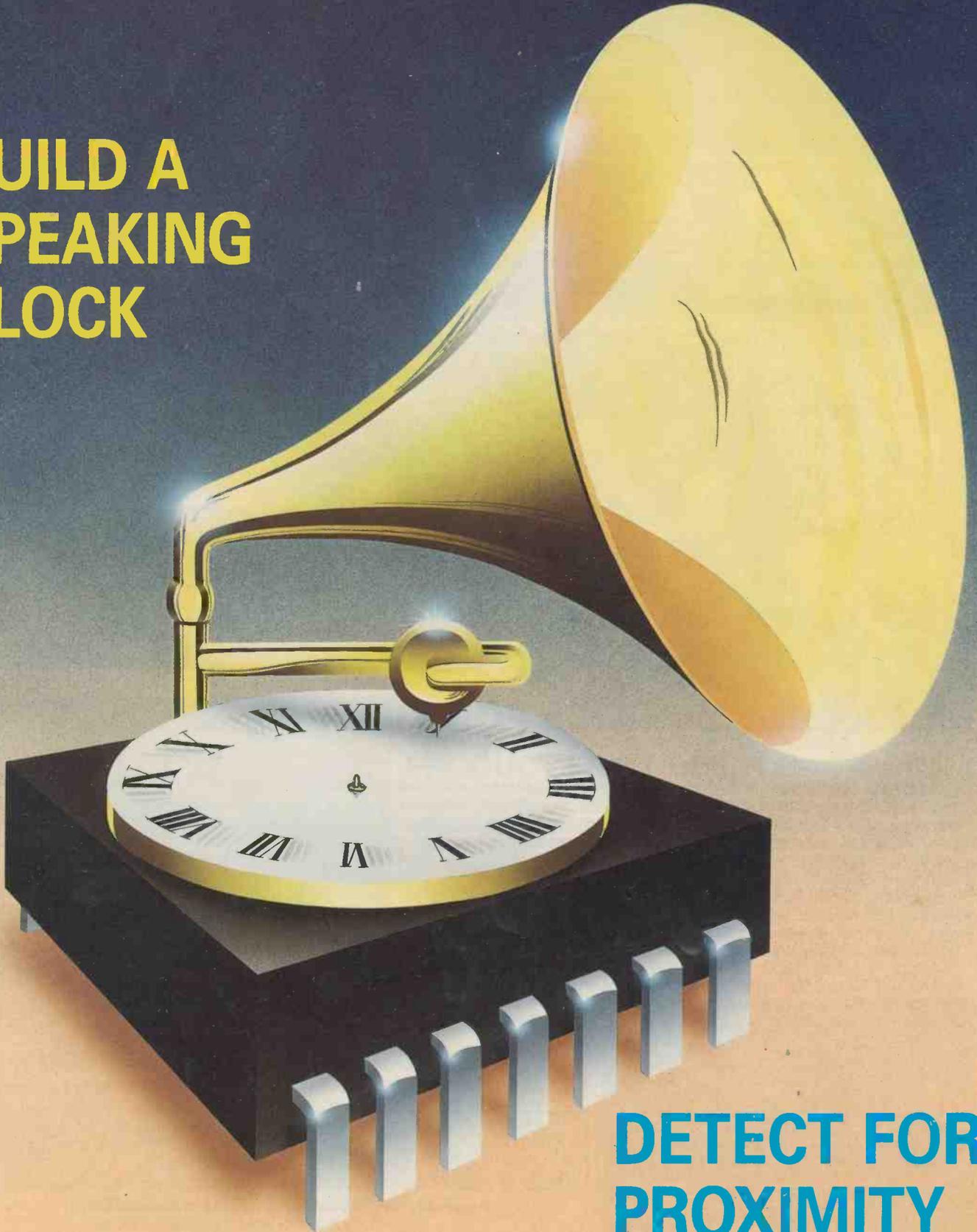
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MASTER SYSTEMS type 2/12 microprocessor controlled V22 full duplex 1200 baud. This fully BT approved model employs all the latest features for error free data comms at the staggering speed of 120 characters per second, saving you 75% of your BT phone bills and data connect time !! Add these facts to our give away price and you have a superb buy !! Ultra slim unit measures only 45 mm high with many integral features such as Auto answer, Full LED status indication, RS232 interface, Remote error diagnostics, SYNC or ASYNC use, SPEECH or DATA switching, integral mains PSU, 2 wire connection to BT line etc. Fully tested, EXCELLENT slightly used condition with data and full 120 day guarantee. **£95.00 (E)**

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CONCORD V22 1200 baud as new **£330.00 (E)**  
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**EX EQUIPMENT NICAD cells by GE** Removed from equipment and believed in good, but used condition. "F" size 7Ah 6 for £8 (B) Also "D" size 4Ah 4 for £5 (B)

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## Special Offer EXPERIMENTORS PSU ONLY £16.95 (C)

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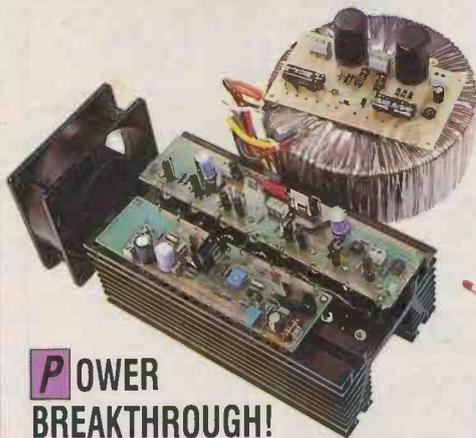
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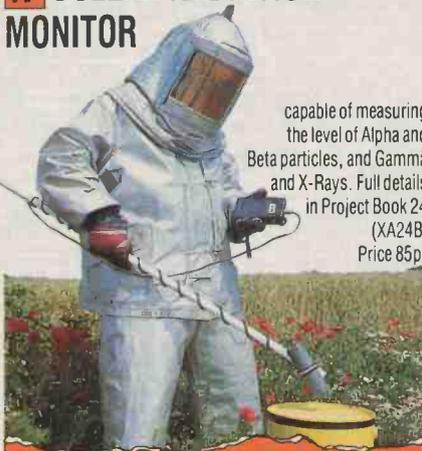


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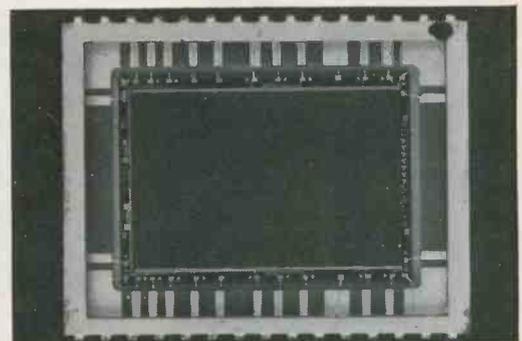
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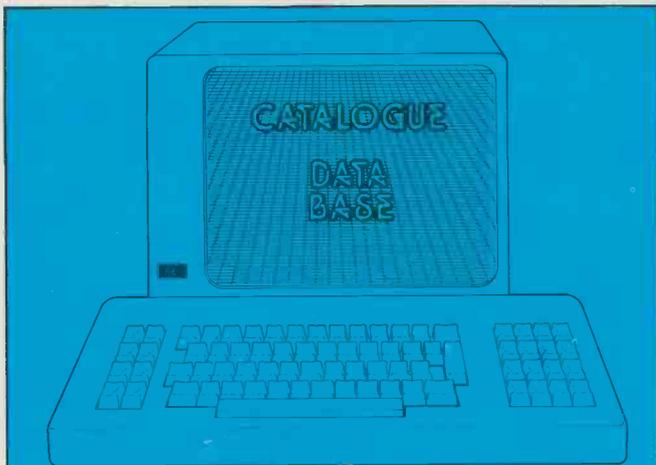
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*We have recently received the following catalogues and literature:*

**STEBUS USERS.** In response to many requests the STE manufacturers and users group has produced the STE Awareness Brochure, which is now available free of charge to intending users of the STEbus. The brochure answers many questions asked by first time users of the STEbus, detailing its structure, protocols and characteristics. **STE Manufacturers and Users Group**, PO Box 149, Reading, Berks, RG33HB. 07357 4976.

**Thurlby Electronics** have a new eight page full colour shortform catalogue of their range of test and measurement equipment. **Thurlby Electronics**, New Road, St Ives, Huntingdon, Cambs, PE17 4BG. 0480 63570.

**Thame Components** have sent the Harris Analog Pocket Application Guide No 5. Over 100 pages of audio opamp specifications and applications notes relating to Harris Semiconductors make this a worthwhile addition to any serious designer's bookshelf. **Thame Components Ltd**, Thame Park Road, Thame, Oxon, OX9 3XD. 0844 214561.

**Anville Instruments**'s multipage brochure outlines their range of standard and custom-built thermocouple, platinum resistance thermometer and thermistor temperature sensors. **Anville Instruments**, Watchmoor Trade Centre, Watchmoor Road, Camberley, Surrey, GU15 3AJ. 0276 684613.

**West Hyde Developments** have just celebrated their 25th Anniversary and we are sure that they would be delighted to send information about their range of boxes and other enclosures to anyone with a serious interest. West Hyde were one of PE's founding advertisers and as part of their celebrations they had on display a copy of PE Volume 1 Issue 1. (We at PE shall also be celebrating our 25th anniversary soon — doesn't time fly when you're popular?). **West Hyde Developments Ltd** are at 9-10 Park Street Industrial Estate, Aylesbury, Bucks, HP20 1ET. 0296 20441.

## Schlumbering Quietly

A full-colour eight-page brochure from Schlumberger describes their new 7150plus digital multimeter, detailing the many novel features of this 3½- to 6½-digit versatile instrument.



Features include a smart automatic digital filter which reduces noise to  $\pm 1$  count, measurement of dc voltage and current, true rms voltage and current, resistance and temperature. AGPIB interface is also included, as are designed-in reliability, fast and simple remote or front-panel calibration, and exceptional ease of use. The brochure outlines the manufacturing philosophy and the stringent factory testing which enable Schlumberger to offer a two-year warranty on the instrument with a promise of outstanding life expectancy.

Contact: Bernard Parkes, Schlumberger Instruments, Victoria Road, Farnborough, Hants, GU14 7PW. Tel: 0252 54433.

## WHAT'S NEW



### HF Analyser

Number One Systems' popular PC circuit analysis package, Analyser II, has been the subject of a major revision to include analysis of microwave striplines and transmission lines. An extremely rare feature in low cost design tools, analysis of these high frequency components will make a large contribution to taking away the difficulty and 'black art' nature of hf circuit design.

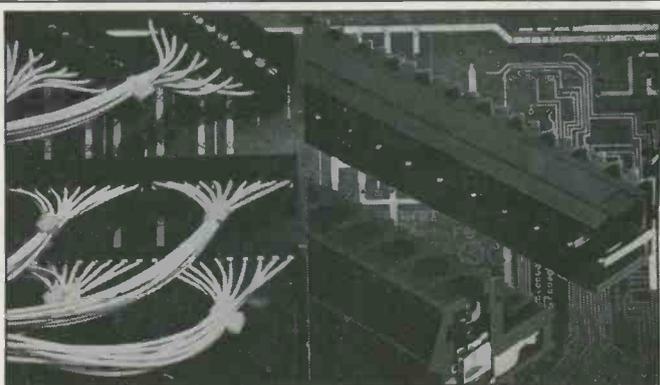
This addition will offer design engineers at rf and higher frequencies the facility of rapid evaluation of designs that include these elements for gain, phase, input and output impedance, and group delay. The resulting ease of seeing the effects of design changes and tolerances means that designing hf networks is no longer a chore.

Other benefits to users are the

avoidance of expensive test and measuring equipment, and the need for continued breadboarding during circuit development. These are particularly awkward issues in rf design work. Results of the analysis are presented in tabular or graphic form so the user can spot and measure response peaks and notches, phase reversals, and impedance changes where matching is important.

Analyser is supported by free updates for six months, and a telephone query hotline. Its operating system is for PC-DOS and MS-DOS, needs a memory of 192K minimum, and a disk size of 5¼inch. The price is £195.00 plus VAT.

Contact: Number One Systems Ltd, Harding Way, Somersham Road, St Ives, Huntingdon, Cambs PE17 4WR. Tel: 0480 61778.



### Klippons

A new modular connector system for pcbs has been announced by Klippon.

The BLA/SLA range is available in a single row format from 2 to 24 poles and in a double row format with up to 48 poles. In addition to its modular facility, which permits block building to suit individual customer requirements, the

system features ease of termination as well as assembly and is designed to be vibration-proof. Manufactured in pbtp for high reliability and stable performance, BLS/SLA has an operational temperature range of 120°C and a 8A current rating.

Contact: Klippon Electricals, Power Station Road, Sheerness, Kent ME12 3AB. Tel: 0795 580999



## Hot Charts

Electronic Temperature Instruments are pleased to announce to PE readers the addition of the Rushtrak chart recorders to the range of temperature measurement instrumentation.

Rushtrak strip chart recorders are available to measure both temperature and humidity. The compact size and flexibility of the recorders make them ideal for continuous monitoring of computer rooms as well as component storage areas.

The temperature recorders are available utilising Pt100 or thermocouple probes. E.T.I. manufacture a wide range of temperature sensors, providing almost limitless range capability. Multi-channel recorders can be used for independent recording of up to four channels, particularly useful as a number of rooms or buildings can be monitored at one central point.

The humidity chart recorder is designed to monitor both temperature and relative humidity of air. The recorder samples the humidity sensor every eight seconds and prints a dot on the chart. Four seconds later, the recorder switches to the temperature channel and its sensor. The series of dots make continuous lines that are easy to read.

The prices start at £199.00 for the basic temperature recorder. Quantity discounts are available.

**Contact:** Electronic Temperature Instruments Ltd, PO Box 81, Worthing, W. Sussex, BN13 3PW. Tel: 0903 202151.



## Topform

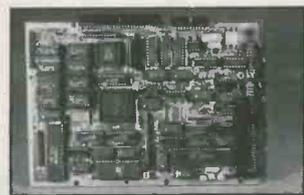
User-friendliness is one of the keywords used by Topform Electronic Services in describing their new Task-Master 901.

Representing a new concept in low cost programmable

controllers the Task-Master offers an innovative low cost alternative to in-house custom built test equipment and plcs. Using basic programming the unit can be expanded in a 'family' concept manner through various add-ons. The current family members include a-d, d-a, RS232, and an 8-bit bidirectional version. A multitasking facility enables up to ten routines to be performed in parallel with the main program. Integral program storage is via an eprom and enables dedicated computer use.

The Task-Master 901 is available on a free ten-day trial offer and is priced at £255 with add-ons starting from £150.

**Contact:** Topform Electronic Services, Unit 60, Buddle Road, Clay Flatts Industrial Estate, Workington, Cumbria, CA14 3YD. Tel: 0900 67436.



## All Aboard

The SB180FX single-board computer announced by JB Designs contains all that is needed on an OEM and is based around the high-integration HD64180 Z80-compatible microprocessor, and has a complete set of peripheral interfaces.

Both floppy and optional hard disc interfaces are built-in and facilities are provided to drive a Centronics printer, a modem and an operator terminal. In addition there are 24 lines of uncommitted parallel IO.

The board is available without software, or with a full suite of operating system, monitor, assembler, linker, debugger and a wide range of utility programs. The extra facilities of the HD64180 cpu allow it to address a full 512K bytes of dram which can be fitted to the board. Most of this is easily configured as a ram-disc.

The card can be used alone, or combined with the GT180



## COUNTDOWN

*If you are organising any event to do with electronics, big or small, drop us a line - we shall be glad to include it here.*

**Please note:** Some events listed here may be trade or restricted category only. Also, we cannot guarantee information accuracy, so check details with the organisers before setting out.

**Regular courses for R.A.E.**, and also for Morse. Grafton Radio Society, Elizabeth Garrett Anderson School, Rising Hill Street, London N1.

**Regular weekly courses for Radio Amateurs Exam (C8G 765).** Tuesday 7.30 to 9.30. Hendon College, Corner Mead, Grahame Park, Colindale, London NW8 5RA. Tel: 01-200 8300.

**Jul 1-2.** Minster School Science Fair, displaying the most up to date products in school science equipment, books, software etc. Local and national industries will also demonstrate the relevance of science education in their own fields. M. Bossard, The Minster School, Nottingham Road, Southwell, Notts NG25 0HG. Southwell 814000. *PE like to publicise events of this nature.*

**Sep 6-8.** Coil winding. Wembley Conference Centre. 0799 26699.

**Sep 8-12.** Sim-Hifi Ives. International video and consumer electronics show. Milan. 02-4815541.

**Sep 27-30.** DES. Design Engineering Show. National Exhibition Centre. Birmingham.

**Oct 11-13.** British Laboratory Week. Grand Hall, Olympia. 0799 26699.

**Oct 18-20.** Internepoon. Electronic Packaging Show. Metropole Convention Centre, Brighton.

**Nov 1-3.** Custom Electronics & Design Techniques Show. Heathrow Penta. 0799 26699.

**Nov 29-Dec 1.** DMC-PC. Drives, motors, programmable controllers etc. National Exhibition Centre, Birmingham. 0799 26699.

graphics expansion card, which provides high resolution graphics using the Hitachi HD64384 ACRTC graphics processor.

The one-off price of the board, without software, is £259.

**Contact:** J.B. Designs & Technology Ltd, 15 Market Place, Cirencester, Glos. GL7 2PB, Tel: 0285 68122.

clock offers IRIG-B time code, RS 232 interface, 1/5/10 MHz squarewaves and a 1Hz reference pulse as the ultra-precise time mark. This capability makes it a cost-effective option for communications, standards laboratories and geophysical applications, as well as the scientific community.

Its simple operating routines mean the user has only to select the best antenna site and enter his position ( $\pm 1^\circ$ ) before the GPS-DC becomes fully automatic — including the acquisition of the best satellites. The instrument's three most used functions — time, status and position — have been reduced to single button operation, while all other features are addressed via a 16-key pad on the front display.

**Contact:** Measurement Limited, Berrington Road, Leamington Spa, Warwickshire, CV31 1NB. Tel: 0926 35411.

## Syncing Clock

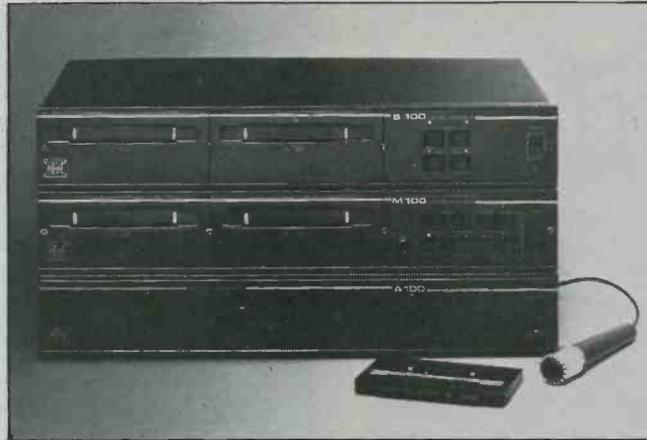
The GPS-DC synchronised clock has been launched into the UK by Measurement Limited as a low cost time and frequency addition to its Global Positioning System product range.

A truly global instrument aimed at a wide range of applications, the clock is designed to provide precise time within  $\pm 200$  nanoseconds. As well as a sharp visual display, the

## Gemini Spotted

Gemini have introduced a new microprocessor controlled music system which provides a cost effective solution where background music and spot announcement facilities are required for business, leisure and workplace environments.

The 100 Series system features attractive styling and state of the art electronic circuitry to make it not only highly functional and compact, but easy to install and operate. It is ideal for pubs, clubs, restaurants, hotels, retail outlets, leisure centres and factory workplaces. And its modularity means it can be configured for large and small places and spaces as well as integrating with users' existing equipment. One module can be incorporated to enhance a current system and others added later as required.



Three main modules comprise the system: the M100 master unit, the A100 amplifier and the S100 optional slave unit.

The M100 has twin autoreverse cassette decks and the latest touch switch controls and led indicators for tape eject/advance,

treble, bass and volume adjustments. For ease of access, the mic input connector is located on the rear panel and a control button on the microphone allows for spot announcements with simultaneous music fade out. An

auxiliary connection point on the rear panel allows users to operate their own radio or compact disk through the system.

When additional playing time is required, users simply connect the S100 twin autoreverse cassette unit to their M100. Up to eight slave units can be plugged in to give a continuous and unattended playing sequence of 18 cassettes.

Output from the A100 amplifier is 100 watts plus per channel of professional quality sound in stereo or mono over multi-speaker arrangements. There are additional power options of 30W/50W/100W, 8 ohm impedance (stereo/mono) or 100 volt line output (mono only).

**Contact:** Gemini Systems Ltd, Unit 5, Watchmoor Road, Camberley, Surrey, GU15 3AQ. Tel: 0276 683744.



## Pinting The Way

DSP Design are the first company to offer an 8-bit bus processor board based on the V25, the latest high integration 8086 code-compatible microcontroller from NEC. The PC-compatible processor means that popular MS-DOS software development tools available for the IBM PC can be used to generate target code for the SV25 board.

The all CMOS design makes it ideal where low power consumption, high noise immunity and extended temperature range are important factors in maximising system reliability. Running at 8MHz, the SV25 packs the greatest range of functions yet seen on a single 8-bit bus Eurocard.

Three byte-wide memory sockets each support EPROM or RAM devices from 8K to 128K bytes. Another socket is provided to accept serial EPROM devices up to 2K bytes to hold security or configuration information.

**Contact:** DSP Design, 100 St Pancras Way, London NW1 9ES. Tel: 01-482 1773.

## Intelligent Architecture

Intel are consolidating the future of their 32-bit microprocessor architecture. In a thick pile of information recently released they have announced 16 new VLSI products and development tools designed specifically for embedded control applications. The products include the new 80960 32-bit microprocessor and its first three derivative processors, plus a customised 386 microprocessor. Flash memories and a new non-volatile memory technology are also being introduced.

Embedded control processors, controllers and memories are semiconductors designed to be programmed to manage specific tasks. They are then 'embedded' into products to provide them with intelligence and functionality. Typical applications range from consumer electronics (eg VCRs, CD players, microwave ovens) to office equipment such as copiers, laser printers and modems. Transportation, avionics, industrial automation, telecommunications and automotive products represent other suitable applications.

The 80960 architecture uses RISC (reduced instruction set computer) design techniques to deliver a high performance architecture that can be easily modified or proliferated into market-specific processors. (Sir Clive Sinclair spoke of RISC architecture in the feature published in PE Jun 88). Intel will use this 'core architecture' as a basis for 32-bit embedded processors well into the next decade.

## Busby's Public Challenge

OfTel report that the first step has been taken to introduce competition in the provision of payphone services. Currently British Telecom have the monopoly in public call boxes, but Mercury Communications are to be allowed to provide a similar service.

The new call boxes will connect directly to Mercury's digital network and will accept coins and credit cards. The possibility of other companies operating public call boxes is being considered.

Let's hope that competition will drastically reduce the number of out-of-order boxes currently experienced. OfTel reports that in a recent independent survey, of 7000 call boxes visited nationwide 24% were out of order. My wife's recent independent survey of seven call boxes revealed 100% failure at our local railway station — she had to walk three miles home as she'd missed the bus and couldn't phone me!

**OfTel** are at Atlantic House, Holborn Viaduct, London EC1N 2HQ. Tel: 01-822 1644 and 01-353 4020.

## CHIP COUNT

*New component details received:*

**74F30XXX range.** The high performance fast buffers and transceivers in this range have been specifically designed to handle low impedance environments of PCB backplanes and signal busses. They can drive lines with characteristic impedances as low as 30 ohms. Other features include — incident-wave 30 ohm transmission line switching, high output currents (+160mA and -67mA), 'flow-through' signal design, multiple centre-package supply pins, low V<sub>CC</sub> shut-off circuit, 'light-load' ±20µA npn inputs.

The devices now available are —

**N74F3037.** Quad 2-input NAND totem-pole buffer.

**N74F3038.** Quad 2-input NAND open collector buffer.

**N74F3040.** Dual 4-input NAND totem-pole buffer.

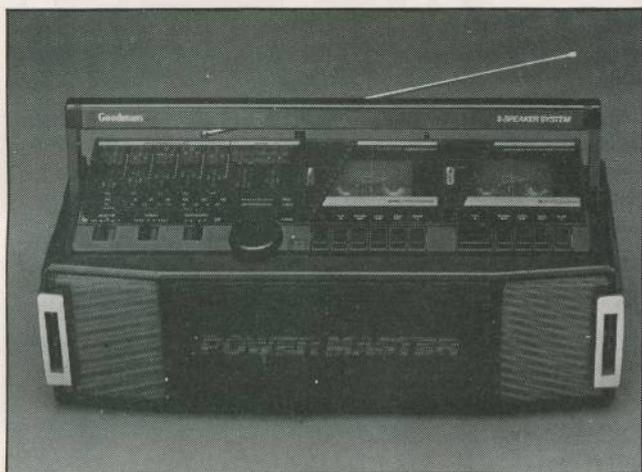
**N74F30240.** Octal inverting open collector buffer.

**N74F30244.** Octal non-inverting open collector buffer.

**N74F30245.** Octal non-inverting transceiver.

**N74F30640.** Octal inverting transceiver.

These devices are manufactured by Philips Components Ltd, Mullard House, Torrington Place, London WC1E 7HD. 01-580-6633. (Philips Components is the new name adopted by Mullard.)



### Quadro Power

Goodmans have expanded their range of portables with the introduction of the SW840 Powermaster and Quadro 901 portable tv/radio.

The SW840 is the latest addition to Goodmans range of high performance, Powermaster radio/cassettes. Featuring a double cassette, with 5-band graphic equaliser, high speed dubbing and continuous play, the SW840 has a five speaker system for superior sound. Two 4in bass units and two piezo tweeters, combine with a further bass unit with separate amplifier for extra

boost all combine to provide a powerful portable at a retail price of around £90.00.

The Quadro 901 joins a comprehensive range of radio, black and white tv and cassette units. Retailing around £79.90, it features a 5in black and white tv with mw/vhf radio. The 3-way power operation of the 901 provides versatile usage in the home, car, boat, caravan etc, and comes with its own shelf stand.

Contact: Sharon South/Celia Lynch, Goodmans, 2 Marples Way, Kingscroft Centre, Havant, Hampshire, PO9 1JS. Tel: 0705 486344.



### Mini Radio Times?

Sony has introduced a tiny new receiver with most of the facilities of the paperback-sized ICF 7600D in an audio cassette sized package.

The new model is the ICF-SW1S, selling at around £250, is available in a convenient briefcase styled carrycase to cater for robust treatment.

In the case you'll find the receiver itself, an active antenna, multivoltage ac adapter for use from mains power anywhere in the world, and high quality stereo headphones. Sony also throws in a copy of its latest

"Wave Handbook" to identify the signals available.

Capable of receiving fm stereo, mw, lw and sw, the radio is the ideal business or holiday travel companion. Sony has a proud tradition in radio technology, introducing their first transistor radio in 1957.

The ICF-SW1S has pll synthesised tuning and a memory which enables the user to store 10 favourite stations from across the bands. Travellers will also enjoy the fact that it doubles as an alarm clock.

"We have thought through every stage of this receiver and tried to come up with a package which offers great benefits with no need to buy things like ac adapters, headphones, or antenna as extras. With the SW1S everything comes in one convenient package," says Yoshi Nagayawa Sony Radio Marketing Manager.

"It's a good job we changed the name to Sony all these years ago, I don't think that the old name of Tokyo Tsuchin Kogyo Kabushiki Kaisha would have fitted on a receiver so small," he joked.

Contact: Andrea Coppen, Sony (UK) Limited, Sony House, South Street, Staines, Middlesex, TW18 4PF. Tel: 0784 67371/67385.

### Noise Noser

Bruel & Kjaer have highlighted an advanced new instrument combination for simple determination of the frequency content of noise.

The combination provides a solution which is both powerful and easy to use for wide-ranging applications such as circulation of noise rating values, detection of tonal sources in boundary noise investigations, determination of noise reduction strategies, and specification of hearing protectors.

The measurement system is based on the handheld 2231 Modular Precision Sound Meter, which is fitted with a frequency analysis module controlling a 1/1-1/3 octave filter set. The module maintains use of the 2231 as a normal integrating sound meter, and to the high intrinsic performance of the instrument adds the computing power to yield accurate frequency analyses.

Hardcopy of results in an easily-understood graphical or digital format is obtained by using BK's 2318 portable



documentation printer, or an alternative compatible printer via the serial interface.

According to the type of noise under assessment, various parameters such as sound incidence, full scale deflection and time weightings can be set on the sound level meter. To increase the versatility of the measurement system numerous special functions, for example a fixed integration time per channel, or a particular printout mode or format, can be selected.

Contact: Bruel & Kjaer (UK) Ltd, 92 Uxbridge Road, Harrow HA3 6BZ. Tel: 01-954 2366.



### Beating Maplin

The all new Maplin programmable electronic metronome is designed to be an essential item of equipment for musicians of all persuasions and capabilities from hi-brow to hi-beat.

Its features include audio and visual beat and accent indication, variable tempo from slow (adagio) to fast (presto), programmable time signature on 7-segment displays.

Despite its robust construction, the unit is light weight, compact and easily transportable. It is housed in a small plastic box incorporating a 9V battery.

The module kit, reference LM49D, can be assembled in a short time by any electrical, electronic or audio enthusiast, and costs just £26.96 including vat. It is available from any Maplin shop.

### Hi-D ccd cam

Mitsubishi Electric Corporation of Japan has developed a high-definition charge-coupled device (ccd) camera suitable for monitoring uses.

It is the industry's first one-million pixel ccd camera with a built-in electronic shutter and the ccd used in it was jointly developed by Mitsubishi Texas Instruments.

The HT-1000S employs a superhigh-density ccd with one million pixels as the image sensor and has a high-speed electronic shutter with a speed of up to 1/2,600 second to capture a subject travelling or rotating at high speed as a clear black-and-

white still image.

The image section is 1,024 pixels (horizontal) by 512 pixels (vertical), as the horizontal resolution is more than 850 lines for a clean image. Large-scale integration chips are used for the ccd peripheral circuits to ensure a long life and high reliability. The camera, 70mm wide, 70mm high and 210mm deep, weighs about 950 grams.

The development of the HT-1000S by Mitsubishi Electric expands the applications of ccd cameras to new areas. The company expects the HT-1000S to be used in industrial, monitoring and research areas for character and shape recognition, flaw detection and measurement.

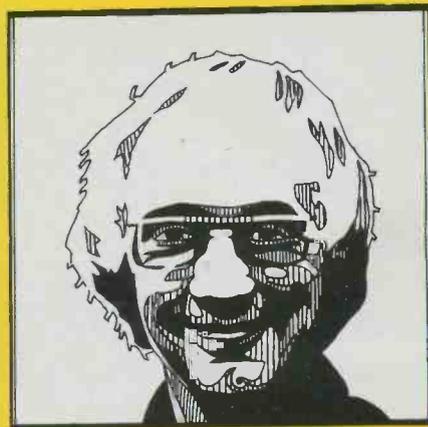
# CRYSTAL GAZING'S COLOURFUL FUTURE

By Barry Fox

Winner of the 1987 UK Technology Press Award

## THE SCREEN THAT FELL FLAT

*Take your pixels – before somebody else does. The deepest frustration belongs to those who toil and sweat and can't get to market.*



In 1953 Lord (J. Arthur) Rank, of the Rank Organisation, set up a Foundation to donate prizes for research work done in the two fields which most interested him — nutrition (from Rank's start in flour milling) and opto-electronics (from his later work in the film industry).

This year, one of the prizes was split between seven researchers for their work on liquid crystal tv screens. This is a classic example of a seminal invention being made in the West, but exploited in the Far East.

The pioneering work on lcd screens was done by Thomas Peter Brody, while at Westinghouse in America. He headed a team of thirty who found out how to deposit thin film transistors on a flat panel and so directly address individual cells of a liquid crystal display.

Ten years later research done at the Royal Signals and Radar Establishment at Malvern and the University of Dundee showed that amorphous silicon, as developed for solar cells, was the best material to use for making the thin film transistors. Amorphous silicon is non-crystalline, and much easier to apply evenly over large areas. But neither Malvern nor Dundee had the resources to create panels suitable for the consumer market.

Westinghouse had succeeded, as far back as 1972, in making a 15 by 15cm square panel, with 12,000 elements. Five years later Westinghouse made a panel with 30,000 elements. They were suitable for computer graphics and text. But then the company lost interest in lcd screen technology; the original work had been funded by government military contract and Westinghouse was not interested in consumer applications.

In 1981 Brody left Westinghouse and set up his own company, Panelvision, with sights set on the computer and tv market. By 1984 Panelvision had made a 25cm diagonal display with 256,000 elements, but the company was underfunded. The next year it was bought out by military avionics company Litton Industries. They too were not interested in consumer applications.

By then the Japanese had moved in. The first liquid crystal colour tv screen was made in 1983 by Seiko but the break-

through came in 1985 when Matsushita (Panasonic) found a way of improving both colour reproduction, and brightness when the picture is viewed off axis. Although obviously bitter about the way Western research has been handed on a plate to Japanese industry for exploitation, Brody is gracious in the way he salutes the Japanese achievement.

"The picture on the Panasonic three inch tv set is as good as you would get from a colour tube," he says.

The Japanese, past masters at production engineering, found a way of accurately mass producing a 7.5cm diagonal screen, made up from 100,000 picture elements divided into triplets of red, green and blue. Most important, they realised the need to tune the thickness of the liquid crystal material to the wavelength of the light.

Because red, green and blue light have different wavelengths, the red, green and blue cells each have different dimensions, matched to the wavelength of red, green and blue light.

Says Brody, "You ain't seen nothing yet — I believe this is the start of another major solid state revolution, comparable to the transistor in economic impact."

I asked Brody about the popular notion that before long television sets will have flat lcd colour panels that you hang on the wall. "In the end that is inevitable," he told me. "But it's a long, long way off. The large screen colour tube will be the last thing to be replaced."

The tv industry clearly shares Brody's faith in the colour tube as we now know it. Sony is investing in expanded tube production at its crt plant at Bridgend, Wales. On the day that three of its lcd engineers shared the Rank prize with Peter Brody, Matsushita announced that it was spending \$160 million on a new factory to build cathode ray tube colour screens at Troy in Ohio, USA. This plant will be jointly owned by Matsushita and Philips, under a joint venture deal signed way back in 1952. Significantly, however, tube production at Troy will be centred on 74cm and 84cm crts, rather than the smaller sizes for portable sets which are more likely to be replaced by lcds.

"The future of lcd is in new applications for which tv tubes aren't

suitable," says Brody. "Already in Japan they are making two or three million pocket tv sets a year. The next step will be to make pocket sets with larger screens, 13cm diagonal instead of 7.5cm. Then there's the computer market. In three or four years computers will be using colour lcd screens instead of colour tubes."

"It will take that long because remember you are not talking about integrated circuits, where you keep doubling the amount of elements, and all along you have something to sell. Here you have nothing to sell until you have a screen with around 100,000 elements. For high definition computer graphics, you need about 1.5 million lcd elements, half a million blue, half a million red and half a million green, all accurately arranged in triplets.

"Already the Japanese are planning to put a flip down lcd tv screen on each seat in their Bullet train. Airlines are doing the same. In the future every telephone will have one. Although high quality moving pictures won't go down an ordinary telephone line, you can build up still images slowly."

The list of applications is endless. Lcd screens will be used in cars to display engine functions. Already flat panels are being used on aircraft flight decks, for navigation and instrumentation display.

The Panasonic pocket tv, which has 100,000 elements, has been selling in Japan for two years now, for around 60,000 yen (£250). They should be in British shops in time for this Christmas.

Already Panasonic has gone a stage further, by building a tv projector using the same screen display as the pocket tv. A bright light is shone through the lcd panel and the image focussed on a wall screen by a projection lens.

Peter Brody, having seen two employers lose interest and fail in the lcd business, has now started a third company of his own. He acts as a consultant for computer manufacturers, like Apple, which will eventually use lcd screens. Brody is understandably pretty sour.

"There is a saying in America about

*Continued on page 18*

**Editor:**

John Becker

**Sub-Editor:**

Helen Armstrong

**Technical Illustrator:**

Derek Gooding

**Advertisement Sales:**

Sarah Holtham

**Business Manager:**

Mary-Ann Hubers

**Circulation:**

David Hewett

**Publisher:**

Angelo Zgorelec

**Editorial and Advertising Address:**

Practical Electronics,  
Intra House, 193 Uxbridge Road,  
London W12 9RA  
Tel: 01-743 8888  
Telecom Gold: 87: SQQ567

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# KICKING THE BUCKET



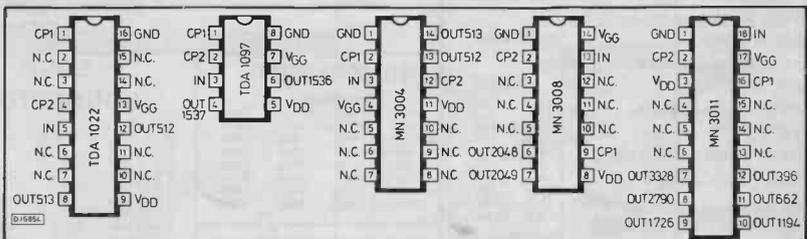
*It seems only yesterday I first praised the new TDA1097 Bucket Brigade Delay chip. In fact, I think it was introduced in 1983.*

*Until then probably the most common delay chip used was the TDA1022 whose arrival in about 1977 had enabled solid state electronics to replace mechanical spring line units. The TDA1022 had its drawbacks in that it was a bit noisy, attenuated the signal, and had a maximum usable delay of only 51ms. The TDA1097 was much quieter, didn't reduce the signal level and had a delay of 153ms.*

*Sadly, the manufacturers, Mullard, have now dropped both chips. Even though digital techniques are well capable of delaying audio signals for echo, reverb and so on, bdds have the big advantage of simplicity and cheapness. It is hard to understand why Mullard should find them uneconomic, though Reticon seem to think similarly as their SAD1024 is no longer available either.*

*Happily, all is not lost for the analogue effects constructor for at least Panasonic appear intent on keeping their range of bdds. Their MN3004 has the same 512 stages as the TDA1022, and the MN3008 with its 2048 stages is near enough equal to the TDA1097's 1536. Alternatively there is the MN3011 with its 3328 stages and six output taps. But unfortunately for designs already published, these chips are not pin-compatible with the Mullard bdds. This means that although existing circuits can probably use the Panasonic chips in place of the Mullard ones, connections on pcbs will have to be rerouted.*

*If any of you are building a Mullard bbd type project but can't find the chips (though some suppliers still have stocks — ring me and I'll tell you who) and want to try using the Panasonic ones instead, the pin-outs are below, though I cannot guarantee total uniformity in the results:*



*Mullard have changed in other respects as well — in fact they are no longer called Mullard. The company was founded in 1920 by Stanley Mullard and continued to trade under his name even after they became part of the Philips group in 1927. Since April, though, they have been called Philips Components Ltd, which name, the company believe, will enhance their international image. With eight plants in the UK and around 8000 employees we hope they will continue to produce products like tv tubes, semiconductors, capacitors and other familiar devices.*

*We are sorry that a household name like Mullard should cease to exist, but if times have to change who can delay them?*

**THE EDITOR**

## BBC Computer & Econet Referral Centre

<b>AMB15 BBC MASTER £346 (a)</b>		<b>AMB12 BBC MASTER Econet £315 (a)</b>	
AMC06 Turbo (65C - 02) Expansion Module			£99 (b)
ADC08 512 Processor	£195 (b)	ADJ24 Advanced Ref Manual	£19.50 (c)
ADF14 Rom Cartridge	£13 (b)	ADF10 Econet Module	£41 (c)
ADJ22 Ref Manual Part 1	£14 (c)	ADJ23 Ref Manual Part II	£14 (c)
		BBC Master Dust Cover	£4.75 (d)

### BBC MASTER COMPACT

A free packet of ten 3.5" DS discs with each Compact SYSTEM 1 128K Single 640K Drive and bundled software £385 (a)  
 SYSTEM 2 System 1 with a 12" Hi Res RGB Monitor £469 (a)  
 SYSTEM 3 System 1 with a 14" Med Res RGB Monitor £599 (a)  
 Second Drive Kit £99 (c) Extension Cable for ext 5.25" drive £12.50 (d)

View 3.0 User Guide £10 (d)	Viewsheet User Guide £10 (d)
BBC Dust Cover £4.50 (d)	1770 DFS Upgrade for Model B £43.50 (d)
ADFS ROM (for B with 1770 DFS & B Plus) £26 (d)	1.2 OS ROM £15 (d)
ACORN 280 2nd Processor £329 (a)	ACORN 6502 2nd Processor £173 (b)
MULTIFORM 280 2nd Processor £289 (b)	ACORN IEEE Interface £269 (a)
TORCH 280 2nd Processor ZEP 100	£229 (a)
TZDP 240. ZEP 100 with Technomatic PD800P dual drive with built-in monitor stand.	£439 (a)

**META Version III** - The only package available in the micro market that will assemble 27 different processors at the price offered. Supplied on two 16K roms and two discs and fully compatible with all BBC models. Please phone for comprehensive leaflet £145 (b).

We stock the full range of ACORN hardware and firmware and a very wide range of other peripherals for the BBC. For detailed specifications and pricing please send for our leaflet.

## PRINTERS & PLOTTERS

<b>EPSON</b>	<b>STAR NL10 (Parallel Interface)</b> £209 (a)
EPSON LX86 £189 (a)	STAR NL10 (Serial Interface) £279 (a)
Optional Tractor Feed LX80/86 £20 (c)	STAR Power Type £229 (a)
Sheet Feeder LX80/86 £49 (c)	<b>BROTHER HR20</b> £329 (a)
FX800 £319 (a)	
FX1000 £449 (a)	<b>COLOUR PRINTERS</b>
EX800 £409 (a)	Dotprint Plus NLO Rom for Epson versions for FX, RX, MX and GLP (BBC only) £28 (d)
LQ800 (80 col) £439 (a)	<b>PLOTTERS</b>
LQ1000 £589 (a)	Hitiachi 672 £459 (a)
<b>TAXAN</b>	Graphics Workstation (A3 Plotter) £599 (a)
KP815 (160 cps) £249 (a)	Plotmate A4SM £450 (a)
KP915 (180 cps) £369 (a)	
<b>JUKI</b>	
6100 (Daisy Wheel) £259 (a)	
<b>NATIONAL PANASONIC</b>	
KX P1080 (80 col) £149 (a)	

## PRINTER ACCESSORIES

We hold a wide range of printer attachments (sheet feeders, tractor feeds etc) in stock. Serial, parallel, IEEE and other interfaces also available. Ribbons available for all above plotters. Pens with a variety of tips and colours also available. Please phone for details and prices.

**Plain Fanfold Paper with extra fine perforation (Clean Edge):**  
 2000 sheets 9.5" x 11" £13 (b) 2000 sheets 14.5" x 11" £18.50 (b)  
 Labels per 1000s: Single Row 3" x 1 7/16" £5.25 (d) Triple Row 2-7/16" x 1 7/16" £5.00 (d)

## MODEMS

All modems carry a full BT approval

### MIRACLE TECHNOLOGY WS Range

WS4000 V21/23 (Hayes Compatible, Intelligent, Auto Dial/Auto Answer) £149 (b)

WS3000 V21/23 Professional As WS4000 and with BELL standards and battery back up for memory £245 (b)

WS3000 V22 Professional As WS3000 V21/23 but with 1200 baud full duplex £450 (a)

WS3000 V22 bis Professional As V22 and 2400 baud full duplex £595 (a)

WS3022 V22 Professional As WS3000 but with only 1200/1200 £350 (a)

WS3024 V22 Professional As WS3000 but with only 2400/2400 £450 (b)

WS2000 V21/V23 Manual Modem £95 (b)

DATA Cable for WS series/PC or XT £10 (d)

**DATATALK Comms Package**  
 \* If purchased with any of the above modems \* £70 (c)

**PACE Nightingale Modem V21/V23 Manual** £75 (b)  
 (Offer limited to current stocks)

### SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV - has a serial and parallel I/O routines. Can be used as an emulator, cassette interface. Softly II £195.00 (b)  
 Adaptor £276.4  
 2564 £25.00

### SPECIAL OFFER

2764-25 £3.00 (d);  
 27128-25 £5.00 (d);  
 6264LP-15 £4.00 (d);

### RT256 3 PORT SWITCHOVER SERIAL INTERFACE

3 input/1 output or 1 input/3 output manual channel selection. Input/output baud rates, independently selectable 7 bit/8 bit, odd/even/none parity. Hardware or software handshake 256K buffer, mains powered £375 (b)

### PB BUFFER

Internal buffer for most Epson printers. Easy to install. Inst. supplied. PB128 128K £99 (c)

## I.D. CONNECTORS

(Speedblock Type)			
No of ways	Header	Recept	Edge Conn.
10	90p	85p	120p
20	145p	125p	185p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

## D CONNECTORS

No of Ways				
	9	15	25	37
<b>MALE:</b>				
Ang Pins	120	180	230	350
Solder	60	85	125	170
IDC	175	275	325	-
<b>FEMALE:</b>				
St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
St Hood	90	95	100	120
Screw Lock	130	150	175	-

## TEXTPOOL ZIF

SOCKET5	24-pin £7.50
28-pin	£9.10
	40-pin £12.10

## DISC DRIVES

5.25" Single Drives 40/50 switchable:	
TS400 400K/640K	£114 (b)
PS400 400K/640K with integral mains power supply	£129 (b)
5.25" Dual Drives 40/80 switchable:	
TD800 800K/1280K	£199 (a)
PD800 800K/1280K with integral mains power supply	£229 (a)
PD800P 800K/1280K with integral mains power supply and monitor stand	£249 (a)
3.5" 80T DS Drives:	
TS351 Single 400K/640K	£99 (b)
PS351 Single 400K/640K with integral mains power supply	£119 (b)
TD352 Dual 800K/1280K	£170 (b)
PD352 Dual 800K/1280K with integral mains power supply	£187 (b)
PD853 Combo Dual 5.25"/3.5" drive with p.s.u.	£229 (a)

## 3M FLOPPY DISCS

Industry Standard floppy discs with a lifetime guarantee. Discs in packs of 10

5 1/4" Discs		3 1/2" Discs	
40 T SS DD	£10.00 (d)	40 T DS DD	£12.00 (d)
80 T SS DD	£14.50 (d)	80 T SS DD	£20.00 (d)
		80 T DS DD	£25.00 (d)

## FLOPPICLENE DRIVEHEAD CLEANING KIT

FLOPPICLENE Disc Head Cleaning Kit with 28 disposable cleaning discs ensures continued optimum performance of the drives. 5 1/4" £12.50 (d) 3 1/2" £14.00 (d)

## DRIVE ACCESSORIES

Single Disc Cable £6 (d)	Dual Disc Cable £8.50 (d)
10 Disc Library Case £1.80 (d)	30 x 5 1/2" Disc Storage Box £6 (c)
50 x 5 1/2" Disc Lockable Box £9.00 (c)	100 x 5 1/2" Disc Lockable Box £13 (c)

## MONITORS

<b>RGB 14"</b>		<b>MONOCHROME</b>	
1431 Std Res	£179 (a)	TAXAN 12" HI-RES	
1451 Med Res	£225 (a)	KX1201G green screen	£90 (a)
1441 Hi Res	£365 (a)	KX1203A amber screen	£95 (a)
<b>MICROVITEC 14" RGB/PAL/Audio</b>		<b>PHILIPS 12" HI-RES</b>	
1431AP Std Res	£199 (a)	BM7502 green screen	£75 (a)
1451AP Std Res	£259 (a)	BM7522 amber screen	£79 (a)
All above monitors available in plastic or metal case.		8501 RGB Std Res	£139 (a)
<b>TAXAN SUPERVISION II</b>		<b>ACCESSORIES</b>	
12" - Hi Res with amber/green options.		Microvitec Swivel Base	£20 (c)
IBM compatible	£279 (a)	Taxan Mono Swivel Base with clock	£22 (c)
Taxan Supervision III	£319 (a)	Philips Swivel Base	£14 (c)
		BBC RGB Cable	£5 (d)
		Microvitec	£3.50 (d)
<b>MITSUBISHI</b>		Taxan E5 (d)	Monochrome £3.50 (d)
XC1404 14" Med Res RGB, IBM & BBC compatible	£219 (a)	Touchtec - 501	£239 (b)

## ERASERS

UV1T Eraser with built-in timer and mains indicator. Built-in safety interlock to avoid accidental exposure to the harmful UV rays. It can handle up to 5 eroms at a time with an average erasing time of about 20 mins. £59 + £2 p&p. UV1 as above but without the timer. £47 + £2 p&p. For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eroms. UV141 has a built in timer. Both offer full built in safety features UV140 £69, UV141 £85, p&p £2.50.

## EXT SERIAL/PARALLEL CONVERTERS

Mains powered converters  
 Serial to Parallel £48 (c)  
 Parallel to Serial £48 (c)  
 Bidirectional Converter £105 (b)

### Serial Test Cable

Serial Cable switchable at both ends allowing pin options to be re-routed or linked at either end - making it possible to produce almost any cable configuration on site. Available as M/M or M/F £24.75 (d)

### Serial Mini Patch Box

Allows an easy method to reconfigure pin functions without reworking the cable assy. Jumpers can be used and reused. £22 (d)

### Serial Mini Test

Monitors RS232C and CCITT V24 Transmissions. Indicating status with dual colour LEDs on 7 most significant lines. Connects in Line. £22.50 (d)

## CONNECTOR SYSTEMS

### I.D. CONNECTORS

(Speedblock Type)			
No of ways	Header	Recept	Edge Conn.
10	90p	85p	120p
20	145p	125p	185p
26	175p	150p	240p
34	200p	160p	320p
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	9	15	25	37
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IDC	175	275	325	-
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St Pin	100	140	210	380
Ang Pins	160	210	275	440
Solder	90	130	195	290
IDC	195	325	375	-
St Hood	90	95	100	120
Screw Lock	130	150	175	-

## TEXTPOOL ZIF

SOCKET5	24-pin £7.50
28-pin	£9.10
	40-pin £12.10

### EDGE CONNECTORS

	0 1	0 155
2 x 6-way (commodore)	-	300p
2 x 10-way	150p	-
2 x 12-way (vic 20)	-	350p
2 x 18-way	-	140p
2 x 23-way (ZX81)	175p	220p
2 x 25-way	225p	220p
2 x 28-way (Spectrum)	200p	-
2 x 36-way	250p	-
1 x 43-way	260p	-
2 x 22-way	190p	-
2 x 43-way	395p	-
1 x 77-way	400p	500p
2 x 50-way (S100conn)	600p	-

### EURO CONNECTORS

DIN 41612	Plug	Skt
2 x 32 way St Pin	230p	275p
2 x 32 way Ang Pin	275p	320p
3 x 32 way St Pin	260p	300p
3 x 32 way Ang Pin	375p	400p
IDC Skt A + B	400p	-
IDC Skt A + C	400p	-

For 2 X 32 way please specify spacing (A + B, A + C).

### MISC CONNS

21 pin Scart Connector	200p
8 pin Video Connector	200p

### AMPHENOL CONNECTORS

36 way plug Centronics (solder 500p (IDC) 475p)  
 36 way skt Centronics (solder) 550p (IDC) 500p  
 24 way plug IEEE (solder) 475p (IDC) 475p  
 24 way skt IEEE (solder) 500p (IDC) 500p  
 PCB Mtg Skt Ang Pin  
 24 way 700p 36 way 750p

### GENDER CHANGERS

25 way D type	
Male to Male	£10
Male to Female	£10
Female to Female	£10

### RS 232 JUMPERS

(25 way D)	
24" Single end Male	£5.00
24" Single end Female	£5.25
24" Female Female	£10.00
24" Male Male	£9.50
24" Male Female	£9.50

### DIL SWITCHES

4-way 90p	6-way 105p
8-way 120p	10-way 150p

### RIBBON CABLE

(grey/metre)		
10-way	40p	34-way 160p
16-way	60p	40-way 180p
20-way	85p	50-way 200p
26-way	120p	64-way 280p

### DIL HEADERS

Solder			IDC		
14 pin	40p	100p	14 pin	40p	100p
16 pin	50p	110p	16 pin	60p	110p
18 pin	60p	120p	18 pin	70p	120p
20 pin	75p	130p	20 pin	85p	130p
24 pin	100p	150p	24 pin	120p	150p
28 pin	130p	170p	28 pin	160p	170p
40 pin	200p	225p	40 pin	200p	225p

### ATTENTION

All prices in this double page advertisement are subject to change without notice. ALL PRICES EXCLUDE VAT Please add carriage 50p unless indicated as follows: (a) £8 (b) £2.50 (c) £1.50 (d) £1.00

74 SERIES		74179		74LS272		1.25	
7400	0.30	74179	0.80	74LS272	1.25	4076	0.65
7401	0.30	74180	1.05	74LS273	0.80	4077	0.25
7402	0.30	74181	0.80	74LS280	1.80	4078	0.25
7403	0.30	74182	0.80	74LS283	0.80	4081	0.24
7404	0.38	74183	1.00	74LS290	0.80	4082	0.25
7405	0.40	74184	1.00	74LS292	14.00	4085	0.80
7406	0.40	74185	1.00	74LS293	14.00	4086	0.75
7407	0.40	74186	1.00	74LS294	14.00	4089	1.20
7408	0.30	74187	1.00	74LS295	14.00	4093	0.35
7409	0.30	74188	1.00	74LS296	14.00	4094	0.90
7410	0.30	74189	1.00	74LS297	14.00	4095	0.90
7411	0.30	74190	1.00	74LS298	14.00	4096	0.90
7412	0.30	74191	1.00	74LS299	14.00	4097	2.70
7413	0.50	74192	1.00	74LS300	14.00	4098	0.75
7414	0.70	74193	1.00	74LS301	14.00	4099	0.99
7415	0.36	74194	1.00	74LS302	14.00	4501	0.36
7416	0.36	74195	1.00	74LS303	14.00	4502	0.35
7417	0.36	74196	1.00	74LS304	14.00	4503	0.36
7420	0.36	74197	1.00	74LS305	14.00	4504	0.95
7421	0.80	74198	1.00	74LS306	14.00	4505	3.60
7422	0.36	74199	1.00	74LS307	14.00	4506	1.20
7423	0.36	74200	1.00	74LS308	14.00	4510	0.55
7424	0.36	74201	1.00	74LS309	14.00	4511	0.55
7425	0.36	74202	1.00	74LS310	14.00	4512	0.55
7426	0.36	74203	1.00	74LS311	14.00	4513	1.50
7427	0.36	74204	1.00	74LS312	14.00	4514	1.10
7428	0.36	74205	1.00	74LS313	14.00	4515	1.10
7429	0.36	74206	1.00	74LS314	14.00	4516	0.55
7430	0.36	74207	1.00	74LS315	14.00	4517	2.20
7431	0.36	74208	1.00	74LS316	14.00	4518	0.48
7432	0.36	74209	1.00	74LS317	14.00	4519	0.32
7433	0.36	74210	1.00	74LS318	14.00	4521	1.15
7434	0.36	74211	1.00	74LS319	14.00	4522	0.80
7435	0.36	74212	1.00	74LS320	14.00	4523	0.80
7436	0.36	74213	1.00	74LS321	14.00	4524	0.80
7437	0.36	74214	1.00	74LS322	14.00	4525	0.80
7438	0.36	74215	1.00	74LS323	14.00	4526	0.80
7439	0.36	74216	1.00	74LS324	14.00	4527	0.80
7440	0.36	74217	1.00	74LS325	14.00	4528	0.80
7441	0.36	74218	1.00	74LS326	14.00	4529	0.80
7442	0.36	74219	1.00	74LS327	14.00	4530	0.80
7443	0.36	74220	1.00	74LS328	14.00	4531	0.80
7444	0.36	74221	1.00	74LS329	14.00	4532	0.80
7445	0.36	74222	1.00	74LS330	14.00	4533	0.80
7446	0.36	74223	1.00	74LS331	14.00	4534	0.80
7447	0.36	74224	1.00	74LS332	14.00	4535	0.80
7448	0.36	74225	1.00	74LS333	14.00	4536	0.80
7449	0.36	74226	1.00	74LS334	14.00	4537	0.80
7450	0.36	74227	1.00	74LS335	14.00	4538	0.80
7451	0.36	74228	1.00	74LS336	14.00	4539	0.80
7452	0.36	74229	1.00	74LS337	14.00	4540	0.80
7453	0.36	74230	1.00	74LS338	14.00	4541	0.80
7454	0.36	74231	1.00	74LS339	14.00	4542	0.80
7455	0.36	74232	1.00	74LS340	14.00	4543	0.80
7456	0.36	74233	1.00	74LS341	14.00	4544	0.80
7457	0.36	74234	1.00	74LS342	14.00	4545	0.80
7458	0.36	74235	1.00	74LS343	14.00	4546	0.80
7459	0.36	74236	1.00	74LS344	14.00	4547	0.80
7460	0.36	74237	1.00	74LS345	14.00	4548	0.80
7461	0.36	74238	1.00	74LS346	14.00	4549	0.80
7462	0.36	74239	1.00	74LS347	14.00	4550	0.80
7463	0.36	74240	1.00	74LS348	14.00	4551	0.80
7464	0.36	74241	1.00	74LS349	14.00	4552	0.80
7465	0.36	74242	1.00	74LS350	14.00	4553	0.80
7466	0.36	74243	1.00	74LS351	14.00	4554	0.80
7467	0.36	74244	1.00	74LS352	14.00	4555	0.80
7468	0.36	74245	1.00	74LS353	14.00	4556	0.80
7469	0.36	74246	1.00	74LS354	14.00	4557	0.80
7470	0.36	74247	1.00	74LS355	14.00	4558	0.80
7471	0.36	74248	1.00	74LS356	14.00	4559	0.80
7472	0.36	74249	1.00	74LS357	14.00	4560	0.80
7473	0.36	74250	1.00	74LS358	14.00	4561	0.80
7474	0.36	74251	1.00	74LS359	14.00	4562	0.80
7475	0.36	74252	1.00	74LS360	14.00	4563	0.80
7476	0.36	74253	1.00	74LS361	14.00	4564	0.80
7477	0.36	74254	1.00	74LS362	14.00	4565	0.80
7478	0.36	74255	1.00	74LS363	14.00	4566	0.80
7479	0.36	74256	1.00	74LS364	14.00	4567	0.80
7480	0.36	74257	1.00	74LS365	14.00	4568	0.80
7481	0.36	74258	1.00	74LS366	14.00	4569	0.80
7482	0.36	74259	1.00	74LS367	14.00	4570	0.80
7483	0.36	74260	1.00	74LS368	14.00	4571	0.80
7484	0.36	74261	1.00	74LS369	14.00	4572	0.80
7485	0.36	74262	1.00	74LS370	14.00	4573	0.80
7486	0.36	74263	1.00	74LS371	14.00	4574	0.80
7487	0.36	74264	1.00	74LS372	14.00	4575	0.80
7488	0.36	74265	1.00	74LS373	14.00	4576	0.80
7489	0.36	74266	1.00	74LS374	14.00	4577	0.80
7490	0.36	74267	1.00	74LS375	14.00	4578	0.80
7491	0.36	74268	1.00	74LS376	14.00	4579	0.80
7492	0.36	74269	1.00	74LS377	14.00	4580	0.80
7493	0.36	74270	1.00	74LS378	14.00	4581	0.80
7494	0.36	74271	1.00	74LS379	14.00	4582	0.80
7495	0.36	74272	1.00	74LS380	14.00	4583	0.80
7496	0.36	74273	1.00	74LS381	14.00	4584	0.80
7497	0.36	74274	1.00	74LS382	14.00	4585	0.80
7498	0.36	74275	1.00	74LS383	14.00	4586	0.80
7499	0.36	74276	1.00	74LS384	14.00	4587	0.80
7500	0.36	74277	1.00	74LS385	14.00	4588	0.80

74LS SERIES		74ALS SERIES		4000 SERIES		74S SERIES	
74LS00	0.24	74ALS00	0.45	4000	0.20	74S00	0.50
74LS01	0.24	74ALS01	0.45	4001	0.24	74S01	0.50
74LS02	0.24	74ALS02	0.45	4002	0.25	74S02	0.50
74LS03	0.24	74ALS03	0.45	4003	0.25	74S03	0.50
74LS04	0.24	74ALS04	0.45	4004	0.24	74S04	0.50
74LS05	0.24	74ALS05	0.45	4005	0.24	74S05	0.50
74LS06	0.24	74ALS06	0.45	4006	0.25	74S06	0.50
74LS07	0.24	74ALS07	0.45	4007	0.25	74S07	0.50
74LS08	0.24	74ALS08	0.45	4008	0.60	74S08	0.50
74LS09	0.24	74ALS09	0.45	4009	0.45	74S09	0.50
74LS10	0.24	74ALS10	0.45	4010	0.45	74S10	0.50
74LS11	0.24	74ALS11	0.45	4011	0.24	74S11	0.50
74LS12	0.24	74ALS12	0.45	4012	0.25	74S12	0.50
74LS13	0.24	74ALS13	0.45	4013	0.26	74S13	0.50
74LS14	0.24	74ALS14	0.45	4014	0.60	74S14	0.50
74LS15	0.24	74ALS15	0.45	4015	0.70	74S15	0.50
74LS16	0.24	74ALS16	0.45	4016	0.70	74S16	0.50
74LS17	0.24	74ALS17	0.45	4017	0.55	74S17	0.50
74LS18	0.24	74ALS18	0.45	4018	0.30	74S18	0.50
74LS19	0.24	74ALS19	0.45	4019	0.80	74S19	0.50
74LS20	0.24	74ALS20	0.45	4020	0.80	74S20	0.50
74LS21	0.24	74ALS21	0.45	4021	0.60	74S21	0.50
74LS22	0.24	74ALS22	0.45	4022	0.60	74S22	0.50
74LS23	0.24	74ALS23	0.45	4023	0.30	74S23	0.50
74LS24	0.24	74ALS24	0.45	4024	0.48	74S24	0.50
74LS25	0.24	74ALS25	0.45	4025	0.24	74S25	0.50
74LS26	0.24	74ALS26	0.45	4026	0.90	74S26	0.50
74LS27	0.24	74ALS27	0.45	4027	0.60	74S27	0.50
74LS28	0.24	74ALS28	0.45	4028	0.60	74S28	0.50
74LS29	0.24	74ALS29	0.45	4029	0.75	74S29	0.50
74LS30	0.24	74ALS30	0.45	4030	0.35	74S30	0.50
74LS31	0.24	74ALS31	0.45	4031	1.25	74S31	0.50
74LS32	0.24	74ALS32	0.45	4032	1.00	74S32	0.50
74LS33	0.24	74ALS33	0.45	4033	1.25	74S33	0.50
74LS34	0.24	74ALS34	0.45	4034	2.50	74S34	0.50
74LS35	0.24	74ALS35	0.45	4035	2.50	74S35	0.50
74LS36	0.24	74ALS36	0.45	4036	2.50	74S36	0.50
74LS37	0.24	74ALS37	0.45	4037	1.10	74S37	0.50
74LS38	0.24	74ALS38	0.45	4038	1.00	74S38	0.50
74LS39	0.24	74ALS39	0.45	4039	0.80	74S39	0.50
74LS40	0.24	74ALS40	0.45	4040	0.60	74S40	0.50
74LS41	0.24	74ALS41	0.45	4041	0.55	74S41	0.50
74LS42	0.24	74ALS42	0.45	4042	0.50	74S42	0.50
74LS43	0.24	74ALS43	0.45	4043	0.60	74S43	0.50
74LS44	0.24	74ALS44	0.45	4044	0.60	74S44	0.50
74LS45	0.24	74ALS45	0.45	4045	1.00	74S45	0.50
74LS46	0.24	74ALS46	0.45	4046	0.80	74S46	0.50
74LS47	0.24	74ALS47	0.45	4047	0.60	74S47	0.50
74LS48	0.24	74ALS48	0.45	4048	0.55	74S48	0.50
74LS49	0.24	74ALS49	0.45	4049	0.80	74S49	0.50
74LS50	0.24	74ALS50	0.45	4050	0.80	74S50	0.50
74LS51	0.24	74ALS51	0.45	4051	0.65	74S51	

# SPEAKING CLOCK

BY STEPHEN HUNT  
I SPEAK YOUR DATA

*In the beginning was the Word ... and time began. Seconding the SPO256AL speech chip to verbalise the output of a real-time clock may be a less momentous event, but it continues an ancient and honourable tradition!*

Many articles have been designed around the SPO256AL speech synthesiser. However, the majority of them have been simply for experimentation in conjunction with a home computer and serve no real application. This article describes how the allophone speech system can be used to produce a speaking clock which may be invaluable to a blind person or simply a novelty clock demonstrating the use of current electronic devices.

The block and circuit diagrams are shown in Fig.1. The system forms a simple microprocessor controller which is used to process data from the real time clock. The speaking clock uses a 6802 micro-processor in conjunction with a 2716 eeprom, 6821 pia and an ICM7170 real time clock. The heart of the system is the program stored in the rom.

## MEMORY MAP

The eeprom occupies locations 8000H to 87FFH (2K). The address decoding for IC3 uses A15 via an inverter IC6a when the eeprom is enabled low. The pia, IC2, is selected by A14 and A2, corresponding to location 4004H. To prevent the pia and eeprom being selected at the same time A15 is also connected to CS2. RS0 and RS1 are connected to A0 and A1 respectively and are used to select internal registers which control port operations. The pia places the speech synthesiser in the memory map.

It might appear at first that using a pia to interface with IC4 and a few switches is over complicating matters. Alternatively, octal buffers such as the 74LS244 type of devices could be used but would require extra decoding logic, take up more room and cost more. The 6821 has three select lines (CS0, CS1 and CS2) which can be connected to appropriate address lines to place it in the memory map, and allows for a much simpler approach. The 6821 also contains two user ports, A and B which can be set by software as inputs or outputs as required. The speaking clock program requires PA0 to PA6 to be outputs and PA7 to be an input line. Port B lines are all set as inputs. Port A controls the

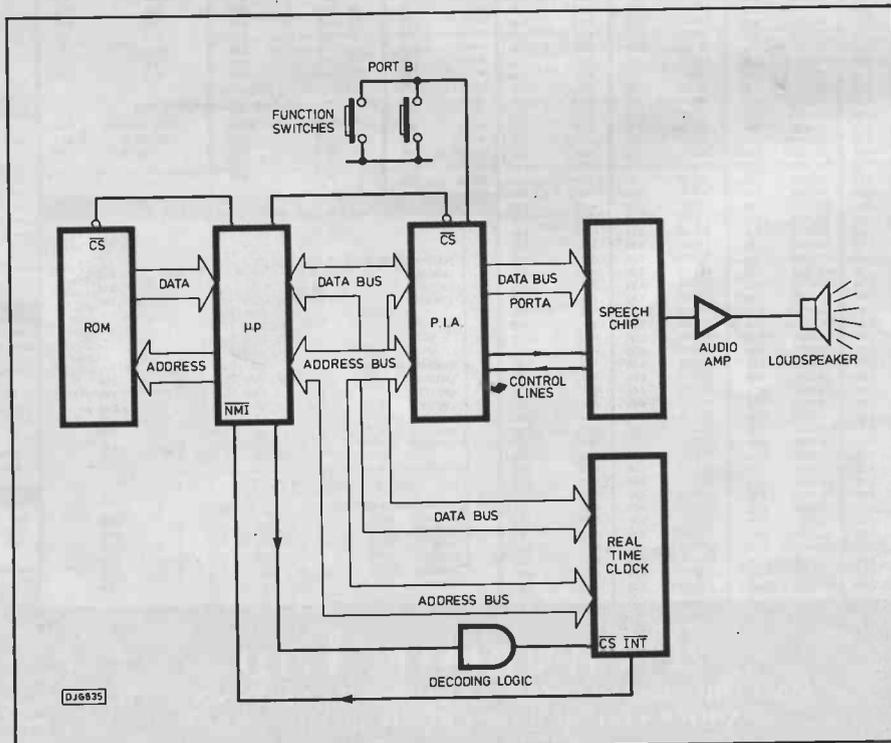
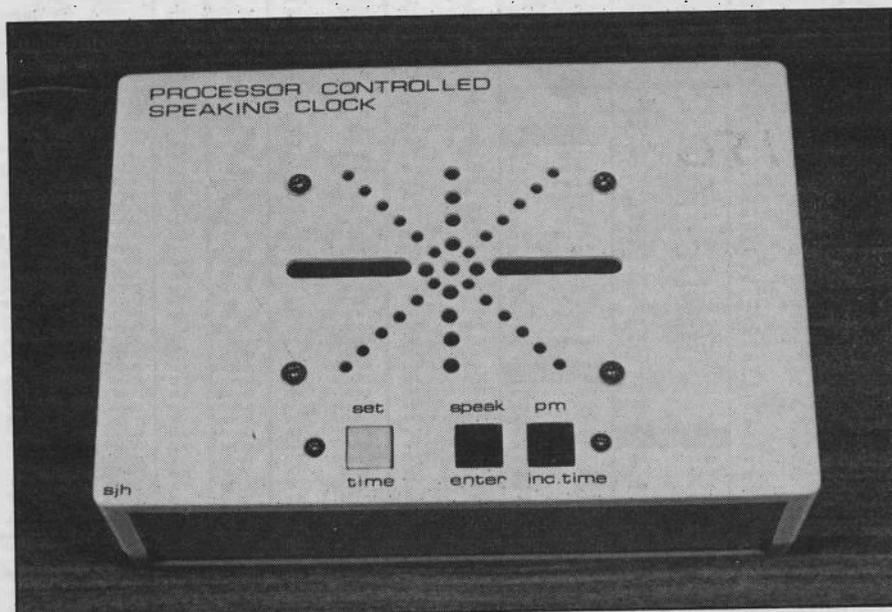


Fig.1. Block diagram for the speaking clock

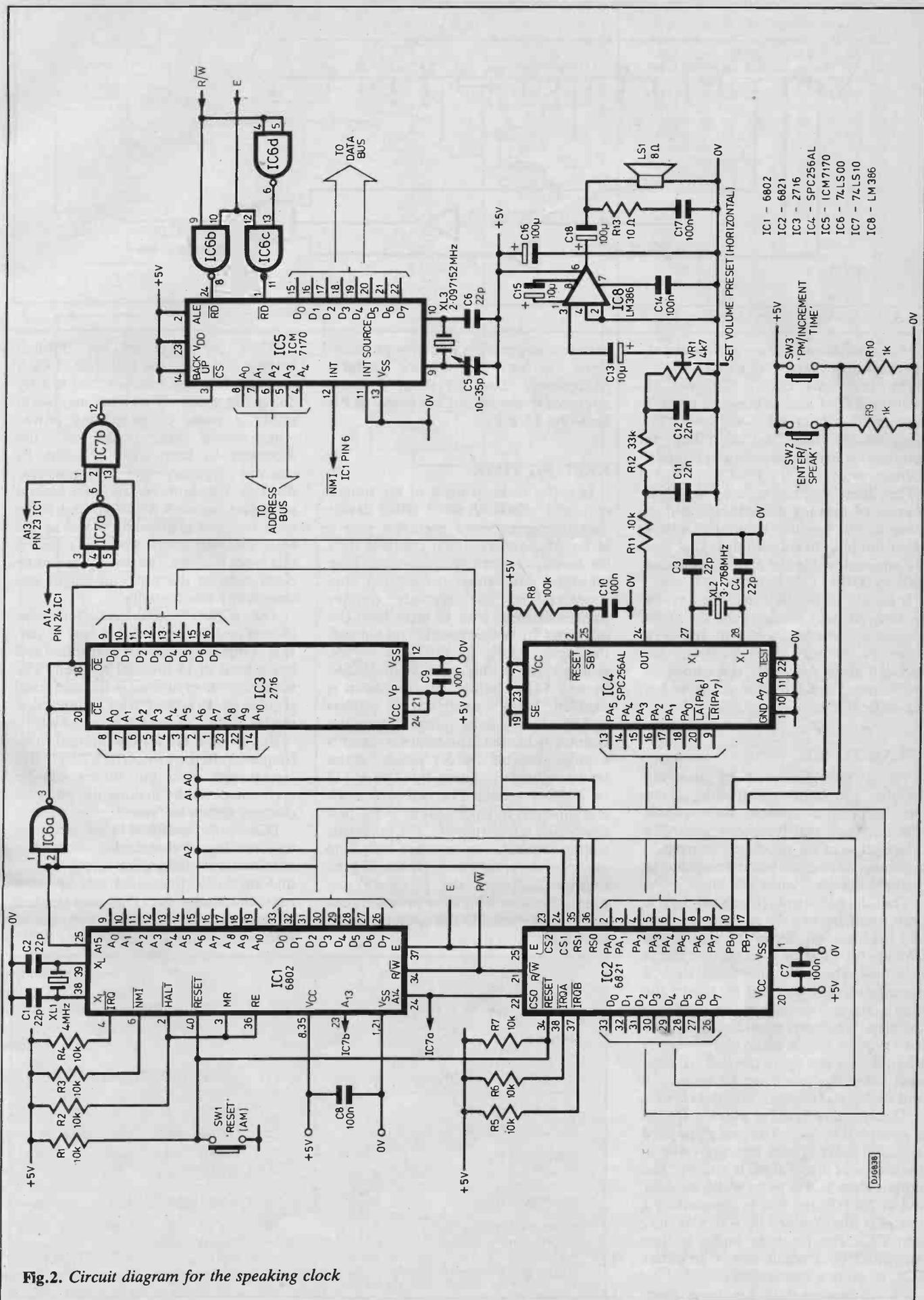


Fig.2. Circuit diagram for the speaking clock

# SPEAKING CLOCK

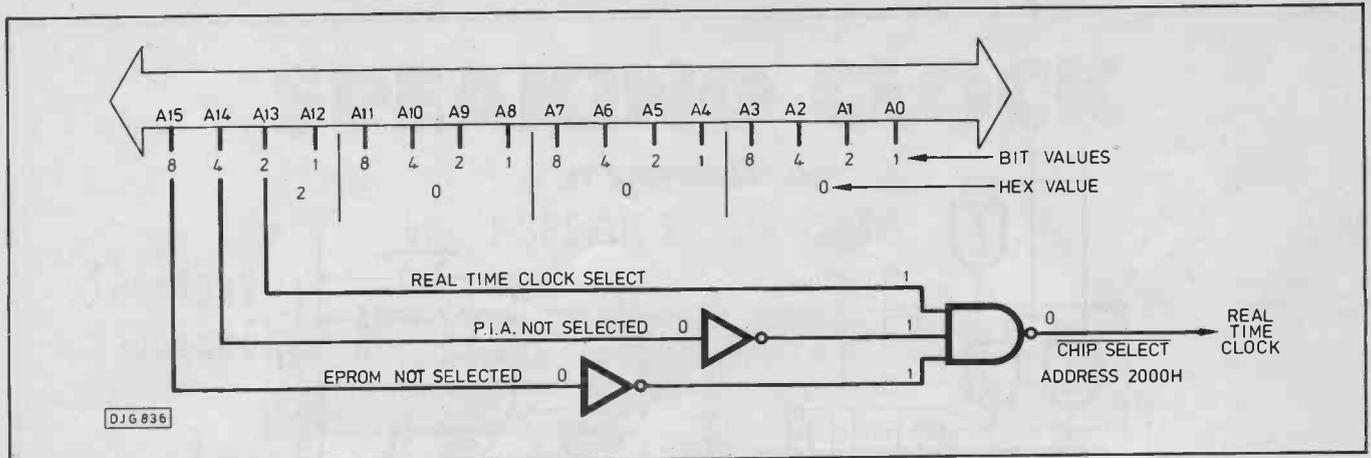


Fig.3. Obtaining address decoding

speech synthesiser while port B looks at the function switches, S2 and S3.

The real time clock, IC5, sits at location 2000H and is selected by IC7 from address lines A13, A14 and A15. Fig.3 shows how the decoding is obtained. All other decoding is done in a similar way.

The speaking clock uses a small amount of ram for data storage and as a stack for holding return addresses when jumping to subroutines. This ram is contained within the 6802 at locations 0000 to 007FH (128 bytes).

It should be realised that the devices are only partially decoded and therefore appear in several blocks in memory. However, as only three locations are decoded in the 64K area, this causes no problems of accidental enabling and is therefore perfectly acceptable.

## SPEAK TO ME

Words are generated by stringing together allophones which make up the basic sounds of speech. By carefully selecting them a fairly reasonable quality of speech can be produced bearing in mind the limitations when compared to digitally encoded voice systems.

The data control (handshaking) is performed by two lines, load address and load request. When the synthesiser is ready for data the load request line is held low. Then the allophone data is placed onto the bus and by taking the load address low latches the data into the chip. While it is speaking (busy) the load request line is taken high and only when it goes low again can you send the next data. The processor looks at PA6 and PA7 of IC2 to control the data flow.

The speed or pitch at which it speaks is governed by XL2. The prototype used a 3.2768 MHz crystal but any value in the range of 3 to 3.5 MHz will do. The output from IC4 is pulse width modulated at 20kHz and this is removed by a low pass filter formed by R11, C11, R12 and C12. The resulting audio is then amplified by a small power amplifier, IC8, to drive a loudspeaker.

No allophone data has been given

here as many readers will have probably come across this device before. (*Allophone Data Principles were discussed in the MicroChat article in PE Sept-Oct 87. Ed.*)

## KEEPING TIME

In order to keep track of the time a real-time clock is used. This device contains an onboard oscillator and a series of registers which contains data for hours, minutes, seconds etc. These registers are simply cascaded up-counters, ie, the seconds counter sequences from zero to sixty then the carry-out from this counter increments the next, which in this case is the minutes. The counters can be preloaded to any value before the oscillator is enabled. Each register has an address and by sending data to that address the counter is loaded. The hours counter is a programmable divider which can be set by software to divide by 12 or 24 (12 or 24 hour mode). The real-time clock is completely independent from the processor and is free running. The processor simply preloads the registers with time data and starts the clock. By reading the register addresses the processor can obtain the time which the program then sorts out to provide the speech synthesiser with word data.

When the processor has finished reading data from the real-time clock it scans the function switches. Not exactly doing too much, is it? This may seem rather a waste of processing power. Alternatively, you could use the processor to keep time by using its internal registers as programmable dividers. This however, requires several processor registers which are not being used for data manipulation and as the 6802 has only three working registers this is not feasible. The use of a real-time clock reduces the program length and complexity substantially.

The ICM7170 real-time clock was chosen mainly because it is easy to use. It is completely software controlled and has a total of 18 internal registers. The main register of interest is the command register which is used to set up operation modes. Table 1 shows the assigned bits.

Bits D0 and D1 set the internal clock frequency. In the prototype a 2.097MHz crystal was used but others can be accommodated by making the program changes shown in Table 2.

D2 is set to zero for 12 hours. Stopping and starting of the clock's counters is obtained by writing a 0 or 1 respectively into the bit location. D4 sets up interrupts for alarms and D5 is used as a test bit which clocks the counters at a faster rate. D5 and D7 are not used.

D7	D6	D5	D4	D3	D2	D1	D0
—	—	TEST	INT	RUN	12/24	FREQ	FREQ

Table 1

CRYSTAL FREQ	D0	D1	PROGRAM CHANGES
32.768KHZ	0	0	0010 00 04BC 08
1.048576MHZ	0	1	0010 01 04BC 09
2.097152MHZ	1	0	AS IN HEX LIST
4.194304MHZ	1	1	0010 03 04BC 0B

Table 2

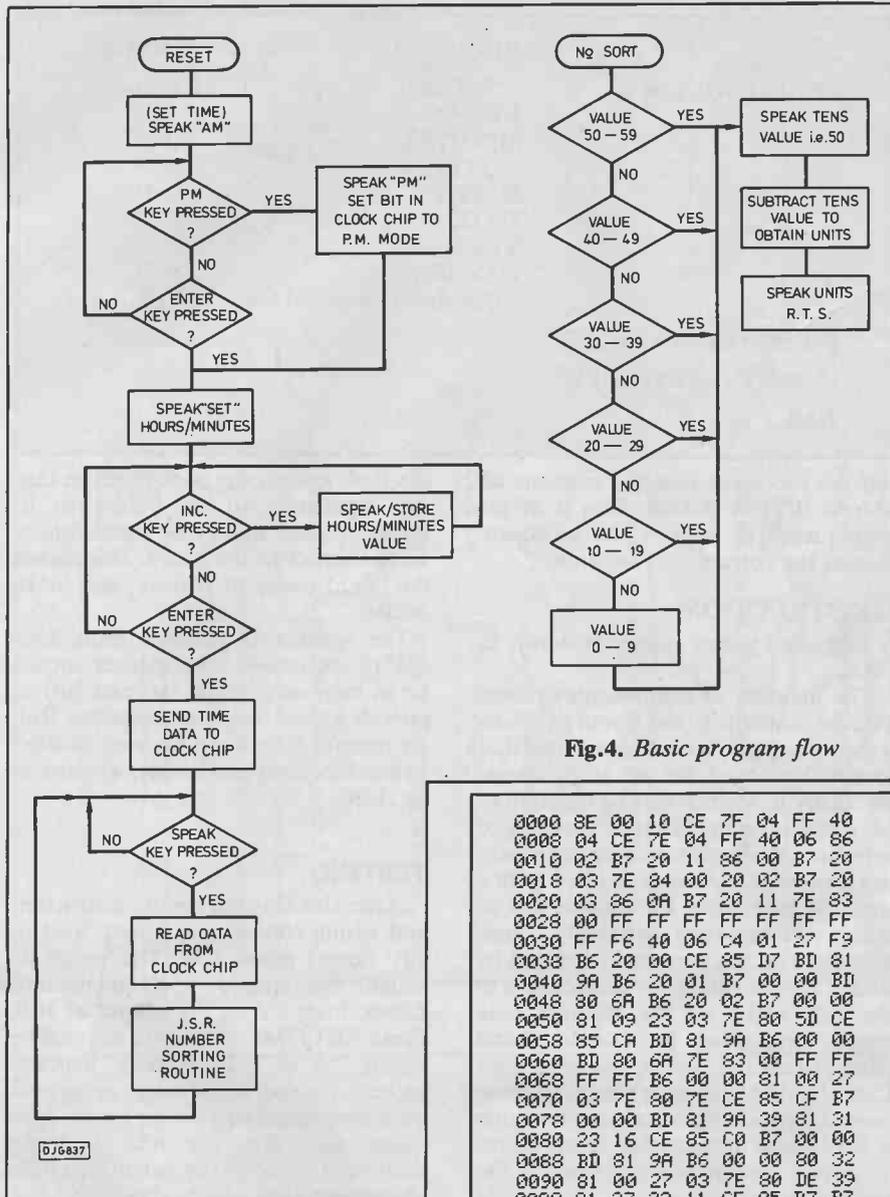
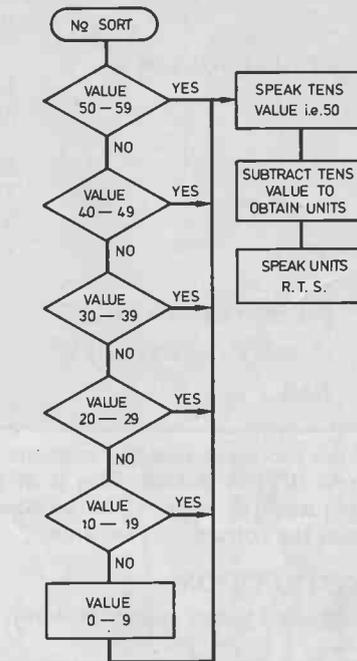


Fig.4. Basic program flow

The ICM7170 was not specifically designed for the 6800 series of micro-processors. The device has both active-low read and write lines. IC6B to IC6D gate the processor's E line with the r/w line to provide IC5 with the required RD and WR signals. A simple inverter cannot be used between the two lines as this would not take into account the r/w timing cycle. In order to synchronise the r/w signals with the processors clock, 02 of the clock cycle ('E' line) is also gated with the r/w line.

## PROGRAM OPERATION

After switching on you need to set up the time. By pressing 'SET TIME' the clock will say "AM". Pressing 'INC' sets to pm, or pressing 'ENTER' causes it to say "SET HOURS". By pressing 'INC' the hours are spoken in turn (1 to 12). When the required hour has been spoken pressing 'ENTER' stores this value in the hours register. It then says "SET MINUTES". Pressing 'INC' then advances the tens of minutes (10, 20, 30, 40, 50). When the required value has



0000	8E	00	10	CE	7F	04	FF	40
0008	04	CE	7E	04	FF	40	06	86
0010	02	B7	20	11	86	00	B7	20
0018	03	7E	84	00	20	02	B7	20
0020	03	86	0A	B7	20	11	7E	83
0028	00	FF						
0030	FF	F6	40	06	C4	01	27	F9
0038	B6	20	00	CE	85	D7	BD	81
0040	9A	B6	20	01	B7	00	00	BD
0048	80	6A	B6	20	02	B7	00	00
0050	81	09	23	03	7E	80	5D	CE
0058	85	CA	BD	81	9A	B6	00	00
0060	BD	80	6A	7E	83	00	FF	FF
0068	FF	FF	B6	00	00	81	00	27
0070	03	7E	80	7E	CE	85	CF	B7
0078	00	00	BD	81	9A	39	81	31
0080	23	16	CE	85	C0	B7	00	00
0088	BD	81	9A	B6	00	00	80	32
0090	81	00	27	03	7E	80	DE	39
0098	81	27	23	11	CE	85	B7	B7
00A0	00	00	BD	81	9A	B6	00	00
00A8	80	28	7E	80	90	81	1D	23
00B0	11	CE	85	AE	B7	00	00	BD
00B8	81	9A	B6	00	00	80	1E	7E
00C0	80	90	81	13	23	11	CE	85
00C8	A2	B7	00	00	BD	81	9A	B6
00D0	00	00	00	14	7E	80	90	81
00D8	09	23	03	7E	81	34	81	09
00E0	27	28	81	08	27	1E	81	07
00E8	27	26	81	06	27	28	81	05
00F0	27	2A	81	04	27	2C	81	03
00F8	27	2E	81	02	27	30	CE	85
0100	00	7E	81	9A	CE	85	32	7E
0108	81	9A	CE	85	38	7E	81	9A
0110	CE	85	29	7E	81	9A	CE	85
0118	21	7E	81	9A	CE	85	1A	7E
0120	81	9A	CE	85	14	7E	81	9A
0128	CE	85	0D	7E	81	9A	CE	85
0130	07	7E	81	9A	81	0A	27	26
0138	81	0B	27	28	81	0C	27	2A
0140	81	0D	27	2C	81	0E	27	2E
0148	81	0F	27	30	81	10	27	32
0150	81	11	27	34	81	12	27	36
0158	CE	85	97	7E	81	9A	CE	85
0160	3F	7E	81	9A	CE	85	46	7E
0168	81	9A	CE	85	50	7E	81	9A
0170	CE	85	5A	7E	81	9A	CE	85
0178	64	7E	81	9A	CE	85	6D	7E
0180	81	9A	CE	85	78	7E	81	9A
0188	CE	85	83	7E	81	9A	CE	85
0190	8F	7E	81	9A	FF	FF	FF	FF
0198	FF	FF	86	40	B7	40	34	A6
01A0	00	81	FF	26	01	39	A6	00
01A8	F6	40	C4	80	27	03	7E	
01B0	81	A8	08	B7	40	04	7E	81

Fig.5. Hex dump of the speaking clock program

# SPEAKING CLOCK

been spoken pressing 'ENTER' stores this value in a location in ram. Pressing 'INC' now advances the units (1 to 9). Pressing 'ENTER' stores this value in a second location in ram. Adding these two locations together gives the total minutes value which is then stored in the minutes register. The program now jumps to a routine which looks to see if the 'SPEAK' key has been pressed.

On pressing the 'SPEAK' key the 100ths second register is read. This latches the time data to prevent it rolling when reading the various time data registers. The hours register is read and the program jumps to another routine which determines the hour value. Having done this it now jumps to the next routine which sends the required word data to the speech synthesiser. Now the clock has to speak the minutes. To explain this it is best to look at an example.

Suppose the minutes value is 46, the routine determines the group value, which in this case lies between 40 and 49, and so "forty" is sent to be spoken. To obtain the unit value (six) forty is subtracted and "six" is sent to be spoken. Fig. 4 shows the program flow.

A routine also sorts out the grammar. If the minute value is less than ten "OH" has to be spoken before the units value and if zero it has to say "O'CLOCK". (Was Victor Borg consulted about the correct pronunciation of the apostrophe? Ed.)

If the time lies between 1:00am to 11:59am it will say "GOODMORNING THE TIME IS.....". Between the times of 12:00noon to 5:00pm it says "GOOD-AFTERNOON THE TIME IS....." and from 6:00pm onwards it says "GOOD-EVENING THE TIME IS.....".

The machine code listing is shown in Fig. 5 and occupies approximately 1K of code. If any readers might like to enhance or write their own programs, the addresses in Table 3 may be of use.

## FINDING THE STORED PROGRAM

When the processor is reset it looks at the reset vector addresses FFFEh and FFFFh and reads the data at each location. These two bytes are loaded into the processor's program counter and is used as a start location from which to run. As the eeprom sits at memory location 8000h this must be the address held in the program counter.

On looking at the hex listing we see that the reset vector address is stored in locations 07FEh and 07FFh and not the required addresses FFFEh and FFFFh! This is easily explained. As the eeprom is only 2K \* 8 (16K) address lines A0 to A10 are all that are needed to access any location within it. Therefore the bit values A11 to A14 are not seen (A15 selects the eeprom). When FFFEh is sent out by the processor A11 to A14 are 'lost'

	REGISTERS	ADDRESS
REALTIME CLOCK	1/100THS	2000H
	HOURS	2001H
	MINUTES	2002H
	SECONDS	2003H
	MONTHS	2004H
	DATE	2005H
	YEAR	2006H
	DAYOFWEEK	2007H
	COMMAND REGISTER	2011H
	SPEECH SYNTHESISER	
FUNCTION SWITCHES		4006H

Table 3

and the processor sees the contents of address 07FEh instead. This is of no consequence as long as the processor obtains the correct start location.

## CONSTRUCTION

A suggested power supply is shown in Fig. 6.

The majority of components fit onto a double sided pcb, the layout of which is shown in Fig. 7. It is recommended that sockets are used for all ic positions, especially IC3 which may be required to be replaced with different versions of software. Also note the capacitor polarities around IC8. A soldering iron with a small bit is required for construction as many tracks run extremely close together and are very easily bridged by solder. Before fitting any components to the pcb make all the through hole connections using fine single strand wire. (Better still, use pc link pins. Ed.) Care should be taken to ensure all these connections are made as there are quite a few, many being under components. Construction can now continue in the usual manner.

The unit was housed in a Verobox type 75-1411D. The back panel is used as a chassis onto which the transformer is bolted. It also serves as a heatsink for the regulator (IC9). The mains lead passes through a grommet and is secured by a 'P' clip fixed to the base of the box. The earth wire is soldered to a tag bolted to the transformer fixings. A few 3mm holes are drilled in the base under the transformer to aid ventilation.

The pcb is fixed to the base by spacers. Make sure that the far side of the pcb

sits flush against the back panel so that the regulator can be bolted to it. Terminal pins should be used where wires connect to the board. This makes the board easier to remove, and looks neater.

The speaker is attached using four M4\*10 csk screws. The speaker should be as large as possible (at least 3in) to provide a good frequency response. Rub on transfer letters can be used to label switch functions and lacquer applied to fix them.

## TESTING

After checking the board construction and wiring connect a voltmeter (set to 10V range) across C19. The rough dc should be around 7.5V (minimum). Check from 5V on the output of IC9. Press 'SETTIME'. It should respond by saying "A M". If nothing happens recheck your wiring. If you programmed your own eeprom check it for errors. Also make sure that the rom is being addressed (selected) by monitoring IC3's chip-select pin, which should be low. (A15 should be constantly high).

Adjust C5 to obtain an accurate clock time. By trial and error an accuracy of few seconds a day is possible. An alternative method is to write a piece of software which causes the realtime clock to produce an interrupt every second. The interrupt signal can then be monitored with a frequency counter (negative side triggered) and C5 adjusted for a reading of 1.000000 on the display. The first method is accurate enough although more time consuming.

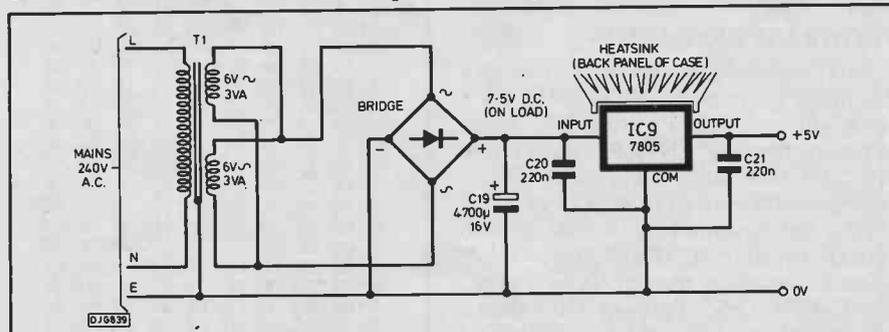
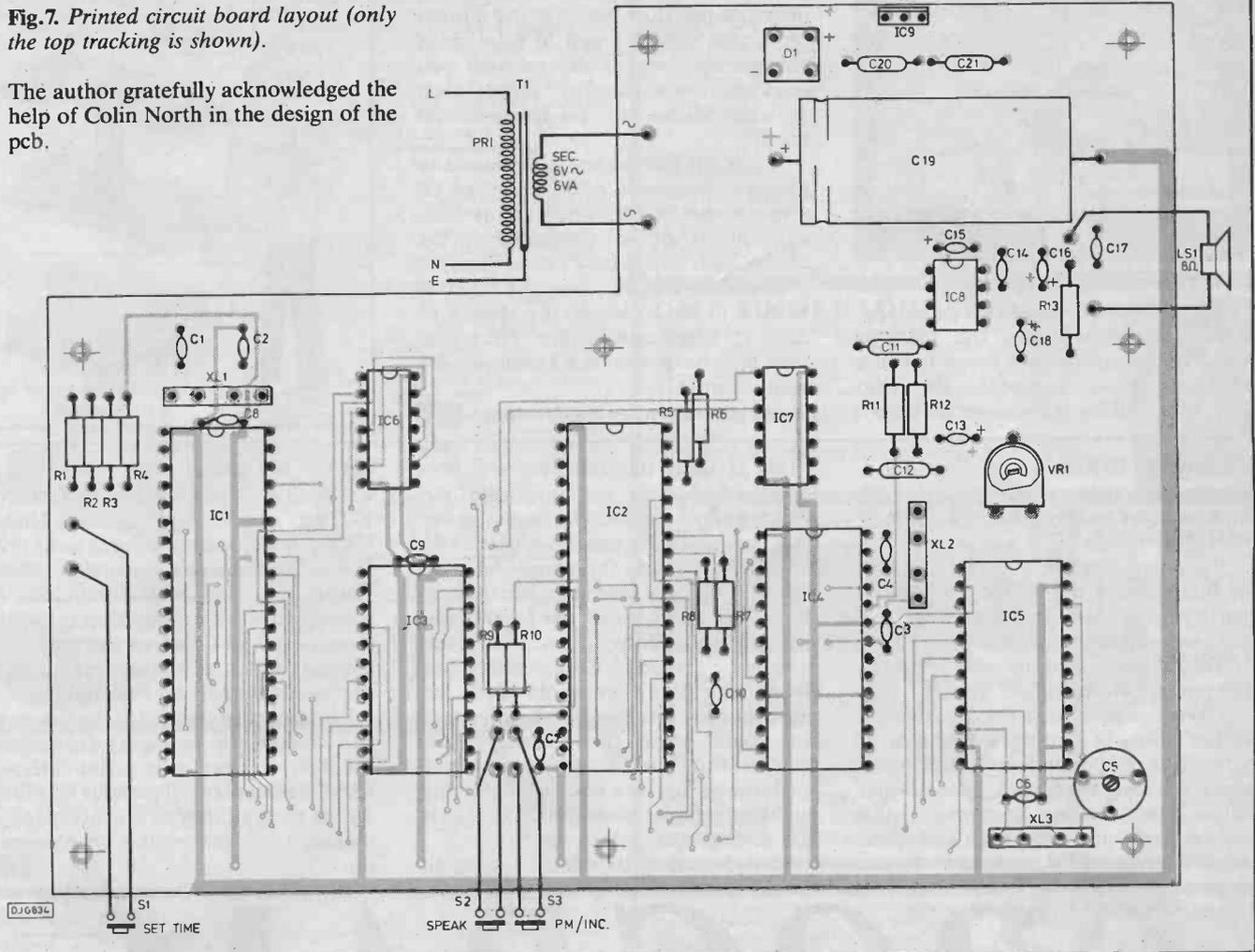


Fig. 6. Power supply circuit diagram

**Fig.7. Printed circuit board layout (only the top tracking is shown).**

The author gratefully acknowledged the help of Colin North in the design of the pcb.



## COMPONENTS

### RESISTORS

R1-R7	10k (8 off)
R9,R10	1k (2 off)
R8	100k
R12	33k
R13	10Ω
All resistors 1/8W 5%.	

### CAPACITORS

C1-C4,C6	22pF ceramic (5 off)
C5	10-35pF variable
C7-C10,C14,C17	100nF ceramic (6 off)
C11,C12	22nF polyester (2 off)
C13,C15	10μF 16V elect (2 off)
C16,C18	100μF 16V elect (2 off)
C19	4700μF 16V elect
C20,C21	220nF polyester (2 off)

## SEMICONDUCTORS

D1	Bridge rectifier 2A 50V
IC1	6802
IC2	6821
IC3	2716 (5V)
IC4	SPO256AL
IC5	ICM7170
IC6	74LS00
IC7	74LS10
IC8	LM386 (6V version)
IC9	7805

## POTENTIOMETER

VR1	4k7 horiz preset
-----	------------------

## CRYSTALS

XL1	4MHz
XL2	3 to 3.5MHz (see text)
XL3	(see text)

## MISCELLANEOUS

T1	0-6V, 0-6V transformer 3VA per winding
S1,S2,S3	SP push make switches (3 off)
Case	Vero type 75-1411D (20.5 × 14 × 7.5cm)
LS1	8 ohm 3in speaker
Pcb, sockets, wire etc.	

## CONSTRUCTOR'S NOTE

One of Stephen's friends has very kindly offered to program any blank eproms sent to him in connection with this project. Send your eeprom with a stamped addressed envelope (or equivalent return postage) to:

Charles Moore,  
101 Heatherstone Avenue,  
Dibden Purlieu, Hythe,  
Hants. SO4 5LE.

(please state value of crystal being used in the real-time clock).

## CONSTRUCTOR'S NOTE

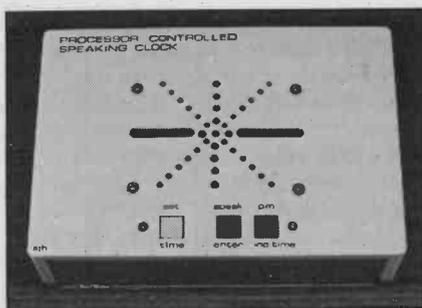
The double sided printed circuit board is available through the PE PCB Service, see page 60.

## STEPHEN HUNT

While preparing Stephen's article for publication, we were distressed to learn of his tragic death. It is his parent's wishes that we should still publish his article. We send our deepest sympathy to his family. Ed.

If you are unable to set up the clock fairly accurately then this is probably due to the crystal not being loaded correctly. Inserting the specified load capacitor (C6) for the crystal should cure the problem. Finally set VR1 to the volume required.

## SPEAKING CLOCK



### STATIC SENSITIVE

During bench testing of the prototype, it was discovered that the realtime clock's interrupt pin was prone to static charges. When "zapped", the chip latches up and draws excessive current.

### LEADING EDGE

*continued from page 8*

how pioneers end up with arrows in their back," he recalls.

Brody has ideas of his own about how to build a very big lcd display. "But I am trying to raise money so I am not yet ready to talk about it."

The oddest part of the story relates to the patents on lcd colour screens.

"Westinghouse filed for a patent on Fisher's idea of putting a thin film of transistors and liquid crystal cells on glass, covering them with colour triplet filters, and viewing the image with transmitted white light, such as a white fluorescent back light," says Brody.

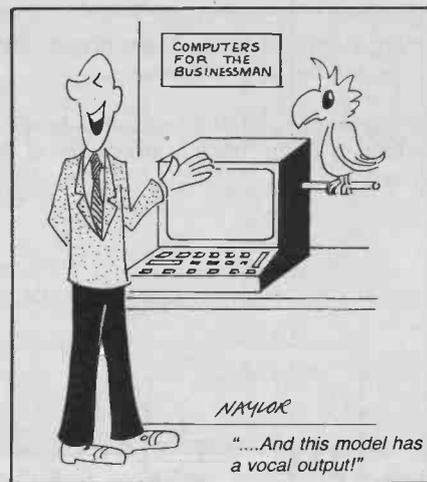
This is due to the fact that the interrupt line does not have the normal protection diodes found in most cmos devices. As long as the relevant pcb tracks are not touched by "aerials" such as screwdrivers etc, no harm should result.

It was felt that adding components to suppress transients could prove to be more trouble than it's worth and as these components are not integrated on the silicon itself would only provide limited protection. However, once the board is housed in an enclosure the chance of latch up is reduced to zero. The prototype has been working faultlessly for many months.

**Please take care when bench testing!** PE

"This is what the Japanese are now doing. And they are infringing the Westinghouse patent. Westinghouse say they are not in the panel business so do not want to spend the money on legal action. Our own company, Panelvision, had exclusive rights on the patents and we tried to enforce them. The International Trade Commission in Washington said they would block the import of lcd sets into North America if we could prove they infringed the patents. But Panelvision went out of the lcd business and now no-one is enforcing the Westinghouse patent, even though it has several years left to run."

To add some further detail I searched



out the key patent, USP 3 840 695. It was filed by Westinghouse, in October 1972 and granted two years later. Under US law it will remain in force until 1991. It was Westinghouse researcher Albert Fischer who hit on the key idea of coating glass with a thin film matrix of transistors and liquid crystal cells, and covering them with a matching matrix of tiny red, green and blue filters.

Westinghouse claimed in the patent to have solved the problem of providing 750,000 colour cells. But despite spending hundreds of millions of dollars on the project, they never succeeded in making a saleable product for consumer use. PE

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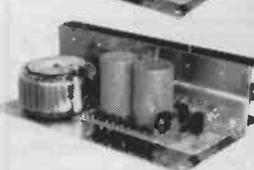
**OMP100 Mk II Bi-Polar** Output power 110 watts R.M.S. into 4 ohms, Frequency Response 15Hz - 30KHz -3dB, T.H.D. 0.01%, S.N.R. -118dB, Sens. for Max output 500mV at 10K, Size 355 x 115 x 65mm. **PRICE £33.99 + £3.00 P&P.**



**OMP/MF100 Mos-Fet** Output power 110 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 80, Slew Rate 45V/uS, T.H.D. Typical 0.002%, Input Sensitivity 500mV, S.N.R. -125dB, Size 300 x 123 x 60mm. **PRICE £39.99 + £3.00 P&P.**



**OMP/MF200 Mos-Fet** Output power 200 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 250, Slew Rate 50V/uS, T.H.D. Typical 0.001%, Input Sensitivity 500mV, S.N.R. -130dB, Size 300 x 150 x 100mm. **PRICE £62.99 + £3.50 P&P.**



**OMP/MF300 Mos-Fet** Output power 300 watts R.M.S. into 4 ohms, Frequency Response 1Hz - 100KHz -3dB, Damping Factor 350, Slew Rate 60V/uS, T.H.D. Typical 0.0008%, Input Sensitivity 500mV, S.N.R. -130dB, Size 330 x 147 x 102mm. **PRICE £79.99 + £4.50 P&P.**

NOTE: Mos-Fets are supplied as standard (100KHz bandwidth & Input Sensitivity 500mV). If required, P.A. version (50KHz bandwidth & Input Sensitivity 775mV). Order - Standard or P.A.



**VU METER** Compatible with our four amplifiers detailed above. A very accurate visual display employing 11 L.F.D. diodes (7 green, 4 red) plus an additional on/off indicator. Sophisticated logic control circuits for very fast rise and decay times. Tough moulded plastic case, with tinted acrylic front. Size 84 x 27 x 45mm. **PRICE £8.50 + 50p P&P.**

**LOUDSPEAKERS 5" to 15" up to 400 WATTS R.M.S.** Cabinet Fixing in stock. Huge selection of McKenzie Loudspeakers available including Cabinet Plans. Large S.A.E. (28p) for free details.



**POWER RANGE**  
 8" 50 WATT R.M.S. Hi-Fi/Disco.  
 20 oz magnet. 1 1/2" ally voice coil. Ground ally fixing escutcheon. Res. Freq. 40Hz. Freq. Resp. to 6KHz. Sens. 92dB. PRICE £10.99 available with black grille £11.99 P&P £1.50 ea.  
 12" 100 WATT R.M.S. Hi-Fi/Disco  
 50 oz magnet. 2" ally voice coil. Ground ally fixing escutcheon. Die-cast chassis. White cone. Res. Freq. 25Hz. Freq. Resp. to 4KHz. Sens. 95dB. PRICE £28.60 + £3.00 P&P ea.

**McKENZIE**  
 12" 85 WATT R.M.S. C1285GP Lead Guitar/Keyboard/Disco.  
 2" ally voice coil. Ally centre dome. Res. Freq. 45Hz. Freq. Resp. to 6-5KHz. Sens. 98dB.  
 PRICE £23.99 + £3.00 P&P ea.  
 12" 85 WATT R.M.S. C1285TC P.A./Disco 2" ally voice coil. Twin cone.  
 Res. Freq. 45Hz. Freq. Resp. to 14KHz. PRICE £31.49 + £3.00 P&P ea.  
 15" 150 WATT R.M.S. C15 Bass Guitar/Disco.  
 3" ally voice coil. Die-cast chassis. Res. Freq. 40Hz. Freq. Resp. to 4KHz. PRICE £57.87 + £4.00 P&P ea.  
 10" 60 WATT R.M.S. 1060GP Gen. Purpose/Lead Guitar/Keyboard/Mid. P.A.  
 2" voice coil. Res. Freq. 75Hz. Freq. Resp. to 7-5KHz. Sens. 99dB. PRICE £19.99 + £2.00 P&P.  
 10" 200 WATT R.M.S. C10200GP Guitar/Keyboard/Disco.  
 2" voice coil. Res. Freq. 45Hz. Freq. Resp. to 7KHz. Sens. 101dB. PRICE £44.76 + £3.00 P&P.  
 15" 200 WATT R.M.S. C15200 High Power Bass.  
 Res. Freq. 40Hz. Freq. Resp. to 5KHz. Sens. 101dB. PRICE £62.41 + £4.00 P&P.  
 15" 400 WATT R.M.S. C15400 High Power Bass.  
 Res. Freq. 40Hz. Freq. Resp. to 4KHz. Sens. 102dB. PRICE £89.52 + £4.00 P&P.

**WEM**  
 5" 70 WATT R.M.S. Multiple Array Disco etc.  
 1" voice coil. Res. Freq. 52Hz. Freq. Resp. to 5KHz. Sens. 89dB. PRICE £22.00 + £1.50 P&P. ea.  
 8" 150 WATT R.M.S. Multiple Array Disco etc.  
 1" voice coil. Res. Freq. 48Hz. Freq. Resp. to 5KHz. Sens. 92dB. PRICE £32.00 + £1.50 P&P. ea.  
 10" 300 WATT R.M.S. Disco/Sound re-enforcement etc.  
 1 1/2" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 92dB. PRICE £36.00 + £2.00 P&P. ea.  
 12" 300 WATT R.M.S. Disco/Sound re-enforcement etc.  
 1 1/2" voice coil. Res. Freq. 35Hz. Freq. Resp. to 4KHz. Sens. 94dB. PRICE £47.00 + £3.00 P&P. ea.

**SOUNDLAB (Full Range Twin Cone)**  
 5" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.  
 1" voice coil. Res. Freq. 63Hz. Freq. Resp. to 20KHz. Sens. 86dB. PRICE £9.99 + £1.00 P&P. ea.  
 6 1/2" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.  
 1" voice coil. Res. Freq. 56Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £10.99 + £1.50 P&P. ea.  
 8" 60 WATT R.M.S. Hi-Fi/Multiple Array Disco etc.  
 1 1/2" voice coil. Res. Freq. 38Hz. Freq. Resp. to 20KHz. Sens. 89dB. PRICE £12.99 + £1.50 P&P. ea.  
 10" 60 WATT R.M.S. Hi-Fi/Disco etc.  
 1 1/2" voice coil. Res. Freq. 35Hz. Freq. Resp. to 15KHz. Sens. 89dB. PRICE £16.49 + £2.00 P&P.

**HOBBY KITS.** Proven designs including glass fibre printed circuit board and high quality components complete with instructions.

**FM MICROTRANSMITTER (BUG)** 90/106MHz with very sensitive microphone. Range 100/300 metres. 57 x 46 x 14mm (9 volt) Price: £8.62 + 75p P&P.  
**3 WATT FM TRANSMITTER** 3 WATT 85/115MHz varicap controlled professional performance. Range up to 3 miles 35 x 84 x 12mm (12 volt) Price: £14.49 + 75p P&P.  
**SINGLE CHANNEL RADIO CONTROLLED TRANSMITTER/RECEIVER** 27MHz. Range up to 500 metres. Double coded modulation. Receiver output operates relay with 2amp/240 volt contacts. Ideal for many applications. Receiver 90 x 70 x 22mm (9/12 volt). Price: £17.82 Transmitter 80 x 50 x 15mm (9/12 volt). Price: £11.29 P&P + 75p each. S.A.E. for complete list.



3 watt FM Transmitter

## BURGALAR ALARM

Better to be 'Alarmed' than terrified. Thandar's famous 'Minder' Burglar Alarm System. Superior microwave principle. Supplied as three units, complete with interconnection cable. **FULLY GUARANTEED.**

**Control Unit** - Houses microwave radar unit, range up to 15 metres adjustable by sensitivity control. Three position, key operated fascia switch - off - test - armed - 30 second exit and entry delay.

**Indoor alarm** - Electronic swept freq siren. 104dB output.  
**Outdoor Alarm** - Electronic swept freq siren. 98dB output. Housed in a tamper-proof heavy duty metal case.

Both the control unit and outdoor alarm contain rechargeable batteries which provide full protection during mains failure. Power requirement 200/260 Volt AC 50/60Hz. Expandable with door sensors, panic buttons etc. Complete with instructions.

**SAVE £138.00** Usual Price £228.85

**BKE'S PRICE £89.99 + £4.00 P&P**

? Why buy a collection of self-assembly boards!

IDEAL for Work-shops, Factories, Offices, Home, etc. Supplied ready built.



## OMP LINNET LOUDSPEAKERS

The very best in quality and value. Made specially to suit today's need for compactness with high sound output levels. Finished in hard wearing black vinyl with protective corners, grille and carry handle. All models 8 ohms. Full range 45Hz - 20KHz. Size 20" x 15" x 12". Watts R.M.S. per cabinet. Sensitivity 1W. 1mtr. dB.

**OMP 12-100 Watts 100dB. Price £149.99**

**OMP 12-200 Watts 102dB. Price £199.99**

Delivery. Securicor £8.00 per pair



## OMP 19" STEREO RACK AMPS



Professional 19" cased Mos-Fet stereo amps. Used the World over in clubs, pubs, discos etc. With twin Vu meters, twin toroidal power supplies, XLR connections. MF600 Fan cooled. **Three models (Ratings R.M.S. into 4ohms). Input Sensitivity 775mV**

**MF200 (100 + 100)W. £169.00**  
**MF400 (200 + 200)W. £228.85**  
**MF600 (300 + 300)W. £322.00**

**Securicor Delivery £10.00**

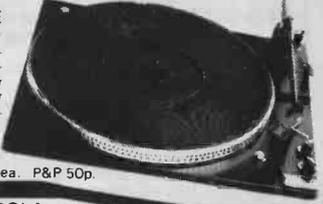
## 1 K-WATT SLIDE DIMMER

- \* Control loads up to 1Kw
- \* Compact Size 4 1/2" x 1" x 2 1/2"
- \* Easy snap-in fixing through panel/cabinet cut out
- \* Insulated plastic case
- \* Full wave control using 8 amp triac
- \* Conforms to BS800

\* Suitable for both resistance and inductive loads. Innumerable applications in industry, the home, and disco's, theatres etc.  
**PRICE £13.99 + 75p P&P**

## BSR P295 ELECTRONIC TURNTABLE

\* Electronic speed control 45 & 33 1/2 r.p.m. \* Plus/Minus variable pitch control \* Belt driven \* Aluminium platter with strobed rim \* Cue lever \* Anti-skate (bias device) \* Adjustable counter balance \* Manual arm \* Standard 1/2" cartridge fixings \* Supplied complete with cut out template \* D.C. Operation 9.14v D.C. 65mA.  
 Price £36.99 - £3.00 P&P.

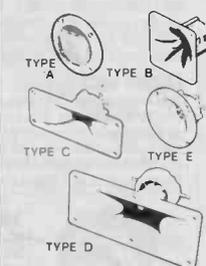


ADC Q4 mag. cartridge for above. Price £4.99 ea. P&P 50p.

## PIEZO ELECTRIC TWEETERS MOTOROLA

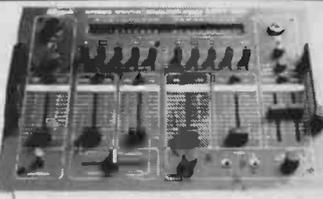
Join the Piezo revolution. The low dynamic mass (no voice coil) of a Piezo tweeter produces an improved transient response with a lower distortion level than ordinary dynamic tweeters. As a crossover is not required these units can be added to existing speaker systems of up to 100 watts (more if 2 put in series). **FREE EXPLANATORY LEAFLETS SUPPLIED WITH EACH TWEETER.**

**TYPE 'A' (KSN2036A)** 3" round with protective wire mesh, ideal for bookshelf and medium sized Hi-Fi speakers. Price £4.90 each + 40p P&P  
**TYPE 'B' (KSN1005A)** 3 1/2" super horn. For general purpose speakers, disco and P.A. systems etc. Price £5.99 each + 40p P&P  
**TYPE 'C' (KSN6016A)** 2" x 5" wide dispersion horn. For quality Hi-Fi systems and quality discos etc. Price £6.99 each + 40p P&P  
**TYPE 'D' (KSN1025A)** 2" x 6" wide dispersion horn. Upper frequency response retained extending down to mid range (2KHz). Suitable for high quality Hi-Fi systems and quality discos. Price £9.99 each + 40p P&P  
**TYPE 'E' (KSN1038A)** 3 3/4" horn tweeter with attractive silver finish trim. Suitable for Hi-Fi monitor systems etc. Price £5.99 each + 40p P&P  
**LEVEL CONTROL** Combines on a recessed mounting plate, level control and cabinet input jack socket. 85 x 85 mm. Price £3.99 + 40p P&P



## STEREO DISCO MIXER

**STEREO DISCO MIXER** with 2 x 5 band L & R graphic equalisers and twin 10 segment L.E.D. Vu Meters. Many outstanding features 5 Inputs with individual faders providing a useful combination of the following:  
 3 Turntables (Mag). 3 Mics. 4 Line plus Mic with talk over switch. Headphone Monitor. Pan Pot. L & R. Master Output controls. Output 775mV. Size 360 x 280 x 90mm.  
 Price £134.99 - £3.00 P&P



**B. K. ELECTRONICS** Dept PE  
 UNIT 5, COMET WAY, SOUTHTEND-ON-SEA,  
 ESSEX, SS2 6TR TEL: 0702-527572

POSTAL CHARGES PER ORDER £1.00 minimum. OFFICIAL ORDERS WELCOME, SCHOOLS, COLLEGES, GOVERNMENT BODIES, ETC. PRICES INCLUSIVE OF V.A.T. SALES COUNTER VISA/ACCESS/C.O.D. ACCEPTED.



### POPULAR BAKERS DOZEN PACKS

(Still available)

All packs are £1 each, if you order 12 then you are entitled to another free. Please state which one you want. Note the figure on the extreme left is the pack ref number and the next figure is the quantity of items in the pack, finally a short description.

- BD2 5 13A spurs provide a fused outlet to a ring main where device such as a clock must not be switched off
- BD7 4 in flex switches with neon on/off lights, saves leaving things switched on
- BD9 2 6v. 1A mains transformers upright mounting with fixed clamps
- BD11 1 6 1/2" speaker cabinet ideal for extensions, takes your speaker. Ref BD137
- BD13 12 30 watt reed switches, it's surprising what you can make with these - burglar alarms, secret switches, relay etc.
- BD22 2 25 watt loud speaker two unit cross-overs
- BD29 1 B.O.A.C. stereo unit is wonderful value
- BD30 2 nicad constant current chargers adapt to charge almost any nicad battery
- BD32 2 humidity switches, as the air becomes damper the membrane switches and operates a microswitch
- BD34 48 2 meter length of connecting wire all colour coded
- BD42 5 13A rocker switch three tag so on/off, or change over with centre off
- BD45 1 24hr time switch, ex-Electricity Board, automatically adjust for lengthening and shortening day. Original cost £40 each
- BD49 10 neon valves, with series resistors, these make good night lights
- BD56 1 mini uniselector, one use is for an electric jigsaw puzzle, we give circuit diagram for this. One pulse into motor, moves switch through one pole
- BD59 2 flat solenoids - you could make your multi-tester read AC amps with this
- BD67 1 suck or blow operated pressure switch, or it can be operated by any low pressure variation such as water level in water tanks
- BD91 2 mains operated motors with gearbox. Final speed 16rpm. 2 watt rated
- BD103A 1 6750MA power supply, nicely cased with input and output leads
- BD120 2 stripper boards each contains a 400v 2A bridge rectifier and 14 other diodes and rectifiers as well as dozens of condensers etc
- BD122 10m twin screened flex with white pvc cover
- BD128 10 very fine drills for p.c.b. boards etc. Normal cost about 80p each
- BD132 2 plastic boxes approx. 3" cube with square hole through top so ideal for interrupted beam switch motors for model aeroplanes, spin to start so needs no switch
- BD134 10 motors for model aeroplanes, spin to start so needs no switch
- BD139 6 microphone inserts - magnetic 400 ohm also act as speakers
- BD148 4 reed relay kits you get 16 reed switches and 4 coil sets with notes on making c.o. relays and other gadgets
- BD149 6 safety cover for 13A sockets - prevent those inquisitive little fingers getting nasty shocks
- BD180 6 neon indicators in panel mounting holders with lens
- BD193 6 5 amp 3 pin flush mounting sockets make a low cost disco panel
- BD196 1 in flex simmerstat - keeps your soldering iron etc always at the ready
- BD199 1 mains solenoid very powerful has 1" pull or could push if modified
- BD210 8 Keyboard switches - made for computers but have many other applications.
- BD210 4 transistors type 2N3055 probably the most useful power transistor
- BD211 1 electric clock mains operated put this in a box and you need never be late
- BD221 5 12v alarms make a noise about as loud as a car horn. Slightly soiled but OK
- BD242 2 6" x 4" speakers 4 ohm made from Radiomobile so very good quality
- BD246 2 tachogenerators, generates one volt per 100 revs
- BD252 1 panostat, controls output of boiling ring from simmer up to boil
- BD259 50 leads with push on 1/4" tags - a must for hook ups - mains connections etc
- BD263 2 oblong push switches for bell or chimes, these can mains up to 5 amps so could be foot switch if fitted into pattress
- BD268 1 mini 1 watt amp for record player. Will also change speed of record player motor
- BD275 1 Guitar mic - clip on type suits most amps
- BD283 3 mild steel boxes approx. 3" x 3" x 1" deep - standard electrical
- BD293 50 mixed silicon diodes
- BD296 3 car plugs with lead, fits into lighter socket
- BD305 1 tubular dynamic mic with optional table rest

Most other packs still available and you can choose any as your free one.

5A BATTERY CHARGER KIT - all parts including case only £5 add £1 postage.

### OVER 400 GIFTS YOU CAN CHOOSE FROM

There is a total of over 400 packs in our Baker's dozen range and you become entitled to a free gift with each dozen packs.

A classified list of these packs and our latest "News Letter" will be enclosed with your goods, and you will automatically receive our next news letter.



### THIS MONTH'S SNIP

**ACORN COMPUTER DATA RECORDER** (ref ALF03) this is a mono data recorder with switchable motor control intended for use with the Acorn Electron or BBC computers but also functions with almost any other computer and can be used for normal record and play back of music and speech.

Six key controls give "PAUSE", "PLAY", "STOP" and "EJECT" "CUE/FAST FORWARD" "REVERSE/REWIND" and "RECORD", fast forward and rewind (100 seconds for C.60). Also tape counter with reset button. Input signal range 5mV to 500mV. Input impedance 40k ohm. Can be battery operated but is supplied with a mains adaptor. Brand new in manufacturer's wrapping. £10 Order Ref: 10P44.

**AN ALLADIN'S CAVE** We have opened another shop in Hove, the address is number 12 Boundary Road which is between Hove and Portslade fairly close to the seafront. When you want to see before you buy and when you want to browse around the special bargains available, this is where you should make for as the Portland Road shop in future will be just mail order. You can of course collect from Portland Road but you should bring in an order complete with reference numbers so that the stores can attend to it easily.

### 9" MONITOR

Ideal to work with computer or video camera uses Philips black and white tube ref M24/306W. Which tube has implosion and X-Ray radiation protected. VDU is brand new and has a time base and EHT circuitry. Requires only a 16V dc supply to set it going. It's made up in a lacquered metal framework but has open sides so should be cased. The VDU comes complete with circuit diagram and has been line tested and has our six months guarantee. Offered at a lot less than some firms are asking for the tube alone. only £16 plus £5 post.

**CASE FOR 9" MONITOR** We have arranged with a metal worker to make cases for the 9" Monitor. Delivery promised for the end of May and the price £12 + £2 post. The case will be made from coated sheet steel, overall size approx. 10" x 10" x 7" high which will give ample space for the Power Supply and external controls if you fit them.

**PROBLEM SOLVED!** We have obtained from the manufacturers of the 9" monitor, the TTL converter which makes it composite input suitable to work with any computer. We have had the printed circuit board made and have all the components and can supply this converter in kit form price £6. Our Ref: 6P4.

**CHINNON 3 1/2" F.D.D.** 80 track 500K. Beautifully made and probably the most compact device of its kind as it weighs only 600g and measures only 140mm wide, 162mm deep and has a height of only 32mm, other features are high precision head positioning - single pluck loading and eject - direct drive brushless motor - Shugart compatible interface - standard connections - interchangeable with most other 3 1/2" and 5 1/4" drives. Brand new with copy of makers manual. at £28.50 plus VAT included.

**CASE** - adaptable for 3 1/2" FDD, has room for power supply components price only £4 includes circuit of PSU. Our Ref 4P8.

**POWER SUPPLY FOR FDD** - 5V and 12V voltage regulated outputs, complete kit of parts will fit into case 4P8 price £8 or with case £11.

**DOUBLE MICRO DRIVES** as fitted to many ICL and some Sinclair computers complete double units with 2 drive motors tape heads, and 2 PCBs each with plug in ULA. Ref. 2G007ES. Price only £5. Ref. 5P113

**SWITCH AC LOADS WITH YOUR COMPUTER** this is easy and reliable if you use our solid state relay. This has no moving parts, has high input resistance and acts as a noise barrier and provides 4KW isolation between logic terminals. The turn on voltage is not critical anything between 3 & 30v internal resistance is about 1k ohm. AC loads up to 10A can be switched. Price is £2 each Ref: 2P183.

### 3 INCH FDD

Hitachi HFD 305 5XA. Recommended for Amstrad 6128 etc. as standard shugart interface suitable for practically all computers. £30 + £3 post.

### MINI MONO AMP

on p.c.b. size 4" x 2" (lapp.) Fitted volume control and a hole for a tone control should you require it. The amplifier has three transistors and we estimate the output to be 3W rms. More technical data will be included with the amp. Brand new, perfect condition, offered at the very low price of £1.15 each, or £13 for £12.00



### LIGHT BOX

This when completed measures approximately 15" x 14". The light source is the Philips fluorescent 'W' tube. Above the light a sheet of fibreglass and through this should be sufficient light to enable you to follow the circuit on fibreglass PCBs. Price for the complete kit, that is the box, choke, starter, tube and switch, and fibreglass is £5 plus £2 post, order ref 5P69.



### VENNER TIME SWITCH

Mains operated with 20 amp switch, one on and off per 24hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only £2.95 without case, metal case - £2.95, adaptor kit to convert this into a normal 24hr. time switch but with the added advantage of up to 12 on/off per 24hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is £3.20.

### POWERFUL IONISER

Generates approx. 10 times more IONS than the ETI and similar circuits. Will refresh your home, office, shop, work room etc. Makes you feel better and work harder - a complete mains operated kit, case included. £11.50 + £3 P&P.

## J & N BULL ELECTRICAL

Dept. P.E., 250 PORTLAND ROAD, HOVE, BRIGHTON, SUSSEX BN3 5QT

MAIL ORDER TERMS: Cash, P.O. or cheque with order. Orders under £20 add £1.50 service charge. Monthly account orders accepted from schools and public companies. Access & B/card orders accepted. Brighton (0273) 734648 or 203500.

### NEW ITEMS

Some of the many described in our current list which you will receive with your parcel.

13A PLUGS good make complete with fuse, parcel of 5 for £2. order Ref. 2P186.

13A ADAPTORS Takes 2 13A plugs, good British make, packet of 3 for £2. order Ref. 2P187.

8" GREEN SCREEN MONITOR Complete, cased and ready to work. Composite input so just right to use with Acorn or other computers or camera. Requires only 15 volt D.C. Has been used for a short period but we have tested and give six months guarantee. Price £17.50 plus £3 post etc.

Some of the many described in our current list which you will receive with your parcel.

Powerful 12 Volt Motor was meant for Sinclair C5 rated at approx. 1/2HP. Ideal to power Go-Kart, loco etc. £15 +£2 post. Order Ref. 15PB. GPO Test Meter 12C1 in real leather carrying case 20000 opv 19 ranges all the usual ones and one extra useful low ohms range, also has provision for shunts to read up to 10 amp current. Details for shunts are given. Price £7.00 Ref. 7P5.

MAINS TO 15VOLT SWITCH MODE POWER SUPPLY with multiple outlets intended to power up to 6x8" Green Screen Monitors. Slightly used but tested and guaranteed working. £20 each plus £2 post. FREE POWER! Can be yours if you use our solar cells - sturdily made modules with new system bubble magnifiers to concentrate the light and so eliminate the need for actual sunshine - they work just as well in bright light. Voltage output is 45 - you join in series to get desired voltage - and in parallel for more amps. Module A gives 100mA Price £1 Our Ref: BD661 Module C gives 400mA Price £2 Our Ref: 2P199 Module D gives 700mA Price £3 Our Ref: 3P42.

SOLAR POWERED NI-CAD CHARGER 4 Ni-Cad batteries AA (HP7) charged in eight hours or two in only 4 hours. It is a complete, boxed ready to use unit. Price £6 Our Ref: 6P3.

50v 20a TRANSFORMER 'C' Core construction so quite easy to adapt for other outputs - tapped mains input. Only £25 but very heavy so please add £5 if not collecting. Order Ref: 25P4.

15A PANEL METER These have been stripped from Government's surplus battery charger units made originally for army use. Unused, tested but of course rather old, diameter 2" can be surface or flush mounted. £3 each Our Ref: 3P40.

METAL PROJECT BOX Ideal size for battery charger, power supply etc; sprayed grey, size 8" x 4 1/4" x 4" high, ends are lowered for ventilation other sides are flat and undrilled. Order Ref: 2P191 Price £2.

20v 0-20v Mains transformers 2 1/2amp (100 watt) loading, tapped primary, 200-245 upright mountings £4. Order Ref: 4P24 add £1 post.

MOST USEFUL CASE constructed entirely from heavy gauge aluminium size approx. 7 1/2" wide 5 1/4" high and 16" long. But its construction is such that it is a very simple job to reduce the length to your own requirements. The long top and both sides are flat and completely free from holes. One end has mains input socket - fuse switch - the other end has output plug - in brand new condition. Price £10 plus £3 postage. Ref 10O35.

12V DC FAN made by the famous PAPST company, these are brushless so are ideal for cooling computers without causing any electrical interference, size approximately 3 1/2 x 3 1/2 x 1 1/2, all brand new. Price £10, our ref: 10P33.

AXIAL FANS very quiet running and purpose designed for cooling instruments etc made by the famous German PAPST company - these are 4 1/2" square approx. 230v mains operated and metal bladed so O.K. in sunbeds and other hot spots - price £8 each. Our Ref: 8P8.

BENCH ISOLATION TRANSFORMER 250 watt again available 230v in and out with plenty of tappings to give exact volts £5, plus £2. Order Ref. 5P5.

3 CORE FLEX BARGAIN No. 1 Core size 5mm so ideal for long extension leads carrying up to 5 amps or short leads up to 10 amps. 15mm for £2. order Ref. 2P189

3 CORE FLEX BARGAIN No. 2 Core size 1.25mm so suitable for long extension leads carrying up to 13 amps - or short leads up to 25A, 10m for £2. order Ref. 2P190

ASTEC P.S.U. Switch mode type so very compact. Normal 230V input. Has 3 outputs - +5V at 3.5 amps, +12V at 1.5 amps and -5V at 0.3 amps. Should be ideal to drive floppy disc units. Regular price around £30, our price only £10 although brand new and unused. Order our ref 10P34.

24 HOUR TIMESWITCH 16A C/O contacts, up to 6 on-offs per day. Nicely cased for wall-mounting. Price £8.00. Ref. 8P6.

CAPACITOR BARGAIN Axial ended 4700 uF at 25V. Superior Jap make, normally 50p each, you get 4 for £1.00 Ref. 613.

MINIATURE BCD THUMB WHEEL SWITCH - Matt black edge switch engraved white on black - gold plated, make before break contacts - size approx. 25mm high 8mm wide 20mm deep - made by the famous Cherry Company and designed for easy stacking - Price £1 each. Ref. BD601.

PIEZO ELECTRIC FAN an unusual fan, more like the one used by Madame Butterfly, than the conventional type, it does not rotate. The air movement is caused by two vibrating arms. It is American made, mains operated, very economical and causes no interference. So it is ideal for computer and instrument cooling. Price is only £1 each. Ref. BD605.

SPRING LOADED TEST PRODS - heavy duty, made by the famous Bulgin company. Very good quality. Price four for £1. Ref. BD597.

TELEPHONE BELLS - these will work off our standard mains through a transformer, but to sound exactly like a telephone, they then must be fed with 25 Hz 50v. So with these bells we give a circuit for a suitable power supply. Price 2 bells for £1. Ref. BD600.

CASE WITH 13A PRONGS - to go into 13A socket, nice size and suitable for plenty of projects such as car battery trickle charger, speed controller, time switch, night light, noise suppressor, dimmers etc. Price - 2 for £1. Ref. BD565.

ALPHA-NUMERIC KEYBOARD - this keyboard has 73 keys arranged in two groups, the main area is a QWERTY array and on the right is a 15 key number pad, board size is approx. 13" x 4" - brand new but offered at only a fraction of its cost namely £3 plus £1 post. Ref: 3P27.

TELEPHONE EXTENSIONS - it is now legal for you to undertake the wiring of telephone extensions. For this we can supply 4 core telephone cable, 100m coil £8.50. Extension BT sockets £2.95. Packet of 50 plastic headed staples £2. Dual adaptor for taking two appliances from one socket £3.95. Leads with B.T. plug for changing old phones. 3 for £2.

WIRE BARGAIN - 500 metres 0.7mm solid copper tinned and p.v.c. covered. Only £3 + £1 post. Ref. 3P31 - that's well under 1p per metre, and this wire is ideal for push on connections.

INTERRUPTED BEAM KIT - this kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken. Main components - relay, photo transistor, resistors and caps etc. Circuit diagram but no case. Price £2. Ref. 2P15.

3-30V VARIABLE VOLTAGE POWER SUPPLY UNIT - with 1 amp DC output. Intended for use on the bench for experimenters, students, inventors, service engineers etc. This is probably the most important piece of equipment you can own. (After a multi range test meter). It gives a variable output from 3-30 volts and has an automatic short circuit and overload protection, which operates at 1.1 amp approximately. Other features are very low ripple output, a typical ripple is 3mV pk-pk, 1mV rms. Mounted in a metal fronted plastic case, this has a voltmeter on the front panel in addition to the output control knob and the output terminals. Price for complete kit with full instructions is £15. Ref. 15P7.

TRANSMITTER SURVEILLANCE (BUG) - tiny, easily hidden, but which will enable conversation to be picked up with FM radio. Can be housed in a matchbox, all electronic parts and circuit. Price £2. Ref. 2P52.



# PROXIMITY DETECTION

BY THE PROF

## GREET YOUR INTRUDERS WITH A WAVE

*Emissary emanations of ethereal electromagnetism emit information about uninvited interlopers — usually in the form of a loud audible alarm. Select from rf, radar, ultrasonic or infra-red for starters.*

A great many applications require that the presence of something, or more usually someone, must be detected. Typical applications are burglar alarms, automatic lighting, and automatic cutouts that operate if (say) someone gets too close to a dangerous piece of machinery while it is operating. Circuits of this type come under the general heading of “proximity detectors”, or “presence detectors” as they are alternatively known these days. There must be almost countless ways of detecting the presence of someone by electronic means, but some of these are rather out-of-date now, or at the other extreme require advanced electronics that takes them beyond the scope of most amateur electronics enthusiasts. This still leaves a substantial number of systems that are of interest to the electronics hobbyist, and in this article we will consider three of these.

### GOING TO GROUND

One of the earliest systems of proximity detection (possibly the earliest) is the type which uses an arrangement of the type shown in the block diagram of Fig.1. Although this is not exactly the most modern approach, it still represents one of the more interesting methods.

The l-c oscillator is at the heart of the unit, and this must have a feedback control that permits very accurate control of the positive feedback level. The degree of feedback used must be such that the circuit is only just able to sustain oscillation. One end of the l-c tuned circuit must be connected to earth (or “ground” if you prefer the Americanism). By this I do not just mean that it must be connected to the earth rail of the detector circuit — it must be literally connected to earth. If the unit is mains powered then the mains earth connection should suffice. If not, then a short wave radio style earth connection with a rod or pipe buried in the ground is needed. Failing this, a “dummy” earth might suffice, as described later in this article. The sensing element is an antenna connected to the non-earth end of the tuned circuit. This can be a length of wire, but in my

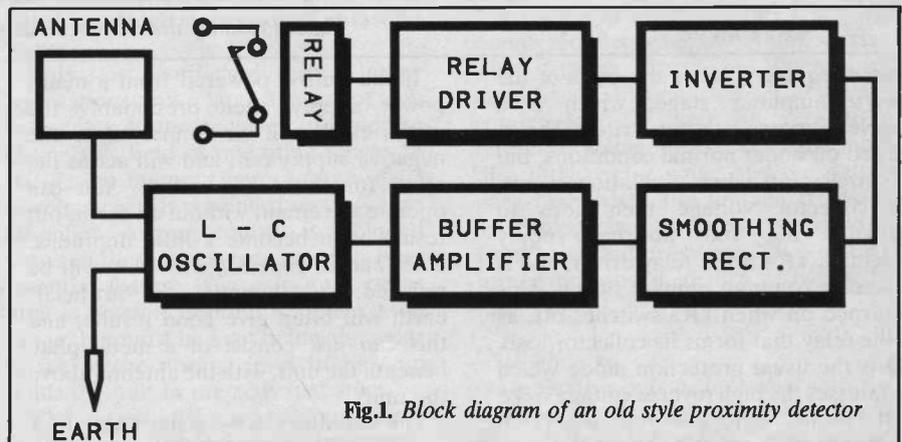


Fig.1. Block diagram of an old style proximity detector

experience a metal plate seems to offer far better sensitivity.

This setup may not seem to offer any obvious means of presence detection other than a bit of esp, but it will in fact work quite well, albeit with rather limited operating range. I suppose that there is more than one way of looking at what happens when someone comes close to the antenna, but the generally accepted explanation is that someone close to or actually touching the antenna increases the capacitance from the antenna to earth. This happens due to your body either being earthed, or acting rather like a mini-earth. The effect on the circuit is to slightly damp the tuned circuit so that the level of feedback is no longer able to sustain oscillation. The rest of the circuit must change this lack of oscillation into a switching action that will drive a relay.

The output of the oscillator first feeds into a buffer amplifier. It seems to be very important to have a low level of loading on the oscillator if a reasonable degree of sensitivity is to be obtained. The output from the buffer amplifier drives a rectifier and smoothing circuit, and this normally provides a strong positive dc output signal. However, when oscillation ceases, the output from this circuit quickly drops to zero volts.

Next an inverter/amplifier stage is used to give an output signal that is normally low, but which goes high when the unit is activated. This stage operates the relay via a simple driver stage, and a pair of relay contacts control the load.

Normally open contacts are used if the load must be switched on when the unit is activated — normally closed contacts are required if the load must be disabled when the unit is activated.

### DETECTOR CIRCUIT

Fig.2 shows the circuit diagram for a proximity detector of this type. As will be apparent from Fig.2, this form of detector can be remarkably simple, and requires no particularly expensive components.

The oscillator has L1 plus the series capacitance of C3 and C4 as the tuned circuit, with the two capacitors providing a centre-tap on the tuned circuit. TR1 operates in the emitter follower mode, and the tuned circuit is coupled to its input by C2. The output of the amplifier is coupled to the centre-tap by C5. An emitter follower only has about unity voltage gain, and generally has a voltage gain of slightly less than unity. However, there is a small voltage step-up through the tuned circuit, and an emitter follower provides plenty of current gain. This enables the circuit to oscillate quite strongly, but VR1 acts as a variable attenuator at the output of the amplifier. In practice this is backed-off to the point where oscillation is only just sustained.

TR2 is the buffer stage, and is another emitter follower. C6 couples the output of TR2 to a standard rectifier and smoothing circuit based on D1 and D2. The oscillator operates at a frequency of a few hundred kilohertz and the relatively low values for C6 and C7 are more

# PROXIMITY DETECTION

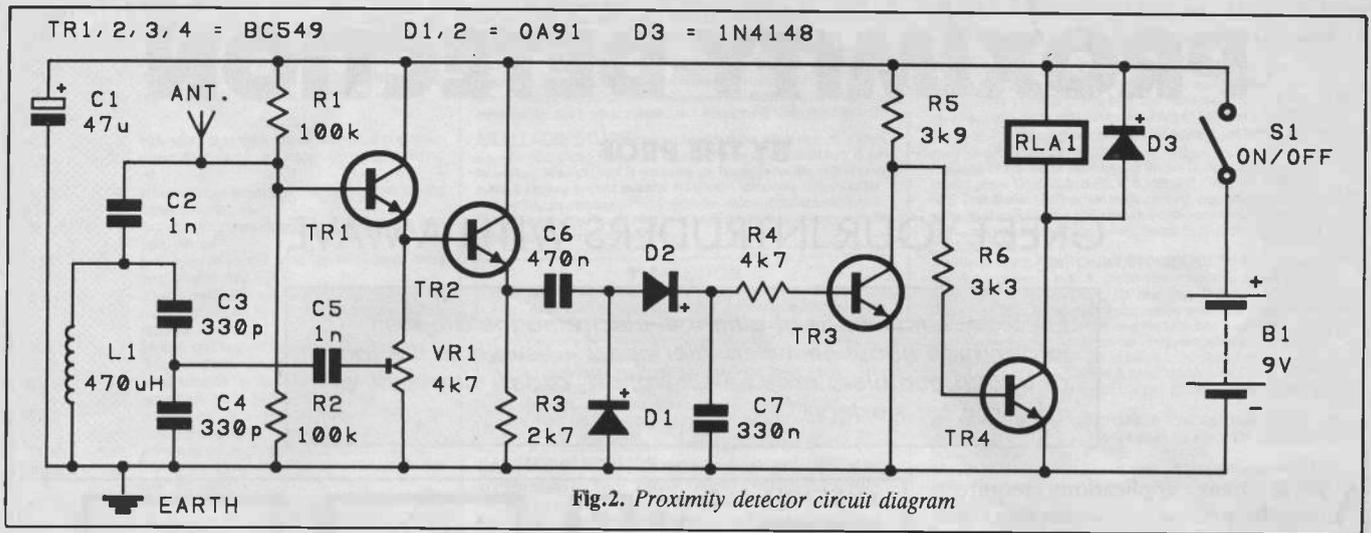


Fig.2. Proximity detector circuit diagram

than adequate. TR3 is the basis of the inverter/amplifier stage, which is a simple common emitter switch. This is turned on under normal conditions, but it switches off when oscillation ceases. Its collector voltage then goes to virtually the full positive supply potential. TR4 is the relay driver, and is a second common emitter switch. This is turned on when TR3 switches off, as D3 is the usual protection diode which suppresses the high reverse voltage spike that would otherwise be generated across the relay coil as it was deactivated.

## PRACTICAL RESULTS

Although L2 has been specified as having a value of 470 $\mu$ H, any value from about 220 $\mu$ H to 2.2mH seems to give good results. This inductor does not need to be a high Q type, and any rf choke within the specified range should work perfectly well. VR1 needs to be adjusted very accurately if the unit is to achieve good results, and the use of a multi-turn trimpot here is virtually mandatory. An ordinary preset potentiometer might not have sufficient resolution to give satisfactory performance. The relay can be any type which can operate on a 6 volt supply, has a coil resistance of about 200 ohms or more, and which has suitable contacts for your intended application. I used an open construction printed circuit mounting type having a coil resistance of 410 ohms.

I operated the circuit from a 9 volt battery, but anyone using the circuit in earnest would be well advised to use a good quality stabilised mains power supply unit. Any significant variations in the supply voltage are likely to either render the unit insensitive or to produce false alarms. The current consumption under stand-by conditions is only about 5 milliamps or so, but this increases by around 30 milliamps when the relay is activated. The exact increase depends on the coil resistance of the relay, and a high coil resistance is advantageous in keeping down the current drain.

If the unit is powered from a mains power supply, then presumably the mains earth will be connected to the negative supply rail, and will act as the earth for the tuned circuit. You can operate the circuit without an earth, but results then become a little unpredictable, and in general, sensitivity will be reduced. A "dummy" or "artificial" earth will often give good results, and this can just consist of a metal plate beneath the unit, with the antenna above the unit.

The antenna can be a short length of wire, but even with VR1 very carefully adjusted, it is then unlikely that a range of more than a few millimetres will be obtained. Much better results are obtained using a metal plate, such as a sheet of aluminium or a sheet of copper laminate board (as used for printed circuit boards). A plate about 300 by 150 millimetres or larger should give good results. Of course, the antenna must be well insulated from earth if good sensitivity is to be achieved.

Adjusting VR1 is a matter of starting with it set for maximum feedback, and then slowly backing it off until the relay switches on. Then advance VR1 just far enough to cause the relay to switch off again.

This type of proximity detector is strictly a short range device. The best range I could obtain was about 400 millimetres or so. Even this sort of range requires a fairly large antenna plate and careful adjustment of VR1. Obviously some applications do not require very much in the way of operating range. This type of detector could, for instance, be used to detect someone on the other side of a door or window, attempting forced entry. Whereas most systems detect an intruder after entry has been achieved, or during the course of entry, this type of sensor can potentially detect someone as soon as they arrive on the scene. The circuit seems to be perfectly capable of operating through a door or window, incidentally. This type of proximity detector certainly represents an interesting line of investigation for the elec-

tronics experimenter, and the cost is extremely low.

## ON REFLECTION

Ultrasonics are much used in presence detector type burglar alarms, and these mostly operate on the Doppler shift principle. There are other ways of using ultrasonics for proximity detection, such as broken beam and "radar" style detectors. The latter represents an interesting approach for short and medium range applications. Although it generally offers lower range than a Doppler shift type detector, it has one or two potential advantages for certain applications.

Probably the biggest drawback of an ultrasonic Doppler shift detector is that it is in many ways too sensitive. What is actually detected is not the presence or otherwise of an object, but movement of an object. These alarms seem well able to detect quite small objects, including such things as moths and other insects which may fly into their area of coverage! A radar type detector operates by detecting waves that are reflected back to the receiver, and small objects will simply not reflect back enough signal to be detected, especially at longer ranges. This potentially offers much better reliability at the cost of reduced range and area of coverage.

Where an ultrasonic radar type detector offers the biggest advantage over a Doppler shift type is probably for outdoors use. Anyone who has tried to use a Doppler shift type detector outdoors will be only too familiar with the problems that arise. Problems with insects etc causing false alarms are that much greater, and there are additional problems with the wind causing turbulence that generates false alarms. Even hail, rain, and snow can trigger a Doppler shift detector, as can something like leaves blowing around in the system's field of "view". While a "radar" type detector is not totally immune to these problems, they generally seem to be somewhat less troublesome.

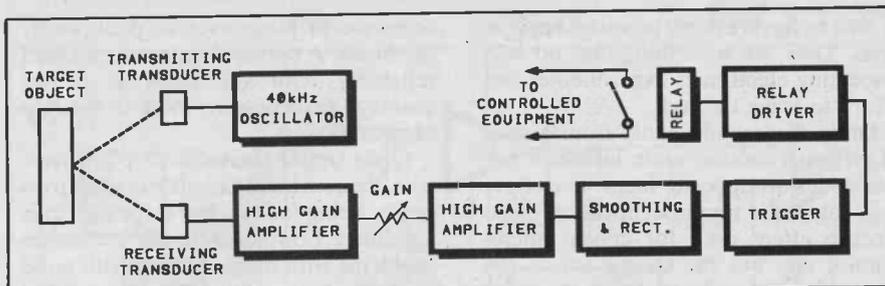


Fig.3. Block diagram for a "radar" style ultrasonic detector

A "radar" type system probably works best out of doors where there will normally be a lack of objects to reflect back the ultrasonic sound waves under stand-by conditions. Indoors there will often be a number of objects to produce reflections (such as items of furniture), as well as walls, the ceiling, etc. It is not that a unit of this type will not operate at all indoors, it is more a case of the range often being rather limited. The sensitivity of the system must be kept down to a level that prevents it from being held in the activated state.

Nothing very complex is required for an ultrasonic radar type detector, and the block diagram of Fig.3 shows the basic requirements. A 40kHz oscillator drives the transmitting transducer, which is a standard 40kHz piezo ceramic type, as used in ultrasonic remote control systems. This gives a continuous ultrasonic tone from the transmitter, and if a suitable target object is present, a significant amount of this signal will be reflected back to the receiving transducer. This is again a standard 40kHz ultrasonic transducer of the type intended for remote control applications.

Ultrasonic remote control systems will normally operate at a range of 12 to 15 metres, but such a long range is not practical in this application. The salient point is that in a remote control system the signal only has to go from point A to point B, whereas in a system of this type it also has to make the trip back to point A again. Even with the signal being reflected with 100% efficiency this gives a halving of the range, and in practice a substantial proportion of the signal is

likely to be absorbed by the target object. The maximum range is likely to be no more than about four or five metres with co-operative target objects, and much less for small objects or those which have high absorption of ultrasonic waves.

This is sufficient for many applications, but a large amount of gain is needed at the receiver in order to obtain this kind of operating range. In the design featured here around 90dB of voltage gain is provided by a two-stage amplifier. A gain control is included between these two stages, and this is an essential feature. The gain must be as high as possible in order to obtain good range, but must be kept below the point at which the normal level of pick up holds the unit in the activated state.

The output of the second amplifier is fed to a rectifier and smoothing circuit. The positive dc signal this produces is fed to a trigger circuit that provides a high output level if the voltage from the smoothing circuit is above a certain threshold level. The output of the trigger circuit operates a relay via a simple relay driver circuit.

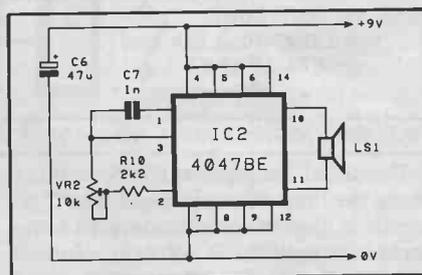


Fig.4. Ultrasonic transmitter circuit

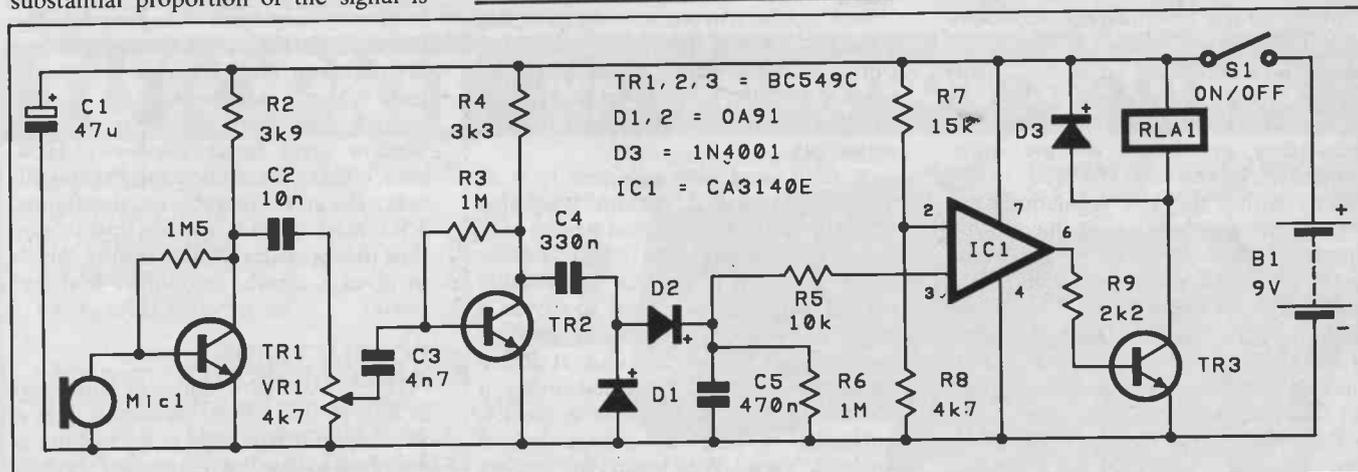


Fig.5. The ultrasonic receiver circuit

## CIRCUITS

The transmitter and receiver circuits are shown in Figs.4 and 5 respectively. The transmitter is basically just a CMOS 4047BE astable/monostable which is used here in the free running astable mode. Its Q and not-Q outputs drive the transducer (LS1) with anti-phase signals, giving a large peak to peak output voltage. VR2 enables the output frequency to be trimmed to the one at which the two transducers give optimum efficiency.

Two common emitter amplifiers are used at the input of the receiver, with volume control style gain control VR1 being used between these two stages. The output of TR2 feeds into a conventional rectifier and smoothing circuit. The trigger circuit is operational amplifier IC1 connected as a voltage comparator. R7 and R8 provide a reference voltage to the inverting input of a little over 2 volts, and the output goes high when the voltage from the smoothing circuit exceeds this voltage. Common emitter switch TR3 is then turned on, and it in turn activates the relay.

## IN USE

Due care needs to be taken with the component layout of this project due to its high level of voltage gain at the receiver and its quite large bandwidth. Also, the input and output of the amplifier are in-phase. The layout must be designed to ensure that there is no obvious path for stray feedback from the input to the output of the amplifier. Consult the retailer's literature to ascertain whether the transmitting and receiving transducers are identical, or there are different components for each circuit. If there are separate receiving and transmitting transducers, make sure you use them the right way round (not that I have ever found an error here to have much effect on performance!). If the receiving transducer has one of its terminals connected to its metal case, make sure that this is the terminal which connects to the negative supply rail so

# PROXIMITY DETECTION

that stray pick up in the input wiring is minimised.

Direct pick up of the transmitted signal is nothing like as troublesome as you might expect. This is due to the highly directional nature of ultrasonic sound waves. Reasonably low direct pick up should be obtained provided the two transducers are not mounted very close together. I found that about 75 to 100 millimetres of separation was quite adequate.

VR2 must be adjusted for good efficiency from the system, and measuring the voltage across C5 is a simple but effective way of obtaining a relative indication of the received signal strength. It is then just a matter of adjusting VR2 for maximum voltage, with VR1 being adjusted to keep voltage readings within reasonable bounds (between about 0.5 and 3 volts should be satisfactory).

Obviously the unit must be sited where it is "looking" into a reasonably open area. With the unit mounted a metre or more from the floor and aimed into a totally vacant area, an average size person can normally be detected at a range of a few metres. With a lot of objects giving reflections under quiescent conditions the unit will probably give much less impressive results. For optimum results VR1 should be advanced as far as possible without the unit being activated. Keep well out of the unit's field of "view" when making this adjustment. The angle of "view" obtained with most ultrasonic transducers is quite narrow, and the unit will almost certainly only offer good range almost directly in front of the transducers.

Anyone wishing to experiment with more sophisticated ultrasonic detectors should consult the issues of PE dated February and March 1987. These dealt with circuits that provide ranging and not just presence detection, using a technique which is basically the same as a bat's "radar".

## HOT STUFF

Most up-market presence detectors seem to rely on microwave radar devices or passive infra-red detectors. The former offer an interesting line of experiment, but the transmitter/receiver units they are based on are quite expensive (about £40.00) and to be strictly within the UK regulations the system as a whole must have type approval. The system of approval seems to operate in a similar manner to the old metal detector licenses, but as yet I do not have definitive information on what is involved in obtaining type approval. This is a subject to which we might return at a latter date.

Passive infra-red detectors are much cheaper, and are free of any licensing requirements. They are very interesting devices for experimentation purposes,

as well as having many practical applications. They are something that no self-respecting electronics experimenter can afford to leave untried!

These devices are made from a slice of a special ceramic material which has electrodes on opposite faces. The effect they rely on is reminiscent of the piezo electric effect used for crystal microphones etc, but the charge across the electrodes is produced by heat rather than twisting of the material. The slice of ceramic material is made very thin in order to give a reasonably fast response time, but we are still only talking in terms of an upper -6dB point at something in the region of 3Hz! The output impedance is very high, and practical devices normally come complete with a built-in source follower buffer stage. The input bias resistor of this amplifier leaks away the charges generated on the sensing element, and this limits the low frequency response (typically to a -6dB point at about 0.2Hz). Due to their very restricted bandwidth these "pyro" sensors can not reliably detect a static infra-red source, and must be used in some form of movement detector.

someone to jump over or duck under the beam. A curtain lens gives excellent reliability with full floor to ceiling coverage (except quite close to the lens of course).

Quite simple electronics are involved, with the low level output from the pyro sensor being fed to a two stage high gain amplifier. Lowpass filtering minimises problems with noise, but it is still noise from the pyro sensor that imposes the upper limit on performance. Some sensors use twin elements connected in anti-phase so that any background noise they pick up tends to be cancelled out. In contrast, as the infra-red signal is swept across the sensing elements it gives a signal of first one polarity and then the other, resulting in a doubling of the peak to peak output voltage.

The output from the amplifier is fed to a window discriminator. Normally the output voltage of the amplifier will stay within the 'window', but when triggered it will stray outside the normal limits. This sends the output of the window discriminator high, and activates the relay via a simple driver stage.

A practical circuit using a pyro sensor is provided in Fig.7. R1 is the load

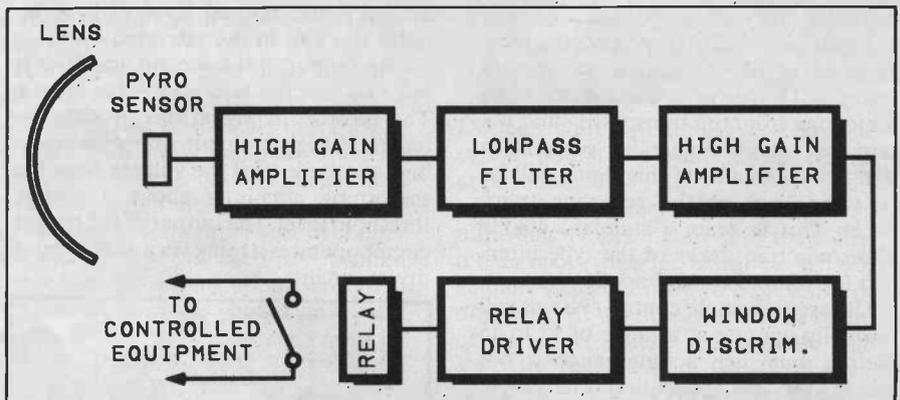


Fig.6. Basic passive infra-red detector block diagram

The usual arrangement is something along the lines shown in Fig.6. The pyro sensor is used in conjunction with some form of lens, which is normally a fresnel type that divides the monitored area into alternate zones of high sensitivity and "blind" spots. Anyone moving from one zone to another produces a varying output from the sensor and activates the unit. Alternatively, a convex lens can be used to give a narrow corridor of high sensitivity.

A third, and very effective type of lens, is the so-called "curtain" type. This is a form of fresnel lens, but it gives only two closely spaced zones of high sensitivity. It gives an effect like an invisible curtain which can be used to divide a room in two. Anyone crossing through the "curtain" triggers the unit. It differs from the response obtained using a convex lens in that it has a narrow horizontal coverage but a large vertical angle of "view". With beam type sensors you have to use several vertically stacked beams in order to make it impossible for

resistor for the source follower in pyro sensor IC1. IC2 and IC3 form what is virtually a high gain, two stage, audio amplifier circuit, but the capacitor values have been made high in value so as to give a suitably extended low frequency response. C5 provides the lowpass filtering. IC4 is the window discriminator, and VR1 is used to "open" and "close" the window. A narrow window gives high sensitivity, a wider window gives lower sensitivity. However, making the window too narrow will make the unit vulnerable to false alarms. VR1 must provide the narrowest window that provides reliable results, which involves a certain amount of trial and error.

## DOUBLE VISION

The SBA02 pyro sensor is contained in a three lead TO-99 style case. It is a twin element type, and in normal use is mounted so that the rectangular window is horizontal. I would strongly recommend the use of lenses specially designed

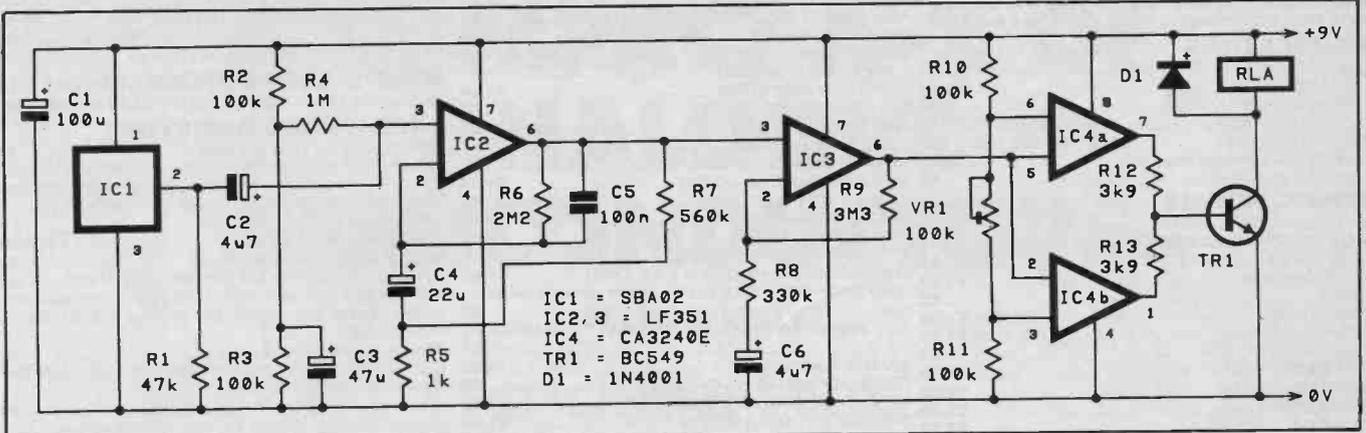


Fig.7. Passive infra-red detector unit

for this type of application as normal lenses seem to be completely useless. We are dealing with very long wavelengths of about 7 to 12 microns, and at these wavelengths ordinary lenses either seem to be opaque or simply let the infra-red pass through without any significant refraction! Two inexpensive fresnel lenses for use with pyro sensors are available, and these are the CE24 and CE26. The former gives a wide angle of coverage while the latter is a curtain type lens. A range of up to about 10 metres can be achieved with the CE24, but the CE26 should give at least three times the range. It has 100 degree field of coverage, but horizontally its two lobes of sensitivity are just 2 degrees wide and separated by two degrees. In an application where this type of response is appropriate it offers an amazing level of performance.

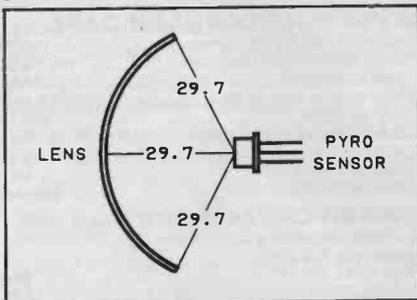


Fig.8. Required lens curvature

These lenses are supplied as what are virtually flat pieces of plastic, and their mountings provide them with the correct curvature (see Fig.8). This requires a little ingenuity, but is not too difficult. A slight lack of accuracy only seems to marginally reduce performance. Ideally the lens mounting should be airtight. Passive infra-red sensors are reasonably free from problems with spurious triggering, but turbulence close to the pyro sensor can cause difficulties. An important point to note is that the CE24 is used horizontally, but the CE26 must be mounted vertically (or "landscape" and "portrait" formats as photographers would have it).

Passive infra-red detectors offer excellent performance, but remember that, unlike the other detectors described in this article, they are movement detectors. They are only sensitive to someone moving across their field of "view". Also, they are heat detectors, and will not detect an object that does not radiate a reasonable amount of heat. This is often an advantage, as it makes them pretty well moth-proof, etc.

The SBA02 pyro sensor, CE24 and CE26 lenses, plus white window material are available from Chartland Electronics Ltd., Twinoaks, Cobham, Surrey, KT11 2QW (Tel. 037284 2553).

## CLOSE ENCOUNTERS

An acquaintance of mine has a burglar alarm that is activated by magnetic switches at strategic points and for a long time it gave him much peace of mind.

Until, that is, he was adopted by a cat. Being a kind hearted fellow he hated keeping Felix out in the cold while he was at work. Instead, he installed a cat door. It has a magnetically operated catch that only responds to a suitable collar around the cat's neck. It's meant to prevent hordes of marauding cats from around the neighbourhood enjoying his hospitality.

Well, this cat, inquisitive as the rest of its race, delighted in investigating around the house, particularly the human entry points it was also accustomed to use. The alarm contact on one of these doors was less precisely adjusted than it should have been, and yes, you've probably guessed it, moggy's magnet collar kept triggering it while Owner was out. It took Owner a long time, though, to realise the cause of the problem!

My window cleaner tells me that he has to be careful when passing parked cars with his metal ladders — it's embarrassing, he says, to explain to irate owners that their car's proximity alarms have not been maliciously set off.

Ed.

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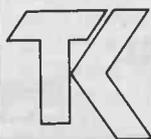
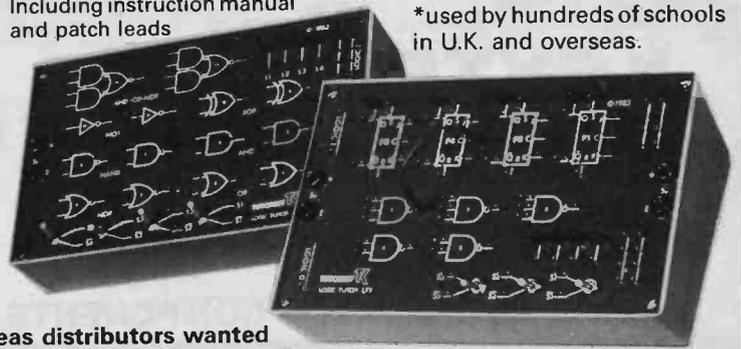
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STC 47WB05T ..... 2/£1  
OMRON RELAY 3.6 volt coil 2p c/o contacts marked G4D-287P-  
BT2 ..... 2/£1

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1N5401 3A 100V ..... 10/£1  
BA158 1A 400V fast recovery ..... 100/£3  
BA159 1A 1000V fast recovery ..... 100/£4  
120V 35A STUD ..... 65p  
BY127 1200V 1.2A ..... 10/£1  
BY254 800V 3A ..... 8/£1  
BY255 1300V 3A ..... 6/£1

6A 100V SIMILAR MR751 ..... 4/£1  
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R47 R62 1R0 1R5 1R8 3R3 6R8 9R1 12R 20R 24R 27R 33R  
51R 56R 62R 68R 100R 120R 180R 220R 270R 390R 560R  
620R 910R 1K0 1K2 1K5 1K8 2K2 2K7 3K3 3K9 4K7 8K2 10k  
15K 16K 20K

W23 or sim 9W 6 of one value ..... £1  
R22 R47 1R0 1R1 15R 56R 62R 100R 120R 180R 220R 300R  
390R 680R 1K0 1K5 5K1 10K

W24 or sim 12W 4 OF ONE VALUE ..... £1  
R50 2R0 9R1 10R 18R 22R 27R 56R 68R 75R 82R 100R 150R  
180R 200R 220R 270R 400R 620R 1K0 6K8 8K2 10K 15K

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# A COMPACT A-Z OF ANALOGUE SEMICONDUCTORS

BY CHRIS KELLY

## STACK IN THE BOX

*Analogue circuits have held the fort against the digital invasion by jumping on the ic bandwagon – from single-function devices, to matched transistor pairs to whole circuits, all on a single chip.*

Before the 1960s, analogue techniques were dominant in the world of electronics. Digital methods played a minor role simply because of the complexity and expense of making logic circuits from discrete components; just one logic gate required a handful of transistors, diodes and resistors. Advancing and cheaper integrated circuit technology has created a vast range of applications for digital electronics, now seemingly dominating analogue.

But this increase in digital techniques is not to the exclusion of analogue. Look in any supplier catalogue and you will find that many of the time-honoured analogue circuits and some new ones are now available in ic form. They are cheaper, simpler to include in a design and often more efficient than using discrete components. They have opened up a new world of applications.

This A-Z guide gives a general coverage of the many types of circuits available, the terms and jargon used. It should be useful as a refresher for the experienced or as an overview introduction for the newcomer.

### ANALOGUE SWITCH

An electronically controlled switch, based on a semiconductor device such as a fet, which exhibits a low on resistance when the switch is 'closed' and a high off or 'open' resistance. Being a semiconductor device, it exhibits low transient switching compared with the bounce of mechanical switches.

Analogue switches are available in dual-in-line ic packages (see Fig.1), containing a variety of switches. Typical device numbers are:

4051BE & 74HC4051	(1-pole 8-way)
4052BE & 74HC4052	(2-pole 4-way)
4053BE & 74HC4053	(3-pole 2-way)
HI200-5	(dual spst)
HT201-5	(quad spst)

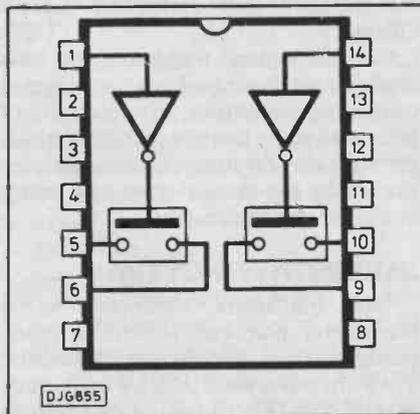


Fig.1. A dual spst analogue switch

### ANALOGUE-TO-DIGITAL CONVERTER (ADC OR A/D)

A device which outputs a digital code which is proportional to an analogue signal present at its input. For example, a 3-bit converter as shown in Fig.2, will give all 1s (111) when the input is a maximum voltage, all 0s (000) when the input is zero, and a binary mixture of 1s and 0s for voltages between zero and maximum.

There are many types of adc, each requiring a *conversion time* from nanoseconds to microseconds depending on the method of conversion. The *resolution* of a converter is the minimum difference in input voltage which causes a binary change of 1 in the digital output.

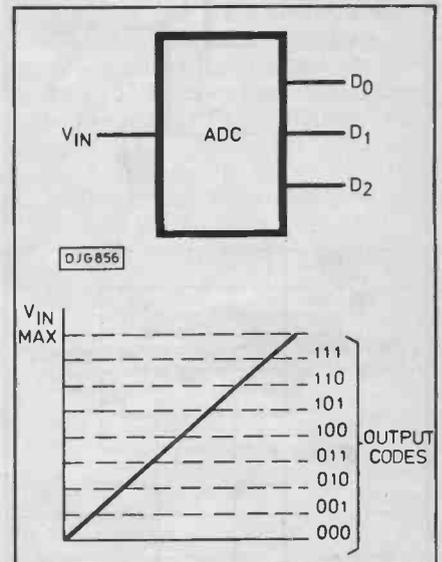


Fig.2. A 3-bit adc showing output codes

A more detailed description of adcs will be given in a future A-Z feature on converters. Typical device numbers are:

ADC0804	8-bit A/D
ADC820CCN	8-bit high-speed A/D
ADC0831CCN	8-bit with serial in/out
ZN448E	8-bit tri-state parallel

### AUDIO ATTENUATOR

An amplifier with a gain less than one, controlled by an external voltage or resistance (see Fig.3).

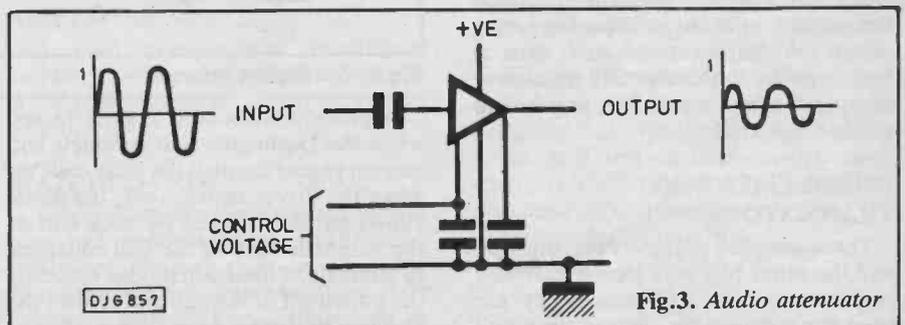


Fig.3. Audio attenuator

## BI-POLAR DEVICE

Semiconductor device which operates using both types of charge carriers: electrons (negative charge carriers) and holes (positive charge carriers). The junction transistor is a bipolar device, whereas the fet is uni-polar because only one charge carrier flows through the channel.

## COMPARATOR

A device for detecting when a varying voltage signal reaches a threshold value. An analogue comparator compares an input voltage against a reference level or against another input, and the output switches state when the input voltage exceeds the other (see Fig.4).

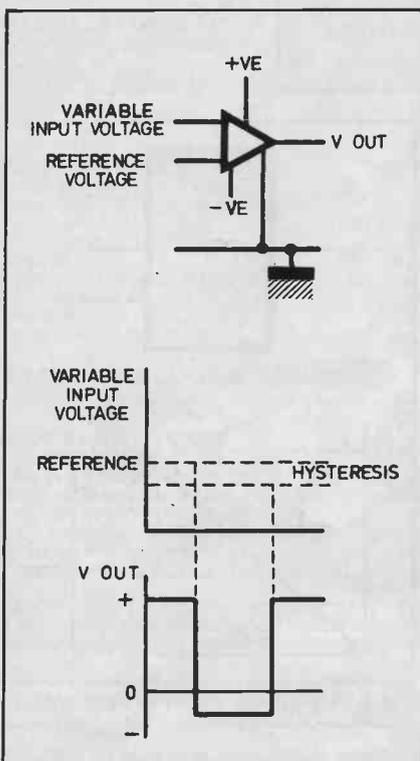


Fig.4. Typical analogue comparator

Operational amplifiers can be used as analogue comparators but special purpose comparators are available. These have quicker switching times and low *hysteresis* which is the difference between the switch-on threshold input voltage and the value to which the input voltage must fall below the threshold for the device to switch off.

The 710, a popular high-speed voltage comparator in a 14-pin ic package, can switch in nanoseconds and has a hysteresis of 2mV. The 319 is a dual comparator in one package, requiring a single supply rail.

## COMPLEMENTARY TRANSISTORS

These are pairs of transistors, one npn and the other pnp with closely matched performance characteristics. They are used for applications such as push-pull

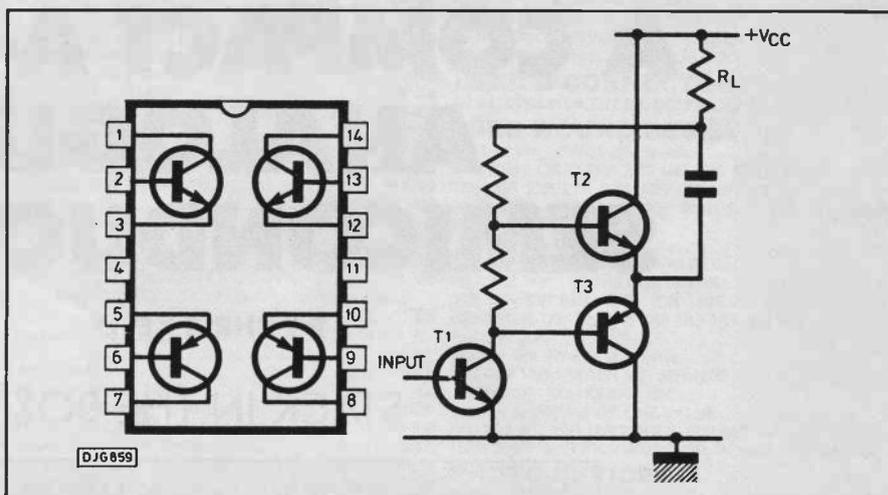


Fig.5. Complementary transistors and push-pull amplifier

amplifiers (Fig.5) where one transistor amplifies the positive half cycles of the signal waveform and the other amplifies the negative half cycles for greater efficiency.

Complementary transistors are now available as single packages, sometimes containing multiple complementary pairs with some thermal matching which means their performance characteristics change by the same degree as a result of change in temperature.

## DARLINGTON DRIVERS

Two transistors connected as a Darlington pair can achieve a much greater current gain than one transistor. They are often used to drive loads such as relay coils (Fig.6) and in series voltage regulators. Quad (four) and octal (eight) Darlington drivers are available in a single ic package, including inbuilt protection diodes.

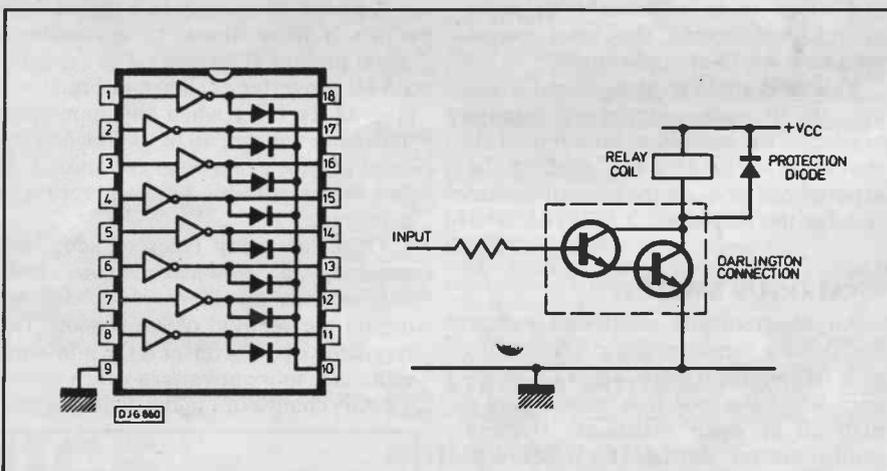


Fig.6. Darlington drivers

A protection diode is reverse-biased when the Darlington pair conducts and current passes through the relay coil. Yet when the driver switches off, the diode allows current, caused by back-emf as the magnetic field of the coil collapses, to circulate. Protection diodes speed up the switch-off of the coil and protect the Darlington drivers from back-emf.

## DELAY LINE

A means of creating a delay in the transmission of an analogue signal for a fixed time interval. Typical applications are for electronic musical effects such as artificial reverberation and introducing delays into public address systems so that the audio signal reaches each speaker simultaneously.

The bucket brigade delay (bbd) principle (Fig.7) is often used where you can imagine the analogy of buckets being passed along a line of people where the contents of each bucket represents a sample of the analogue waveform.

Very simply, analogue switches are opened and closed alternately so that the charge on a line of capacitors is passed along the line, where each charge is a sample of the analogue input. A two-phase clock controls the opening and closing of alternate switches. The result at the output is a series of delayed,

chopped amplitude samples of the input waveform.

The chopping of the waveform introduces many unwanted frequency components which can be removed from the output by filters.

Practical devices include the MN 3044 which is a mos monolithic ic with 512 stages (buckets!) providing delays from

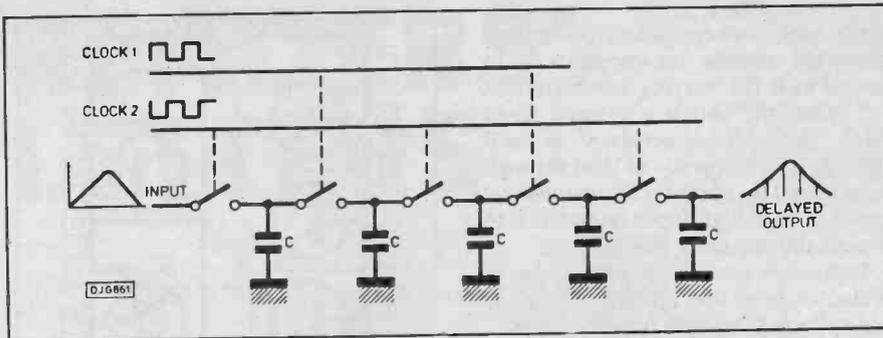


Fig.7. Bucket brigade delay line

2.65ms to 25.6ms. The MN 3011 has 3328 stages with six output taps and having a full delay range of 16.64ms to 166.4ms.

There are many short delay lines available, such as the 63 microsecond delay lines for television receivers, which are not suitable for audio use. The reason for this is that delays in the range of several milliseconds are required for the effects to be audible. As each stage of a delay line introduces its own errors, cascading a number of short delay lines would increase the distortion for audio to an unacceptable level.

## DIGITAL-TO-ANALOGUE CONVERTER (DAC OR D/A)

A device which converts a digital code into a proportional analogue voltage (Fig.8). For example, a 3-bit converter can generate eight levels of voltage, each level representing one of the binary combinations possible with 3-bits.

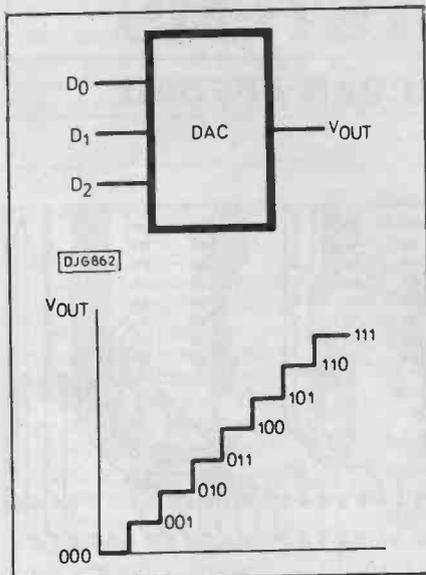


Fig.8. Digital to analogue converter

The output voltage is not true analogue but is in discrete steps, called *quantisation levels*, and no voltages can be output between these levels. This is the source of error in dacs, called *quantisation error*.

Dacs are used for waveform generators, industrial control applications and now in compact disc players to reconstruct the analogue music from digital

codes. An A-Z feature is planned dealing specifically with dac and adc. Typical device numbers:

- DAC0801 8-bit d/a
- AD7581 8-bit 8-channel d/a
- ZN428 8-bit d/a
- DAC703JP 16-bit d/a

## FIELD EFFECT TRANSISTOR (FET)

A semiconductor device which can amplify voltage signals or act as a switch. The fet has certain advantages over the bipolar transistor it is not as susceptible to temperature variations, having high input resistance and low noise which makes it suited for the early stages of amplification.

Very simply, the fet operation is as follows: an input voltage signal applied to the gate terminal creates an electrical field which controls the flow of current from an external source in a channel between *drain* and *source* terminals.

There are three main types of fet. The *junction gate fet* (jfet), the *metal-oxide-semiconductor fet* (mosfet or most) and the *vmos power fet* which has a V-shaped channel for switching high currents (typically 2A) very quickly (tens of nanoseconds).

## HYBRID INTEGRATED CIRCUITS

These have a ceramic support often called a substrate, upon which is mounted several other types of circuit such as silicon chips, power transistors and film resistors. The advantage is that one hybrid package can mix component types which would be difficult to manufacture as a *monolithic ic*.

## INSTRUMENTATION AMPLIFIER

A high performance operational amplifier having substantially lower drift characteristics than standard operational amplifiers.

## MATCHED PAIR

Two transistors manufactured in one piece of semiconductor to exacting tolerances so that their performance characteristics are almost identical. Any change in operating conditions such as

temperature or humidity change affects each of the matched pair equally.

## MONOLITHIC IC

A complete circuit manufactured on a single piece of silicon. The word *monolithic* literally means "single stone". The term *monolithic* can also be used for other devices, eg *monolithic ceramic capacitors*.

## MULTIPLEXER

An analogue multiplexer (Fig.9) contains a number of switches which when selected to "close" one at a time connects the signal path from one input channel to a common output, rather like an electronic version of a multi-way switch. The channel is selected by a code applied to address inputs (A0 and A1 in diagram). Analogue multiplexers are used extensively for data acquisition systems, audio and video switching.

Multiplexers can be built around discrete fets, but are now available as complete ics, such as the LF13508, but are now available as complete ics, such as the LF13508, 8-channel multiplexer or the 16-channel LF13526. Other device numbers:

- 74153 4-line to 1-line
- 74151 and 4512 8-line to 1-line
- 74150 16-line to 1-line

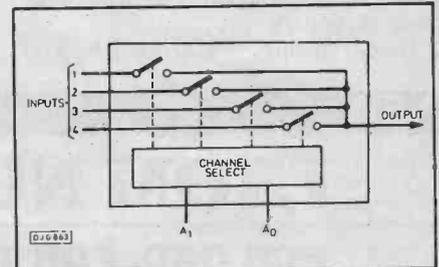


Fig.9. Analogue multiplexer

## OPERATIONAL AMPLIFIER (OP AMP)

A high gain voltage amplifier which is direct coupled (no capacitors) so it is suitable for amplifying dc or ac signals. Operational amplifiers have *differential* inputs, one inverting (-) and one non-inverting (+) and exhibit very high input impedance and very low output impedance. They are used extensively for industrial instrumentation, small signal processing, general purpose amplifiers and summing amplifiers.

Bipolar operational amplifiers have low output impedance and high slew rates (rapid change of output measured in volts per microsecond). Cmos operational amplifiers exhibit very high input impedance and have low power consumption but with lower slew rates.

An A-Z feature is planned dealing exclusively with operational amplifiers and their applications.

- Typical device numbers:
- Bipolar: LM301A 709
  - LM308 741
  - LM324 NE531

cmos/fet: LF441, 442, 443  
LF351, 353, 347  
CA3130

## RMS TO DC CONVERTER

A device which will output a direct current which represents the true rms value of the input signal. The rms value is different for different types of waveforms and ic devices are available which compute for sinewaves, square-waves or any complex waveform containing ac into the mega-hertz region or both dc and ac components.

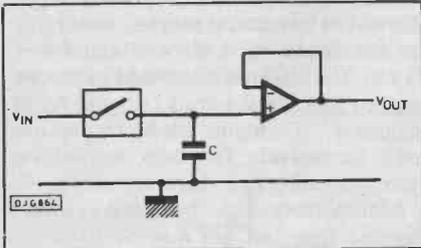


Fig.10. Sample and hold circuit

## SAMPLE AND HOLD (S/H)

For many data acquisition applications, a rapidly changing analogue voltage must be frozen at a particular instant in order that an analogue-to-digital conversion can take place accurately.

The s/h circuitry (Fig.10) includes a fet

switch which when closed (sampling) allows the voltage on capacitor C to change with the varying input voltage,  $V_{in}$ . When the switch is opened (hold state), the voltage across C is held constant which appears as  $V_{out}$  through the buffer. The buffer is an operational amplifier with high input impedance to prevent the capacitor discharging.

*Acquisition time* is the time required to change from one holding voltage to new voltage level with a step of 10V.

*Droop rate* is a measure of the holding voltage fall-off in millivolts per millisecond, and depends on the quality of the capacitor and the high input impedance of the buffer.

## TRANSISTOR ARRAY

A number of transistors in one ic package (Fig.11). Used in applications where space saving or close thermal matching (ie changes in performance due to temperature changes) are important.

A typical device is the CA 3046 which consists of five npn transistors.

## VOLTAGE-CONTROLLED OSCILLATOR

A device which converts a variable analogue input voltage to an output voltage whose frequency is directly proportional to the input voltage. Ics are

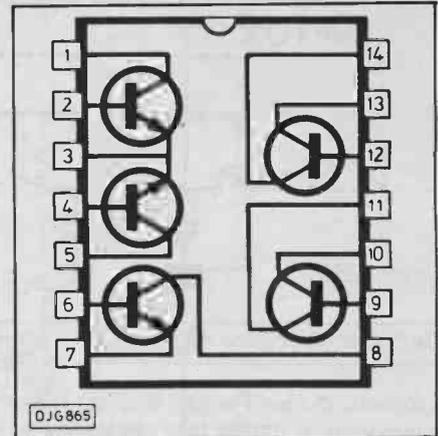


Fig.11. Transistor array

available which output pulses at a frequency proportional to the input voltage and some devices can work in reverse, giving a voltage proportional to the frequency of the input. One frequently used device is the cmos 4046.

PE

## PE BOOK SERVICE

If your looking for more information about analogue circuits see the PE Armchair Book Shop on page 54.

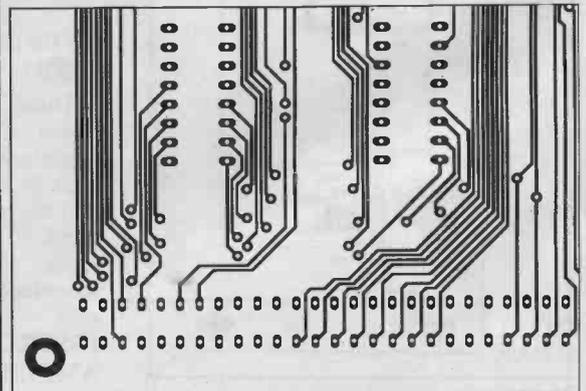
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# READERS' LETTERS

## STARRING PE

Dear Ed,

Over the last few years my electronic dabbling has been neglected, but now having retired, I find there is time to catch up on what I have been missing.

The first thing I did was purchase PE once again and I noticed that you have added 'Spacewatch' to the articles. I also see that *Astronomy Now* is published by the same company as PE. One of my main hobbies over the years has been telescope making, so it occurred to me that there is an opportunity to make a plea for projects on astronomical electronics. How about electronic control of telescopic movements using stepper motors linked to a computer? Electronics could also be used to lock on to a guide star when using an astro camera. There are many other similar areas in which one could use electronics if only someone would produce the projects in print.

There are a lot of amateur astronomers in this country and PE could be a sister magazine to *Astronomy Now* on a practical basis. So please may we have an astro electronics section in PE?

W.C. Trice, Peacehaven.

*I share your views and already have some astronomy-electronics articles coming up relating to infrared and ccd (charge coupled device) photography. These are not constructional articles but features written by researchers at Herstmonceux and Edinburgh Observatories.*

*I should very much like to be offered electronic projects relating to astronomy, and would also welcome further suggestions for them.*

*One idea that Dr John Mason of AN has already discussed with me is the possibility of an astronomical alarm clock. It seems that astronomers keep getting up in the middle of the night to see if the sky is clear enough for observations. All too often they find they've risen unnecessarily as the skies are clouded over. We have chatted about designing some sort of clear sky sensor that will only set off the alarm when really justified. It's not as easy as it might seem and as yet we've come to no practical low-cost conclusion (unhappily, the use of ccd sensors is too expensive to have widespread appeal). Does anyone have any ideas that will allow Dr John to maximise his snore-to-view ratio?*

Ed.

## GENERATING POWER

Dear Ed,

I have read with interest your poignant 'Weather Beaten' Editorial of Jan 88. Please accept my commiserations for the 'technological indignity' you experienced during the Great Gale of '87. We experience frequent power failures in Nairobi, although more usually as a result of human factors than acts of God ...

Anyway, at the moment I am concerned with alternative energy systems for low cost house designs and wonder if you can offer advice regarding small-scale petrol or diesel driven generators manufactured in the UK which might be suitable for recharging 12V car batteries. I have in mind an idea for battery powered fluorescent lighting systems using a generator run on a village cooperative basis. Regrettably solar power panels are still too

expensive in Kenya to consider them as the supply source.

Surprisingly, I haven't been able to obtain information in Nairobi and it seems that where generators are used they are for direct lighting systems rather than for battery charging.

Robin Short, Nairobi, Kenya.

*My phone directory shows five companies who are practically my neighbours:*

*Aggreko Generators Ltd, 89 Beddington Lane, Croydon, Surrey. 01-689 5511.*

*John S Allen & Son Ltd, 4 Downview Road, London SE19. 01-771 3323.*

*Electro Dynamic Construction Co Ltd, Station Approach, St Mary Cray, Orpington, Kent. 0689 32051.*

*Power Mart, 413-415 Ilford Lane, Ilford, Essex. 01-514 0700.*  
*Stephill Generators Ltd, Unit 5, Samuel Jones Ind Est, London SE15. 01-708 0083.*

*Ships chandlers might also be*

*able to help since many boats require 12V or 24V power sources.*

*I am a bit puzzled though—if the generators you know of produce mains voltages, why can't you use a normal battery charger? If they are 24V ac generators, using a heavy-current rectifier feeding into two 12V batteries coupled in series should also be practical. Ed.*

## PICK AND CHOOSE

Dear Mr Becker,

This is to thank you for your letter telling me I had won a subscription to PE in the satellite tv competition.

To be truthful, I am much more pleased to have the prize I won rather than the satellite tv set-up. No doubt it is my age, but I find fewer and fewer tv programmes with any real merit or veracity. Since we are constantly being told that we have the best tv programmes in the world can, I ask, a tele-dish bring us anything more? The real problem with tv is that, unlike steam-radio, it takes total attention for, more often than not, trivia.

I am struggling to find time, as it is, to complete a small circuit that will interface my Apricot portable, with its rgb output, to an ordinary tv set. I suspect the result may be an inverted signal (which won't matter much) and only a 40 column screen (which may prove tedious) but it is a lot cheaper than an rgb monitor. After that I hanker after building my own weather satellite receiver to input to the computer and (hopefully by then) a decent monitor. But I fear I shall go to my grave clutching yet another (to me) incomprehensible circuit diagram.

Thanks for the competition; it was interesting and fun.

Sylvia M. Pick, Ledbury.

*Apart from nature, technology and current affairs programmes I regret that tv does not hold much attraction for me either. The only benefit I usually find in other programmes is that they enable me to doze off prior to getting back to dabbling with the soldering iron.*

*I too would like to get into weather satellite reception and have been having tentative chats with my counterpart on Astronomy Now. Perhaps I'll soon be able to offer a comprehensible circuit.*

*But I hope that neither of us, to rephrase William S, will shuffle off this mortal coil or abjure our rough magic 'till all's refined to potent art. Ed.*

## TEACHER TALKBACK

Dear Tim Pike,

I am a fourth year pupil studying GCSE technology and am making the TeacherTalkback intercom from PE Jan and Feb 88. Where can I obtain the 80 ohm speakers you specify?

Matthew Jowitt, Calver.

Dear Matthew,

80 ohm speakers may be a little difficult to get hold of sometimes but there is no reason why you should not use another relatively high impedance type instead. Some companies work to 64 ohms, and others to 75 ohms. Either of these would be fine. I have looked in some catalogues and offer some possible sources to you —

Circuit, tel 0992 445736. 64 ohms, code 43-02564, 80 ohms, code 43-02580.

Greenweld, tel 0703 772501. 64 ohms, code A302.

Maplin, tel 0702 554161. 64 ohms, code WF57M.

Rapid, tel 0206 272730. 64 ohms, code 35-0135.

Best wishes with your project.

Tim Pike, Orpington.

## THERMAL EXAM

Dear Mr Becker,

For my forthcoming Craft, Design and Technology (CDT) exam I have to produce a paper in which I report on my investigations into electronic methods of measuring and displaying temperature. Have you published any circuits recently which might help me?

Clive White, Portsmouth.

*Part two of the Prof's article on Sensors in PE May 87 specifically covers thermal transducers. Also, my Weather Centre project shows a simple temperature detector in part one, March 88. Coming up shortly is another method as part of a barometric pressure sensing project. Stay hotly with PE!*

Ed.

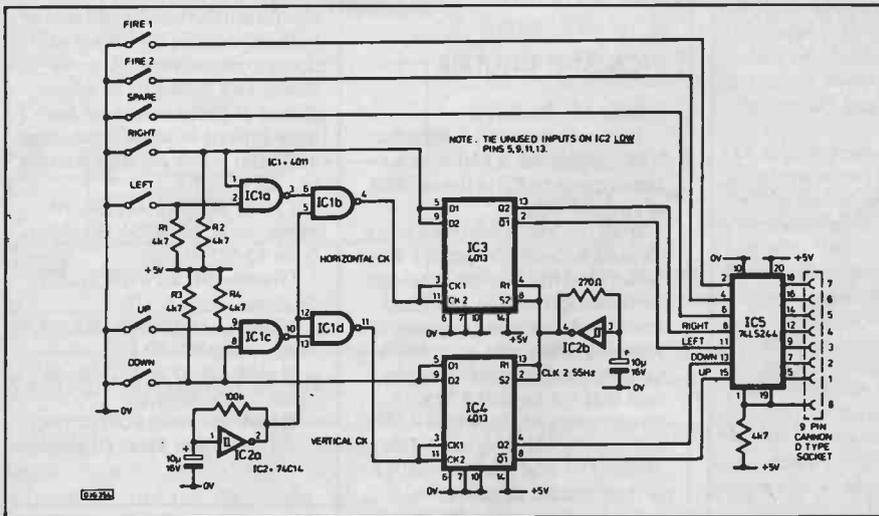
## WEATHER VANES

In the Weather Centre project of Mar-May 88 I commented that weather vanes seemed to be hard to locate. I am pleased to tell you that I have recently found a company who make them. Metalarts of Devon were exhibiting at the Peshurst craft fair in May and have a good range available, from the conventional to the more exotic.

Metalarts of Devon are at the Petrockstow Forge, Petrockstow, Okehampton, Devon. Ed.

# "INGENUITY UNLIMITED"

## AN AMSTRAD MOUSE SIMULATOR



THE joystick port on the Amstrad CPC computers is scanned as part of the keyboard system at a default speed of 50 times every second. Anyone who has tried to use the joystick for accurate control of the screen cursor position will have found it difficult. This is due to the rate at which the computer scans the joy-stick port, requiring only a small movement on the joystick to produce a large movement of the screen position. The following circuit was designed to get around this problem by converting the joystick switch positions into a stream of pulses on the joystick lines, similar to those generated by moving a mouse.

The circuit consists of only five dil ic's these go to make up the input gating from the direction switched, two astable clocks, direction latches and a tri-state buffer to drive the joystick port on the computer. The Schmitt inverter gate IC2a and it's associated components R5 and C1 form the first astable clock which is fed to one of the inputs on gates IC1b

and IC1d whose outputs generate the vertical and horizontal clocks and which are used to clock the position latches IC3 and IC4. The outputs of IC1b and IC1d are normally held high by the low outputs from IC1a and IC1c, only when one of the four position switches are pressed does the relevant clock get gated through to the latch. This signal now clocks the selected position through to the Q2 and NOT-Q1 outputs. This will appear at the joystick port each time the port is scanned. However the second astable clock made from IC2b and R6, C2 clocks the set and reset inputs on the position latches every 18ms, changing the state of the latch outputs to a high state. As the computer only scans the port for a low condition to signify joystick movement it no longer sees the port as active and will cease to increment the screen position.

If the position switches are kept depressed then the position clock will remain active and will re-clock the

position into the latch, appearing once again on the joystick port before being cleared by the second astable clock. The overall effect of this action is to only allow the position switches to be available for reading by the port for a short period of time before being cleared, hence only updating the screen position by small amounts each time. The circuit uses cmos ic's to keep power consumption to a minimum the four pullup resistors R1 to R4 are to prevent the inputs of IC1 from floating when no position buttons are pressed.

A small plastic box used to house the circuit. Seven normally open push-buttons were mounted on the lid, three in a row at the top providing fire1 fire2 and spare fire button. The four position switches were arranged below, similar to the cursor key layout. Wires were taken down from these switches to the main circuit board mounted in the base of the box. Two leads were brought out of the rear of the box, one having a 9 pin socket to connect into the joystick port, the other carried the power to the circuit board. The +5v required may be picked up from the expansion connector pin 27. The usual static precautions should be observed when handling the ic's and the use of dil sockets recommended. When the unit is completed and plugged into the computer, enter the following program:

```
10 cls:mode1
20 locate 20,12:print joy(0)
30 if joy(0)<0 then 20 else 40
```

The following numbers should be displayed on depressing a key on the unit: TOP LEFT=32 TOP CENTER=64 TOP RIGHT=16 UP=1 DOWN=2 LEFT=4 RIGHT=8. If the right numbers appear, clear opout the program and enter the next program. This allows simple line drawings to be created on the screen. The top right key cancels the line, top centre allows cursor movement without drawing, pressing it again returns you back to drawing mode, top left makes the line permanent.

R. Hewertson, Leigh

### Main program for the Amstrad mouse simulator

```
10 CLS:INPUT"sensitivity=";s
20 MODE 1:IN# 3,24
30 x=320:y=200:h=320:v=200:lin=1:GOSUB 140
40 WHILE-1
50 IF INKEY(72)=0 THEN GOSUB 190:v=v+s:GOSUB 190
60 IF INKEY(73)=0 THEN GOSUB 190:v=v-s:GOSUB 190
70 IF INKEY(75)=0 THEN GOSUB 190:h=h+s:GOSUB 190
80 IF INKEY(74)=0 THEN GOSUB 190:h=h-s:GOSUB 190
90 IF INKEY(77)=0 AND LIN=1 THEN GOSUB 240
100 IF INKEY(76)=0 AND LIN=1 THEN GOSUB 270
110 IF INKEY(78)=0 AND LIN=0 THEN GOSUB 270
120 IF INKEY(79)=0 THEN GOSUB 310
130 MEND
140 PRINT CHR$(23);CHR$(1);
150 LOCATE 1,1:PRINT "x=";h;" y=";v;"sensitivity=";s
160 MOVE h,v
170 DRAW# 0,5,2:DRAW# 5,0:DRAW# 0,-5:DRAW# -5,0
180 RETURN
190 IF LIN=0 THEN GOTO 220
200 PRINT CHR$(23);CHR$(1);
210 MOVE x,y:DRAW h,v
220 GOSUB 140
230 RETURN
240 PRINT CHR$(23);CHR$(0);
250 MOVE x,y:DRAW h,v,1:x=h:y=v
260 RETURN
270 GOSUB 190
280 IF LIN=1 THEN LIN=0 ELSE LIN=1:x=h:y=v
290 GOSUB 190
300 RETURN
310 PRINT CHR$(23);CHR$(0);
320 MOVE h,v:DRAW x,y,0:x=h:y=v
330 RETURN
```

### Conference Lamp Controller

THE circuit shown in Fig.1. was used at a conference to enable the chairman to remotely indicate to the speaker: continue talking (green), one minute left (yellow), and stop talking (red). Readily available 3-core mains cable was used instead of the 4-core that would normally be needed.

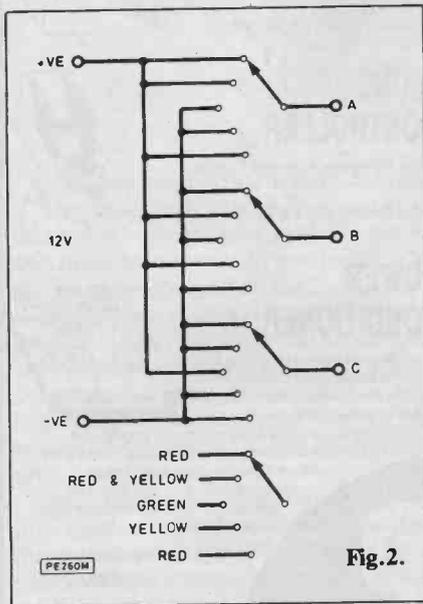


Fig. 2.

### Short Detector

DUE to current needs to have high densities of semiconductors on modern printed circuit boards, accuracy in soldering is of vital importance. As with wrap joints a wrong pin can give devastating results. Looking for bridges and shorts to debug projects can be very frustrating and time consuming. This project was designed to make debugging fast and accurate.

Initially the sensitivity should be set to maximum. The probes from the output marked RT are held against two tracks in the area of the p.c.b. where the short is suspected. This represents the measuring arm and completes the bridge circuit. If the l.e.d. is illuminated the circuit under-test must measure more than 10 Ohms, but if the green l.e.d. is illuminated then the value of the short must be less than 10 Ohms, and the sensitivity control should be adjusted until null is obtained and both l.e.d.s. are extinguished.

Again the bridge is nulled, this procedure is repeated until the sensitivity pot is fully clockwise, indicating zero resistance, therefore the probes are above the short which can now be visually identified and removed.

The measuring component of this circuit is a Wheatstone bridge. The bridge can be balanced for any resistance of 10 Ohms or less, The value of which can be read from a calibrated dial on

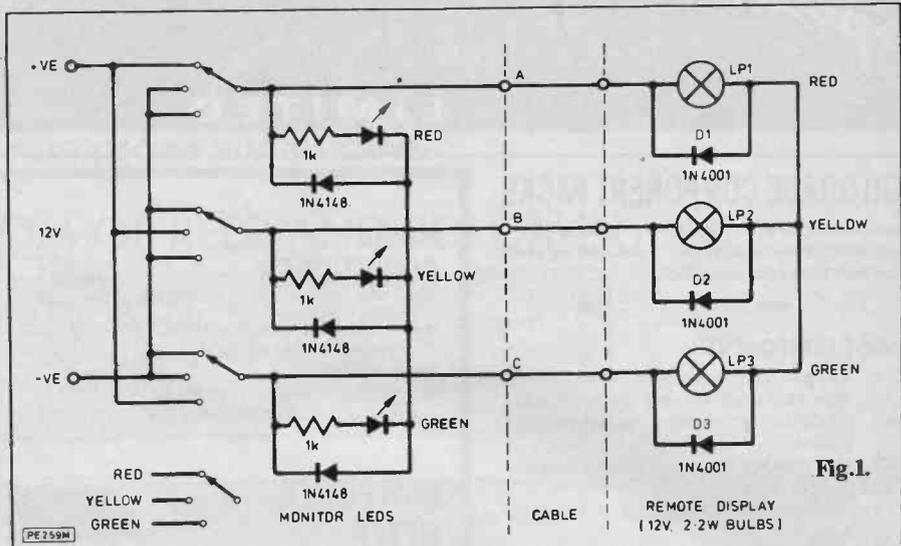


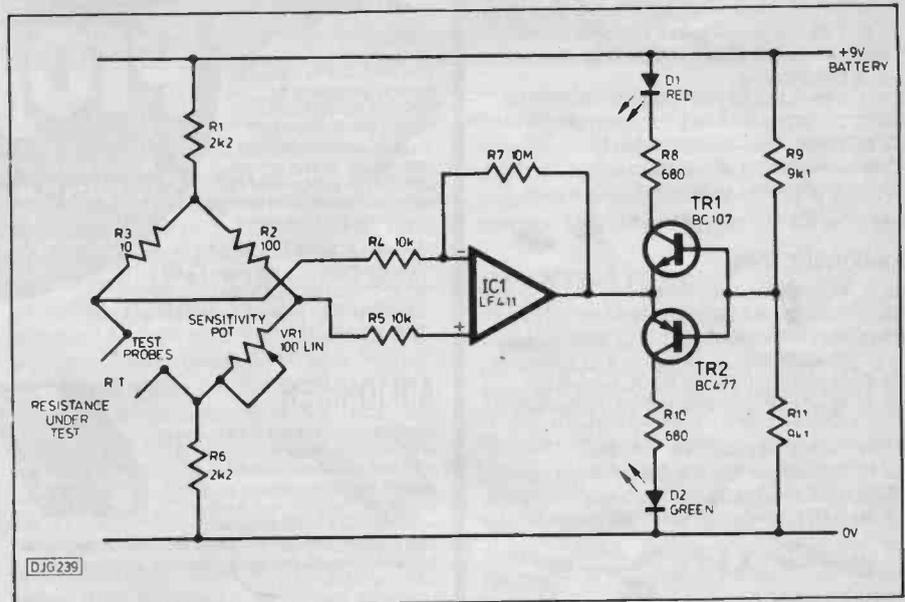
Fig. 1.

Each lamp in the remote display unit has a diode across it which is reverse biased when that lamp is on. For example, if the red lamp is on, line A is connected to the positive supply, and lines B and C are connected to the negative supply by the switch. This forward biases D2 and D3, and reverse biases D1, so turning LP1 on, and LP2 and LP3 off. A similar arrangement of l.e.d.s. on the control unit monitors the status of the remote display. Since only one diode needs to be forward biased,

any two lamps can be on at any one time. Fig. 2. shows the switching required for a traffic light sequence.

The principle can be extended to control any number of lamps with the same number of wires, but it should be remembered that at least one lamp must be off, as at least one diode must be forward biased. The diodes should be rated to carry the combined current of the maximum number of lamps on simultaneously.

K. Wevill, Leicester.



VR1. The op-amp IC1 is used to compare the two arms of the bridge. Because of this arrangement, the output level of IC1 can only be one of three values.

When the bridge is balanced the centre point of both arms V1-V2 will have a differential of zero, therefore both points will be at half rail potential. The inputs of IC1 will be the same, thus the output of IC1 will be half the supply.

The bases of TR1 and TR2 are fixed at half supply potential, so when the bridge is balanced, the Vbe of both transistors is zero and is indicated by both l.e.d.s. being extinguished. If the

bridge is adjusted and voltage V1 becomes positive with respect to V2 the output from IC1 falls to approximately 1V and TR1 is forward biased so illuminating D1.

If the bridge is adjusted such that V1 becomes negative with respect to V2, i.e. adjustment of VR1, or change in RT value, the output from IC1 goes high, approximately 8V, which reverse biases TR1 and forward biases TR2 to illuminate l.e.d. D2. Resistors R8, R10 are used to limit l.e.d. currents.

D.R. Fownes, Wolverhampton

PI.

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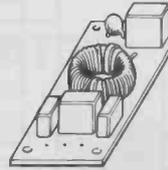
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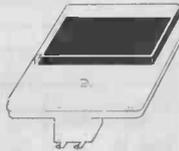
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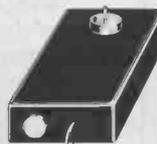
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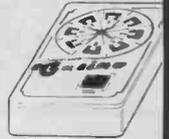
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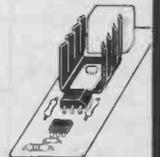
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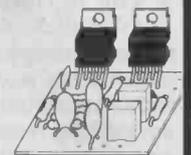
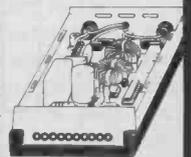


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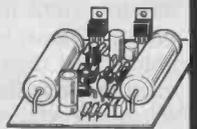
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# CD SIGNAL PROCESSING

PART TWO BY VIVIAN CAPEL

## THE WISDOM OF REED AND SOLOMON

*The binary wordplay needed to squeeze sixty minutes of music onto a three inch disc includes symbolising, interleaving of audio sample frames, three-zero humps, discardable merging bits, delay lines, triple parity checks and double decoding. They say it's great for Heavy Metal...*

A lot has been written as to how cd signals are recorded, but some of that published elsewhere has been vague and often inaccurate. In our last article we saw how the player tracks the disc and produces a data stream; now we shall see how the signal is processed, how a quart is compressed into a pint pot, and what happens when dirt or disc imperfections cause signal errors. We hope also to clear up a few misconceptions along the way.

Many readers will be familiar with the principles of digital recording, but for those that aren't we will start with the basics. When a signal in a recording medium, whether an electric voltage or current, magnetic field, or record groove, varies in proportion to the sound pressure wave that caused it, it is termed an *analogue* signal. It is analogous to the original sound.

Now it is not easy to get the signal to correspond exactly. The system may discriminate in favour of, or against certain frequencies, components can resonate producing frequency peaks, spurious harmonics can be added, and so can noise, frequencies can interact generating sum-and-difference products that were not in the original. Any or all of these can occur during recording and again at playback. The end result is *distortion*.

### DIGITAL RECORDING

An alternative to attempting to accurately record the actual wave is to measure it, record the measurements, then reconstitute the wave from those measurements. It is obvious that once the measurements have been taken nothing can happen to degrade the signal. Noise and distortion can have no effect as long as the reproducer can recognise the numbers. The only problem that can arise is if some of the measurements are lost.

Distortion could arise if the original measurements were inaccurate or they were inadequate to truly represent the analogue signal. There must therefore be a sufficient number of readings or samples so that the waveform can be properly defined. According to the



Photograph of the TR8848 cd radio cassette recorder by courtesy of Pye

*Nyquist Theory*, the sampling rate must be at least twice that of the highest frequency to be represented. In the case of the compact disc, the sampling rate is 44.1kHz, which is sufficient to describe a sine wave of 20kHz, the highest audio frequency recorded. The top frequency is bound to be a sine wave because if it was not, the presence of still higher harmonics would be indicated.

Should frequencies be present that are higher than half the sampling rate, the samples appear to the decoder to be values of a much lower frequency, (see Fig.1). This effect is known as *aliasing*. To prevent it, all frequencies above the required range must be severely curtailed. This is done by means of a steep

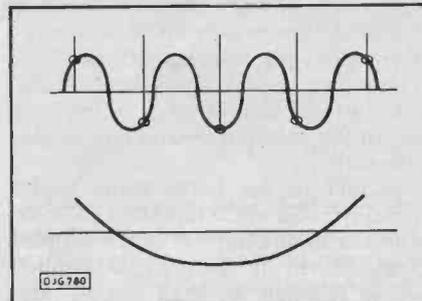


Fig.1. A *aliasing* error. When the sampling rate is lower than the highest frequency, spurious low frequencies are produced

top-cut filter. Having the sampling rate slightly higher than twice the upper frequency limit, besides giving a safety margin, also allows for the filter roll-off.

### QUANTISATION

Each sample is represented by a whole number, so the larger the number of measurable levels the more accurate the sample. For example, if temperature is to be measured in whole degrees, the Fahrenheit scale having 180° between freezing and boiling points will give a more accurate result than Celsius which has only 100°. The error caused by a value falling between two levels is termed *quantisation distortion*. The percentage of error caused say by 2.5 being measured as 2, is far greater than 200.5 being rounded off to 200. It thus follows that the effect of quantisation error is much greater at low signal levels. Decaying sounds die away in a series of steps rather than smoothly, producing what can best be described as a 'crumbling' effect.

One way of overcoming this is to space the levels closer together at the low end, a method known as *non-linear quantisation*. With the compact disc 65,535 levels plus 0 are measured, giving 65,536 possible numbers. This is sufficiently high to give very low quantisation

# CD SIGNAL PROCESSING

distortion even at low levels, so non-linear quantisation is not necessary.

## BINARY CODE

If the sample was recorded as a decimal number, ten different states would be required to represent each digit. This would produce the same problems as an analogue signal, with slight errors producing totally different numbers, especially if these occurred in the left-hand digits. With the binary code, only two states are required to represent 0 and 1, so a series of pulses and gaps can be used. The method is thus termed pulse-code modulation, and is far less likely to result in ambiguity than the use of a decimal number.

While many readers will be familiar with the binary code we will ask them to bear with us for a while for the sake of those who are not. In the binary code, each 1 starting from the right indicates a power of 2 starting with  $2^0$  which is 1, followed by  $2^1$  which is 2, then  $2^2$  which is 4,  $2^3$  which is 8, and so on. The appearance of a 0 in any position indicates the absence of that power from the complete number. Any number up to 65,535 can be represented by 16 binary digits which is therefore the number of digits or bits used for the compact disc.

For comparison, 15 digits can represent up to 32,767 decimal, 14 digits, up to 16,383, and 13 digits up to 8,191. So the extra few bits mean a lot! Actually, 16 bits is somewhat a case of overkill as the excellent quality achieved with the BBC fm stereo broadcasts is obtained after transmission along studio link lines at 13 bits. However, the excess is undoubtedly to wisely achieve a higher-than-necessary standard from the beginning, and so avoid the need for upgrading later when advances in associated equipment could render a lesser specification obsolete.

## FRAME FORMAT

As we have seen, the 65,535 possible signal levels are represented by a 16 digit binary number which is called a **word**. The rh and lh stereo channels are recorded consecutively and so consist of alternate words. This is possible because the data is recorded much faster than it is sampled. Samples are taken at the rate of 44,100 per second from each channel which is 88,200 samples per second. If these were recorded as 16-digit words per sample, this would be 1,411,200 digits or bits per second. The recording frequency is 4,321,800 bits per second, so both channels as well as other data can be recorded consecutively without running out of time. In the reproducer, the samples are stored in a memory as they come off the disc and are then clocked out at the required rate.

Actually, the samples are not recorded as straight 16-bit words. The units need to be shorter because each one is nearly

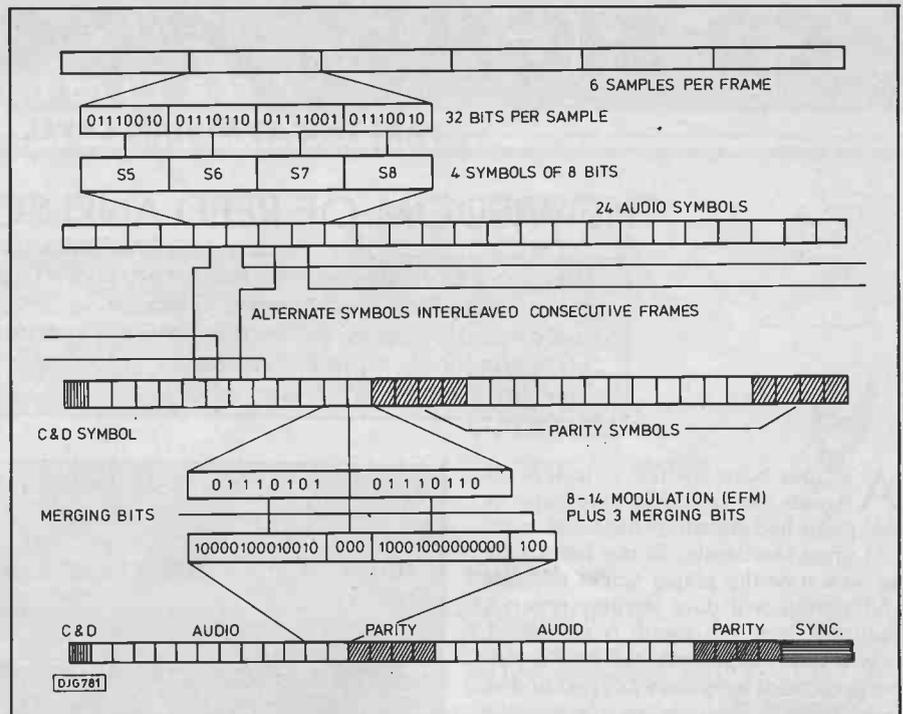


Fig.2. A complete frame showing composition and successive processing

doubled in length later, for a reason we shall see. This would produce unwieldy units which the digital circuits would find difficult to handle. So each word is split into two 8-bit sections called *symbols*.

The two stereo channels are sampled simultaneously so they constitute a single sampling of the sound field at any instant. Hence both are referred to as a single *sample* in compact disc terminology.

There is a set sequence of audio symbols, parity symbols, control and display symbols, and synchronising bits. A complete sequence is known as a *frame*, all frames having the same sequence. (Fig.2.)

The actual sequence is: first, one *control and display symbol*, which gives data as to title and composer, timing and track number and any other required data. This information can then be displayed on a read-out panel in the player, and the player's computer control can search for a particular track number when so instructed. Finding a track is thus much easier than the hazardous pickup setting down procedure which has to be followed with the standard lp record. Although only one 8-bit symbol is allocated per frame, there are 7,350 frames per second, thus giving 58,800 data bits per second which is ample to record the required control and display information.

Second in the frame come twelve audio symbols which represent six 16-bit words or three complete stereo samples. Next, there are four parity symbols whose function we shall discuss later. These are followed by another twelve audio symbols giving a further three audio samples, after which are another four parity symbols. Finally, there are

27 bits of synchronising data which the decoding circuits recognise, and so can tell where one frame ends and the next one starts. As these come between each frame they can be considered either as ending a frame or starting the next one.

A complete frame thus consists of 33 symbols of eight bits, which include six audio samples, plus the 27 sync bits. As there are 7,350 frames per second, this gives us the  $6 \times 7,350 = 44,100$  samples per second that we have previously noted.

Now, the audio samples are not recorded in succession, they are interleaved with those of an adjacent frame by a system of delay lines having a delay time of one frame. Thus frame A is delayed to be concurrent with frame B and the symbols are taken from each in turn. Thus the even ones from A alternate with the odd ones from B. The evens from B are meanwhile delayed so that they in turn are alternated with the odds from C whose even symbols are alternated with D and so on. The interleaving process is thus not just between a pair of adjacent frames, but involves those on either side. It is therefore known as the *Cross-Interleaved Reed-Solomon Code*.

In the playback decoder, the process is reversed, with alternate frames being again applied to delay lines and symbols from each being interleaved, only this time they are really being de-interleaved as the process restores the original positions.

The obvious question is, why go to all that trouble? The answer is that because errors and drop-outs are usually introduced by blobs or scratches on the disc surface, they tend to come in groups rather than being spread out. If frames

were recorded successively, a whole frame or even more could be lost irretrievably. By interleaving them the loss is spread out to parts of several frames instead of one complete one. This enables the error correction circuitry to deal with the errors by averaging from adjacent symbols and other means that we shall discuss presently. It is rather like putting your money on several horses rather than all on one, you are less likely to lose the lot!

## SPOT LIMIT

The number of channel bits that can be recorded depends on the diameter of the light spot that scans the disc. It does not have a sharp boundary so the rated diameter is that at which the intensity is at half value of the centre illumination. It is given by:

$$d = \frac{0.6\lambda}{NA}$$

in which  $d$  is the spot diameter,  $\lambda$  is the laser light wavelength, and  $NA$  is the numerical aperture of the objective lens. For a wavelength of  $0.8 \mu\text{m}$  and a  $NA$  of 0.45, the diameter is  $1 \mu\text{m}$ .

A smaller spot size could be obtained by increasing the  $NA$ , but this reduces the field of focus and would pare down manufacturing tolerances that are already fantastically small. The focusing tolerance for example is just  $\pm 0.5 \mu\text{m}$ , less than the wavelength of the light used!

## EIGHT-TO-FOURTEEN MODULATION

It follows from the foregoing that there is a limit to the amount of information that can be crammed onto a disc. However, a rather ingenious method is used to increase it although at first glance it would appear to make matters worse.

As is well known, the recording takes the form of a spiral track of pits that are excavated at the back of the disc, after which the rear surface is silvered. The track is read from the front through the transparent disc material, so it appears to the light beam as a track of humps.

The humps are  $0.12 \mu\text{m}$  high, so light reflected from them is shifted by a quarter wavelength compared to that reflected from the surrounding flat areas, which are termed *land*. Interference thus causes darkening as the hump passes, and the effect is increased by diffraction which scatters some of the light, because the hump width of  $0.6 \mu\text{m}$  is smaller than the light wavelength.

A common misconception is that the humps and spaces denote the 1s and 0s of the binary data respectively. This is not so; a 1 is indicated by either a leading or lagging hump edge. Such an edge represents a transition from one state to

another, light to dark or vice-versa, and it is these changes that the detecting circuits interpret as a 1. What follows whether light or dark, is interpreted as a 0. If the space between two edges, whether hump or land, is twice the unit length, the detector reads it as two 0s, if three times the length, three 0s and so on until the next edge.

A hump three units long thus conveys five digits, 10001. So by adopting this method, more information can be recorded than if each hump was a 1. But this is not the only means used to try and get a quart into a pint pot.

It is obvious that as the spot cannot read two edges at the same time, the hump cannot be shorter than the diameter of the spot. So in the case of a number having different alternate digits (010101...) the unit of space occupied by one digit cannot be made

shorter than the spot size. However, if all numbers had say three or more adjacent 0s (00010001; 10001000;...) the space unit allocated to each digit could be shorter, and more information could be packed in.

With the standard binary code of course, this is not so; there are many numbers that have different alternate digits. So although the standard binary code has been used in recording and processing up to this stage before actually modulating the recording laser it is converted to a different code altogether. Tables 1 and 2.

This code has no logical progression like the binary code; it is an arbitrary collection of digital numbers, each being assigned to represent a standard binary number. The important thing about them is that each one has three or more adjacent 0s. A 'dictionary' of logic gates

Decimal	Binary	Decimal	Binary
1	1	60	111100
2	10	64	100000
3	11	70	1000110
4	100	80	1010000
5	101	90	1011010
6	110	100	1100100
7	111	110	1101110
8	1000	120	1111000
9	1001	128	10000000
10	1010	130	10000010
11	1011	140	10001100
12	1100	150	10010110
13	1101	160	10100000
14	1110	170	10101010
15	1111	180	10110100
16	10000	190	10111110
17	10001	200	11001000
18	10010	256	100000000
19	10011	300	100101100
20	10100	400	110010000
21	10101	500	111110100
22	10110	512	1000000000
23	10111	600	1001011000
24	11000	700	1010111100
25	11001	800	1100100000
26	11010	900	1110000100
27	11011	1,000	1111101000
28	11100	1,024	10000000000
29	11101	1,200	10010110000
30	11110	1,400	10101111000
31	11111	1,600	11001000000
32	100000	1,800	11100001000
33	100001	2,000	11111010000
34	100010	2,048	100000000000
35	100011	2,500	100111000100
36	100100	3,000	101110111000
37	100101	3,500	110110101100
38	100110	4,000	111110100000
39	100111	4,096	100000000000
40	101000	4,500	1000110010100
41	101001	5,000	1001110001000
42	101010	6,000	1011101110000
43	101011	7,000	1101101011000
44	101100	8,000	1111101000000
45	101101	8,192	1000000000000
46	101110	9,000	10001100101000
47	101111	10,000	10011100010000
48	110000	15,000	11101010011000
49	110001	25,000	110000110101000
50	110010	60,000	1110101001100000

**Table 1. Decimal to binary conversion chart.** It is evident from the number of consecutive 1s, or where only one or two 0s are consecutive, that to substitute a 16-digit binary number with one containing no consecutive 1s and no fewer than three consecutive 0s, a much larger number of digits is required, no fewer than 28 in fact. To avoid excessively long words and unnecessarily complex processing circuits, in the cd system the 16-bit words are split into two 8-bit symbols which are changed to 14-bit symbols. By permitting digits to be recorded in a third of the otherwise required space, this eight/fourteen modulation saves 25% of disc space.

digits	decimal max	digits	decimal max
1	1	9	511
2	3	10	1,023
3	7	11	2,047
4	15	12	4,095
5	31	13	8,191
6	63	14	16,383
7	127	15	32,767
8	255	16	65,535

**Table 2 Maximum Value:** The maximum value for a given number of digits is when all of them are 1s. The maximum for up to 16 digits are:

is used to accomplish the conversion in the recording circuit, and a similar one in the player converts the numbers back to binary code for decoding. The numbers are chosen to best suit the architecture of the logic gate chip, but their actual composition doesn't really matter as long as the recording and playback dictionaries are the same.

It follows then, that the unit space for each 0 can be shorter than the diameter of the light spot because it will never encounter a number with less than three 0s. It is in fact 0.3  $\mu\text{m}$ , a third of the light spot diameter. There is a snag though (isn't there always?). You cannot represent all the binary numbers having 8 digits, with another set of 8 digit numbers having no fewer than three adjacent 0s and no adjacent 1s. The new set must be longer. It needs, in fact, no less than 14 digits to represent each 8-digit symbol (hence the designation: eight-to-fourteen modulation). This incidentally is why the original 16-bit words were split into 8-bit symbols; they would otherwise have grown to an unwieldy 28 bits, and the dictionaries for conversion would have been much larger and more complex. Naturally, this increase to 14 bits erodes some of the advantage gained by using shorter space units, and there is a further problem.

There must as we have seen be a minimum of three consecutive 0s, but there is also a maximum. When there is a long run of consecutive 0s there are no light transitions and so there is no signal change. The circuits that count each unit and so determine the number of 0s could thus get out of synchronisation because the pulses provided by the 1s which they latch on to, are absent. The effect is like a tv receiver in which the frame sync pulses are missing due to a fault. The picture remains steady for a second or two but then slowly drifts up or down the screen and starts rolling.

Another effect of a long run of 0s is that the light beam modulation frequency drops to a low value. The servo systems that control the tracking and automatic focusing operate at low frequencies (below 20kHz), so they could be confused by any modulation within their frequency range and thus malfunction.

Because of these effects, the maximum number of consecutive 0s that can be permitted is ten. This is not difficult to arrange when designing the

new 14-bit numbers, but a snag arises if a number that concludes with a string of say eight 0s is followed by another that starts with seven. Now we have a string of fifteen consecutive 0s and the maximum has been exceeded. There are quite a few combinations that could exceed the limit of ten. Another difficult situation would be if a number that ended with a 1 or 10 was followed by one that started with a 1. In this case there would not be the minimum of three 0s between the 1s so the spot would be too large to read both 1s.

To overcome these problems three extra bits are added at the end of each symbol. These convey no information and are discarded when decoded in the player, but their function is to prevent consecutive or near consecutive 1s and to break up successive 0s between two following numbers. Their composition depends on whether they are separating 1s or 0s. If more than one combination satisfies the requirements, the one chosen is that which gives the lowest ratio between hump and land length. This ratio is known as the *digital sum value*, and the lower it is the lower the noise in the servo frequency band. The extra three bits are known as *merging bits*.

So the addition of the three merging bits to the 14-bit word extends the original 8-bit symbol to 17 bits, seemingly not a very good exercise in economy and space saving! However, because of the recorded unit being only a third of its otherwise minimum length, there is still an overall improvement in information density of 25%. Without it, the maximum time per disc would be 48 minutes instead of 60. Thus many musical works can be recorded complete on one side of a disc that otherwise could not.

## RECAP

At this point perhaps we can pause a little to digest what we have already discussed. The various processes are illustrated in Fig.2 so we will use it to recap. We note at the top that there are six stereo samples in each frame, each consisting of one 16-bit word for each channel, making a total of  $2 \times 16 = 32$  bits for the complete sample. These 16-bit words are each divided into two 8-bit symbols to facilitate later processing. Thus we have four symbols per sample, and 24 for each frame.

Next we see that alternate symbols are interleaved with those of adjacent frames on either side, so that errors or drop-outs are spread over several frames instead of concentrated in one or two. This makes them easier to compensate for later.

Eight parity symbols are added in two blocks of four, (of which more in the next section), and also one control and display symbol at the beginning. Next, the 8-bit symbols are converted into 14-bit symbols that avoid consecutive 1s, and enable the space occupied by one digit to be made only a third of the laser spot size. To prevent consecutive 1s between adjacent symbols or an excessively long run of 0s, three merging bits are added at the end of each symbol which are discarded during replay. This brings the total bits per symbol to 17, yet in spite of the extra number an overall space saving of 25% is achieved.

## ERROR CORRECTION

A major consideration is the possible loss or corruption of the digital signal due to imperfections in the disc, which considering the microscopic size and the astronomical number of humps in each disc is virtually inevitable. The effect of dirt on the disc surface, though minimised by being out of focus, can also cause loss of signal.

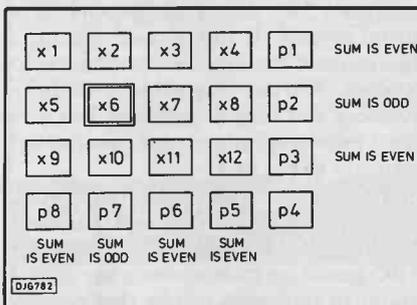
The system of error correction built in to the compact disc is therefore quite elaborate. Firstly, consider how simple corrections of a digital signal can be made by the use of *parity bits*. Imagine a data stream of 8-bit words. Some words will have an odd number of 1s while others will have an even number.

For example, 01101011 has an odd number with five 1s, and so has 01000101 with three. But 01100110 has four, an even number, just as has 01110111 with six. Let us now add an extra bit to each of these so that they always have an even number of 1s. The first number needs an extra 1 and so becomes 011010111; the second also needs another 1 and thus becomes 010001011. In the case of the third number it already has an even number of 1s, but as all words must be of the same length it must have an extra digit, so we add a 0. It thereby becomes 011001100. This applies also to the fourth number which the added 0 turns into 011101110. We have underlined the added digits which we call parity bits because they put all the words on a par respecting the number of 1s they contain.

Later, after recording the stream, we can get a circuit to check each word for an even number of 1s, and if they are correct, to then ignore every ninth digit which is the meaningless parity bit. If though it finds a word with an odd number of 1s, it knows that the word is incorrect. Of course that doesn't tell us which bits are wrong or how many bits in the word are faulty, but it does identify an inaccurate word.

If the stream represents an analogue audio signal, the faulty word can be erased and its value calculated by taking an average of the adjacent words. The value may not be 100% accurate, but it will not be far out and most likely far closer to the original than the erased faulty word, especially if the defect was with one of the high value digits at the beginning of the binary number. This method of correction, known as *interpolation*, is one of several used with the compact disc, but it is possible to identify and correct the actual faulty digit within the word and thereby reproduce the word correctly.

Such identification can be made by forming the digits into parity blocks. This can best be understood by reference to Fig.3. Here we have for the sake of simplicity three 4-digit words, x1-x4; x5-x8; and x9-x12 arranged in a block. Each has a parity bit added at its end just as before, these being p1, p2, and p3.



**Fig.3. Block parity.** With parity bits added to rows and columns, an odd sum for a row and column identifies the incorrect bit at their intersection

In addition to these there are parity bits added to the bottom of each column, p8, p7, p6 and p5, with one at the bottom of the column of line parity bits, p4.

The parity bits at the end of each line make each line have an even number of 1s, while those at the bottom of the columns make the columns even. Let us say now that data bit x6 is wrong; this will make the sum of the 1s in that line odd instead of even, and also it will make the sum at the bottom of that column odd. So by identifying the incorrect column as well as the line, the digit at the intersection is positively identified as the culprit. As binary digits have only two values, changing the faulty one to its opposite must make it right. The bit p4 seems redundant, but it serves to check on the other line parity bits as one of those could be faulty just as much as a data bit.

A question may be asked here, how do you convey a two-word dimensional block along a one-dimensional data stream? The answer is like a tv picture, line by line. It is only drawn and described as a block so that we humans can see how it works. The decoder puts the sequence in a memory then sees it as a number of sums; it adds the digits after every fifth bit (end of line), and it

also sums the first, fifth and ninth digits, the second, sixth and tenth, the third, seventh and eleventh, and the fourth, eighth and twelfth. When it finds a couple of errors it calculates the intersection and promptly changes the digit there. In the compact disc, blocks are formed from groups of symbols rather than individual digits. This achieves the maximum amount of error correction with the minimum number of parity symbols.

The number of incorrect symbols in a block that can be both identified and corrected in the decoder is limited. However, if the faulty symbols are identified and labelled first, the decoder can correct twice as many.

## DECODING AND CORRECTION

As the data stream comes in from the photodiodes, the start of each frame is identified by the synchronising pulses. Next, the 14-bit symbols are converted back to 8-bits by the logic 'dictionary', and the merging bits discarded.

Now the frames are fed into a buffer memory and clocked out at the other end by a quartz controlled clock. The input rate may vary due to wow or other causes, but the output rate is constant so wow can have no effect on the reproduction. The buffer is kept nominally 50% full to allow regulation in both directions, but the actual amount it contains is an indication of whether the motor is running fast or slow. The amount contained is therefore used to generate a control signal for the motor.

The control and display symbol, which is the first of the 33 in each frame is removed and routed to its own circuit. The remaining 32 are then fed in parallel to 32 inputs on the first of two decoders. Alternate inputs have delay lines having a delay length of one symbol which thereby restore the interleaved symbols from successive frames to their correct position. The decoder identifies any faulty symbols and corrects one. Two could be corrected here but with a lower degree of accuracy. So if there are more than one, all are given labels and are passed on uncorrected. The parity symbols serve their purpose in the identification and so go no further.

The audio symbols are dispatched to the second decoder via delay lines that space successive samples by 8-frame intervals so that error groups are well spread out and thereby diluted. As the faulty symbols have been pre-labelled by the first decoder, more can be corrected here, up to four in fact. If there are more than that, all are passed without correction but still retaining their labels.

## INTERPOLATION

Up to four symbols in each frame can be corrected; beyond this interpolation is necessary. Labelled symbols are

erased and their value is estimated from adjacent ones. As odd and even rh and lh channel samples within each frame are interleaved, up to seven consecutive samples can be interpolated. However, owing to the 8-frame spacing introduced by the second decoder, this is multiplied across 56 frames. A two-frame delay line enables a complete frame to be substituted if required, but this reduces the 56-frame capability by two, and delay lines in the recording circuits reduce it by five or six. So reliable interpolation can take place over 48 frames.

This corresponds to some 12,300 data bits or 7.7mm of track length. Distortion increases over the interpolated portion and the bandwidth drops from 20kHz to 10kHz. The maximum burst of errors that can actually be corrected is 4,000 data bits which corresponds to 2.5mm of track length on the disc.

## MUTING

Correction and interpolation will cope with the majority of defects and small blobs of dirt. If though a stream of uncorrectable errors occurs that exceeds the capability of the system, the last resort is muting. The gain is reduced so that the aural effect is that of a drop-out rather than a burst of noise which a stream of uncorrected errors would produce. The gain does not drop suddenly as this would produce harmonics and a sharp click. Instead the drop and rise follow a cosine curve. The drop starts from 32 samples before the error stream, and rises 32 samples after it.

## SMOOTHING THE STEPS

Following correction, the alternate rh and lh signals are separated and applied via filters to the two d-a converters. This though is not the end of the story. After conversion the analogue wave is in the form of steps at the original sampling frequency of 44.1kHz. These must be smoothed out to reproduce the original waveform, and to remove the harmonics of that frequency which could beat with others such as tape bias.

To cut frequencies of 44.1kHz and upwards, a filter of at least 50dB attenuation is required, yet this must have no effect on frequencies of 20kHz which is little more than an octave below it. This is a tall order and one of the principal headaches for the designer. Complex filters having the desired characteristics are likely to produce ringing or other spurious effects in the audio passband.

## OVERSAMPLING

One method commonly adopted for overcoming the filter problem is oversampling. With this, each sample fed to the d-a converters is electronically remembered and repeated before the next arrives. With twice the number of

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samples being presented to the converters, the frequency of the samples is obviously doubled, and the process is termed *two-times oversampling*. In many players the signal is repeated four times so giving *four-times oversampling*. The sample frequencies are thereby increased to twice and four times respectively that of the original sampling rate, that is 88.2 and 176.4kHz. The gap between these and the highest audio frequency is much greater than that between the original sampling rate and the audio band, so the filter can have a less steep slope, be less complex, and have less of an effect on the audio signal.

Of course, the number of samples actually recorded per second has not changed, only the fact that each is used four times (in the case of four times oversampling) in the conversion back to analogue. As it stands, this gives four successive identical samples, which means a level step at a quarter of the frequency, in other words we are back to square one with 44.1kHz steps and nothing has really changed.

Oversampling is therefore only effective if the intermediate steps that follow the first of a new sample are varied. One method of doing this as used by Philips is by means of what is called a transversal filter. (Fig.4.) This consists of 24 delay lines connected in series, each delaying the signal by one sampling period, so giving a total delay of 24 samples at the end. Part of the signal is tapped off at each line four times during each sample period, and it is multiplied by a constantly changing coefficient, then passed to an adding circuit. The products of sample and coefficient are thus added to each of the respective quarters of the preceding 24 signal samples.

The coefficient is a 12-bit word which is added to the 16-bit sample to make a 28-bit word (adding two binary numbers in this manner multiplies them). Its value is chosen for each sample so that the summation does not introduce any extra bits. By this means three intermediate values between the signal samples are obtained.

## 14 OR 16 BITS?

Early 16-bit decoders were quite inaccurate often tending to ignore or falsify the least significant couple of bits. Thus their resolution was no better than a 14-bit decoder, in fact they could be less accurate because their errors were not consistent. Another factor was that 14-bit devices operated much faster than the 16-bit. This permitted the use of oversampling which requires fast operating circuits to handle the high sampling frequencies. Some makers, notably Philips, therefore preferred to use an accurate 14-bit decoder with oversampling.

Quantisation noise is produced in the sampled frequency band which is pro-

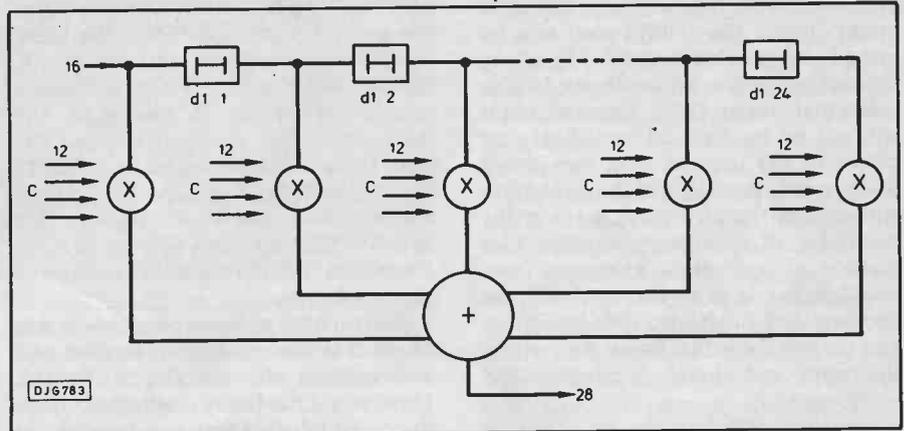


Fig.4. Transversal filter, signal is delayed for 24 sample periods by 24 series delay lines. Output from each is multiplied 4 times by 12-word constant, and added

portional to the size of the steps. If the step size is doubled by reducing the bit number by one, the noise level is also doubled, so increasing it by 6dB. Thus a basic 14-bit system has 12dB more noise than a comparable 16-bit one, actual values being about -84dB and -96dB respectively.

However, with four times oversampling, the noise is spread over a wider frequency spectrum, so that falling within the audio range is some 6dB less, bringing the noise down to -90dB.

When rounding off to 14 bits, there is a rounding off error which at low frequencies is almost the same as adjacent samples. At a sampling rate of 176.4kHz, most of the audio spectrum is at a comparatively low frequency. This error is stored for one sample period and added to the next sample in antiphase, thus virtually cancelling it out.

The effect is to reduce the distortion introduced by casting off two bits, and also reduce noise by some 7dB. Total noise thus becomes -97dB, marginally better than that of the 16-bit system. Of course noise levels of this order are swamped by the music signal and even by the ambience of the recording studio, so are really of academic interest only. However, it does show that by a little circuit ingenuity, 14-bit players can equal the performance of some using the full 16 bits. However, time marches on and so does technical development. 16-bit decoders have improved since those early ones and it should be expected that they will eventually become standard along with oversampling.

It may be thought that all this complicated messing around with the

signal, chopping it up, delaying parts of it, interleaving it, sticking in other bits and pieces, would surely produce a marked deterioration of the result. Well it certainly would if the signal was analogue, but this is the beauty of a digital system. It just records numbers that instruct the dna converter what to produce. You can play about with those numbers and record them any way you like providing they are assembled correctly at the end.

When considering these parameters though it must be remembered that there is a degree of overkill. The excellent BBC music fm transmissions use digital studio to transmitter links that employ only 13 bits and have a high frequency limit of 15kHz. As the upper limit of human hearing is 16kHz, and that only with young adults in their twenties, it can be seen that the cd system has been engineered to give better results than are really necessary.

Conditions in the recording studio, acoustics, microphone placements, and tape editing now have far greater effect on the reproduction than any factor associated with the cd player, other than an actual fault. The same is true for other parts of the domestic side of the system, especially the loudspeakers.

The stereo lp was in its day said by many to be the last word in domestic sound reproduction, so one has to be careful in making similar pronouncements for the cd. It is difficult though to see in what way it could be improved. But on reflection there is one thing. In spite of the mass production of discs and the millions sold, the cost remains far too high.

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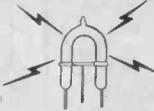


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Supply: 240V AC or 15-24V DC at 10mA. Size (excluding transformer) 9 x 4 x 2 cms. The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.

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- Size (excluding transformer) 9 x 4 x 2 cms.
- The companion transmitter is the MK18 which operates from a 9V PP3 battery and gives a range of up to 60ft. Two keyboards are available MK9 (4-way) and MK10 (16-way), depending on the number of outputs to be used.
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4002	13p 4087	32p 74LS42	32p 74LS245	50p 6820	140p 75161	400p 7824	35p	2v7 to 39V	6p
4006	36p 4084	80p 74LS47	50p 74LS246	50p 6821	140p 75162	700p 7905	35p	1.3W	
4007	13p 4085	48p 74LS48	56p 74LS248	50p 6840	310p 75172	700p 7912	40p	BZY98 RANGE	
4008	36p 4086	56p 74LS54	16p 74LS251	30p 6850	620p 75182	100p 7915	40p	2v7 to 39V	12p
4009	36p 4087	56p 74LS55	17p 74LS253	30p 6850	110p 75183	100p 7918	40p	1.3W	
4025	20p 4099	56p 74LS59	17p 74LS255	35p 8080A	400p 75188	60p 7924	40p	BZY98 RANGE	
4010	21p 4501	40p 74LS73	28p 74LS256	60p 8085A	300p 75189	50p 78L05	28p	1.3W	
4011	13p 4502	36p 74LS74	22p 74LS257	42p 8155	380p 75195	185p 78L12	28p	BZY98 RANGE	
4012	13p 4503	36p 74LS75	28p 74LS258	42p 8156	380p 75222	130p 78L15	28p	1.3W	
4013	19p 4504	32p 74LS76	28p 74LS259	58p 81LS96	120p 75224	340p 78L18	28p	BZY98 RANGE	
4014	35p 4505	55p 74LS78	28p 74LS260	48p 81LS96	130p 75235	155p 78L24	28p	1.3W	
4015	34p 4506	200p 74LS83	43p 74LS266	28p 81LS97	130p 75365	145p 78L05	45p	BZY98 RANGE	
4016	15p 4507	80p 74LS86	40p 74LS273	32p 81LS98	130p 75450	45p 78L12	45p	1.3W	
4017	31p 4508	70p 74LS90	32p 74LS280	40p 8224	270p 75451	42p 78L15	48p	BZY98 RANGE	
4018	31p 4510	37p 74LS91	70p 74LS290	60p 8226	270p 75452	42p 78L18	48p	1.3W	
4019	28p 4511	40p 74LS92	30p 74LS293	30p 8243	250p 75454	65p LM309K	100p	BZY98 RANGE	
4020	35p 4512	42p 74LS93	30p 74LS293	30p 8250	75480	135p LM317X	220p	1.3W	
4021	34p 4513	80p 74LS95	47p 74LS365	37p 8087	1100p 75481	60p LM317T	180p	BZY98 RANGE	
4022	36p 4514	75p 74LS96	60p 74LS366	37p 8251	330p 75482	60p LM322K	420p	1.3W	
4023	13p 4515	75p 74LS107	32p 74LS367	35p 8253	320p 8726	95p LM723	40p	BZY98 RANGE	
4024	25p 4516	40p 74LS109	34p 74LS368	38p 8256	310p 8728	110p 78H0KC	570p	1.3W	
4025	13p 4517	120p 74LS112	36p 74LS373	55p 8256	1200p 8731	330p 78H0SKC	800p	BZY98 RANGE	
4026	60p 4518	38p 74LS113	32p 74LS374	55p 8257	350p 8735	90p 78H12KC	700p	1.3W	
4027	18p 4519	35p 74LS114	38p 74LS374	58p 8259	360p 8736	110p 78J0JC	190p	BZY98 RANGE	
4028	29p 4520	38p 74LS122	400p 84LS390	50p 8271	340p 8737	90p 790JJC	215p	1.3W	
4029	35p 4521	90p 74LS123	42p 74LS383	45p 8272	1200p 8738	110p 79H0KC	800p	BZY98 RANGE	
4030	17p 4522	80p 74LS124	42p 74LS383	45p 8279	1200p 8738	110p 79H0KC	800p	1.3W	
4031	90p 4526	40p 74LS125	36p 74LS387	105p 8282	300p				
4032	54p 4527	44p 74LS126	36p 74LS387	110p 8283	300p				
4033	80p 4528	44p 74LS127	40p 74LS387	200p 8284	440p				
4034	80p 4529	75p 74LS133	34p 74LS387	280p 8287	380p				
4035	45p 4532	52p 74LS136	35p 74LS387	170p 8288	650p				
4036	180p 4551	80p 74LS138	35p 74LS387	72p 8748	1100p				
4037	75p 4553	190p 74LS139	35p 74LS387	40p 8755	1400p				
4038	48p 4555	29p 74LS145	85p 74LS387	270p AY3-1015	290p				
4039	190p 4556	36p 74LS147	120p 74LS387	300p AY3-3000	570p				
4040	36p 4557	190p 74LS148	90p 74LS387	300p SPO26AL2	500p				
4041	38p 4583	80p 74LS151	32p	280ACP1U	180p				
4042	30p 4684	30p 74LS153	40p	280ACP2U	180p				
4043	38p 4685	42p 74LS154	90p	280ADMA	650p				
4044	38p	74LS155	41p	280APD	220p				
4045	72p	74LS156	41p	280APQ	220p				
4046	45p	74LS157	30p	280APR	220p				
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4052	37p	74LS163	48p	280BCTC	480p				
4053	37p	74LS164	48p	280BCTC	480p				
4054	37p	74LS165	48p	280BCTC	480p				
4055	53p	74LS166	74p	280BCTC	480p				
4056	52p	74LS167	82p	280BCTC	480p				
4057	40p	74LS168	82p	280BCTC	480p				
4058	40p	74LS169	82p	280BCTC	480p				
4059	13p	74LS170	80p	280BCTC	480p				
4060	40p	74LS171	80p	280BCTC	480p				
4061	40p	74LS172	80p	280BCTC	480p				
4062	40p	74LS173	80p	280BCTC	480p				
4063	52p	74LS174	39p	6502A	400p	74LS387	200p		
4064	20p	74LS175	42p	6502C	930p	75107	80p		
4065	13p	74LS176	15p	6502D	930p	75107	80p		
4066	13p	74LS177	15p	6502E	930p	75107	80p		
4067	13p	74LS178	15p	6502F	930p	75107	80p		
4068	13p	74LS179	15p	6502G	930p	75107	80p		
4069	13p	74LS180	15p	6502H	930p	75107	80p		
4070	13p	74LS181	15p	6502I	930p	75107	80p		
4071	13p	74LS182	15p	6502J	930p	75107	80p		
4072	13p	74LS183	15p	6502K	930p	75107	80p		
4073	13p	74LS184	15p	6502L	930p	75107	80p		
4074	13p	74LS185	15p	6502M	930p	75107	80p		
4075	13p	74LS186	15p	6502N	930p	75107	80p		
4076	13p	74LS187	15p	6502O	930p	75107	80p		
4077	13p	74LS188	15p	6502P	930p	75107	80p		
4078	13p	74LS189	15p	6502Q	930p	75107	80p		
4079	13p	74LS190	15p	6502R	930p	75107	80p		
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# BATTERY DRIVEN MAINS AND HT CONVERTERS

PART TWO BY GEORGE KERRIDGE

## FAILURES ARE MAINLY CHARGEABLE

*Car batteries pack a lot of punch and can readily become a versatile power source for short mains failures.*

The oscillator circuits looked at so far in part one are all suitable for use in situations where the oscillation frequency is relatively unimportant. As we have just seen such situations can arise where, for example, the end product needed is not an alternating voltage, but a very steady high voltage dc.

### 50HZ SUPPLY

Let's now move on to a circuit that can be used for driving low power 240Vac mains equipment and which requires an accurately controlled 50Hz frequency.

Certainly any of the oscillators shown can be set to run at 50Hz, but the accuracy with which they can be set and maintained at that frequency is less certain than it perhaps should be. Ideally, we need a very accurately controlled 50Hz source. One way is to use a crystal controlled oscillator. This can drive a sequence of sub-dividing counters, either as multiple chips, or as a chip specifically designed for this purpose.

One such readily available chip is the M706B1. (Fig.18). This is a cmos device designed for use as a 50Hz timebase. To achieve this, a 3.2768MHz crystal is connected across two of the pins, together with a couple of capacitors and a resistor. Circuitry within the chip subdivides the 3.2768MHz clock down to 50Hz. This appears at two outputs as squarewaves of opposing phase. The typical current available at the outputs is only about 7.5mA, but this can be used, via current limiting resistors, as the trigger source for controlling transistor driven transformer windings, as in Fig.8, of part one, for example. It can be operated from a power supply with a range of 7Vdc to 15Vdc.

### BATTERY POWER

One point that so far has not been mentioned is the amount of charge avail-

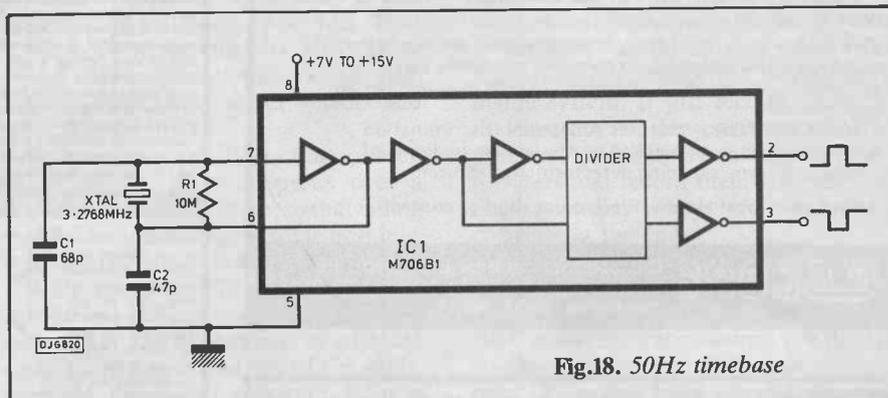


Fig.18. 50Hz timebase

able from a battery. It is all very well having a battery to mains converter designed to deliver many amps to all the necessary equipment, but the battery power source is limited.

A battery is quoted as having a charge capacity of so many amp-hours. This means that when fully charged it can deliver that many amps for that many hours. A car battery for example may deliver 12Vdc at 40 amp hours. It should therefore be capable of supplying 12Vdc at one amp for 40 hours, or 40 amps for one hour. During this discharge time though, the voltage will not remain at precisely 12V (even if it was ever at 12V since it could have started off a volt or so higher than this when fully charged). The delivered voltage will gradually fall during use, and so the final converted ac voltage will drop accordingly.

A unit converting 12Vdc to 240Vac to run, say, a 100W lamp, will need a minimum current input to the converter of at least 8A and probably more. The light bulb will thus work for less than five hours with a 12V 40A hr battery. That is excellent for just a short power cut, but the cuts that some of us in the SE experienced in October 1987 far exceeded five hours.

Obviously there is no reasonable possibility of using a car battery to mains converter to power all the lights and other preferred household equipment. It is reasonable though, to use a dc to

ac converter just for minimal power consumption for a short period of time. Limiting lamp wattage to just 15W at selected areas of the house is one possibility. (In reality, its probably better to use a car bulb powered direct from a spare car battery for many lighting situations).

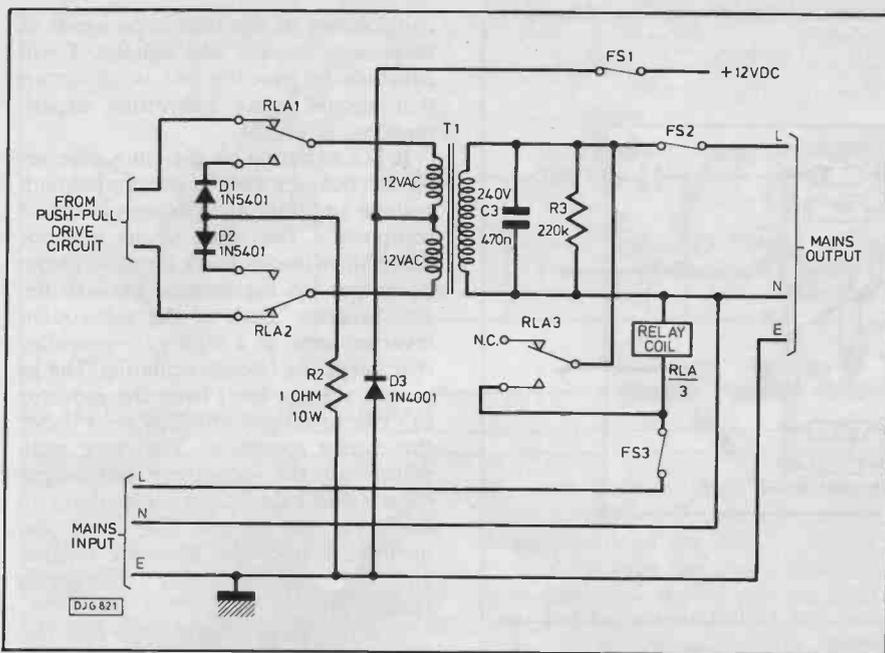
Battery to mains converters are also of considerable use for perhaps powering equipment which it is vital to keep running for a short period of time. One such item is a computer, though the power requirement may be heavy. Other suitable candidates for power backup are alarm clocks, telephone answering machines, and even fish tank heaters.

This brings us to the next possibility, that of automatically switching over to a backup supply if power does fail.

### CHANGEOVER

Considerable thought was given to possible circuitry for automatically switching a battery to mains converter on and off as required. Several options for the use of thyristors in changeover configurations were explored, but I eventually decided to opt for the simpler, and cheaper method of using a relay for the purpose.

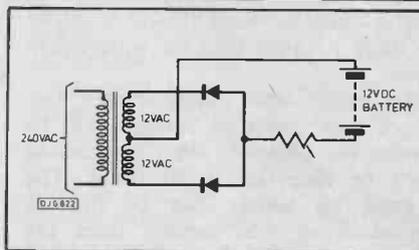
Though relays suffer from a fractional time lag in switching over, they have the beauty of attaining absolute isolation of one circuit from another. Their practice



**Fig.19.** Use of relay for automatic changeover operation

is also more readily understandable for those whose knowledge of electronics is only rudimentary.

Fig.19 shows a suggested relay change-over circuit. The relay coil is of the mains operated type, and only becomes active in the presence of mains supply current. When mains is available the relay contacts switch the live mains line to the output socket. Two other contacts switch the transformer primaries out of circuit from the drive transistors, or darlingtonts, and across to two diodes acting as bridge rectifiers. In this mode the mains voltage appears across the 240Vac winding of the transformer and current is transferred to the two 12Vac windings. These pass power through the diodes and resistor to ground. Since the centre tap of the 12Vac windings is connected to the positive line from the battery, the effect is that the battery is put on trickle charge via the resistor. This is a slightly unusual way of doing things, but it works. Fig.20 shows the equivalent circuit.



**Fig.20.** Equivalent battery charge circuit

12Vac windings back across the driving semiconductor. This is a good example of the point I made earlier, that a transformer can work in both directions.

Although the oscillator will be operational in either mode, and so consume a small amount of current, the drain is immaterial when the battery is on trickle charge. It also means that the oscillator is immediately ready for control the instant that mains power fails.

## MAINS CIRCUIT

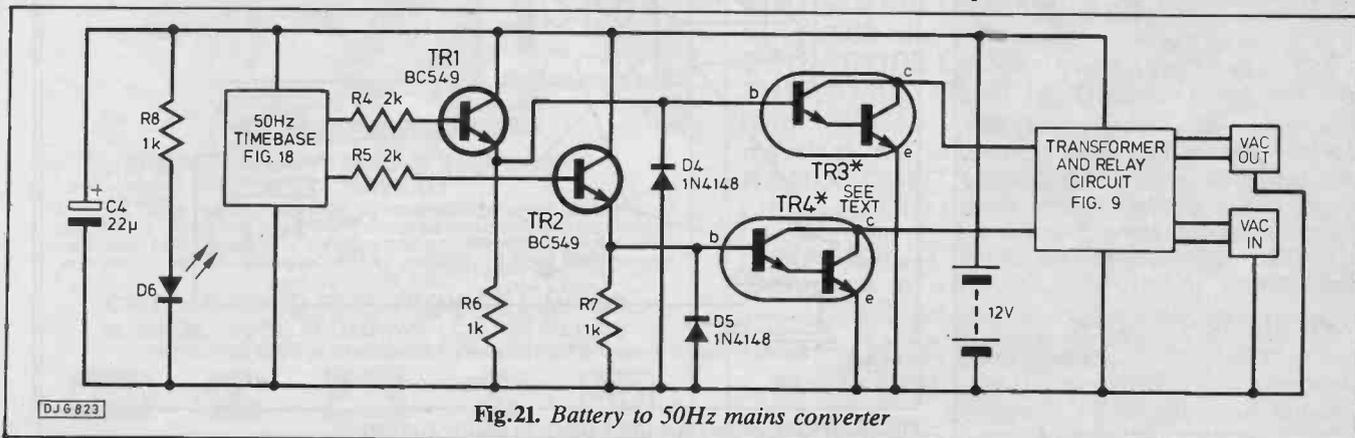
Since there are so many options and circuits for generating ac voltages and high level dc supplies, I am only showing a printed circuit board for the simple substitute mains supply.

The circuit as shown in Fig.21 consists of the 50Hz timer in Fig.18, a darlington drive circuit, and the transformer and relay circuit of Fig.19. Two additional current amplification transistors, TR1 and TR2, are used between the two, enabling the use of darlingtonts capable of sinking up to 20A each from a 12Vdc supply. With the correct choice of transformer, the final output could supply up to about 200W at 250Vac rms. (To achieve the full current rating of TR3 and TR4 it may be necessary to change TR1 and TR2 for types capable of delivering greater drive current).

Note that the oscillator and the centre tap of the transformer could be fed from different batteries if preferred. The transformer supply may also be at a higher voltage level than the oscillator if the situation demands (but not at a lower one). For example, the main current might need to come from a 24Vdc battery, in which case the transformer and darlingtonts must be selected to suit the supply. The oscillator would then run from another dc supply between 7V and 15V, provided that this is equal to or less than the main battery supply.

The automatic changeover circuit has not been allowed for on the pcb shown in Fig.22 and the relay should be fixed to the case chassis. If the relay is not used, the relevant links on the pcb should be connected. Although the darlingtonts are mounted on the pcb **THEY MUST ALSO BE BOLTED TO HEAT SINKS, OR TO THE CHASSIS. IT IS ESSENTIAL TO USE INSULATING WASHERS** between them and the chassis to prevent them shorting out the supply. The battery charger diodes D1 and D2 may get warm during charging and so should be mounted slightly above the pcb. R2 will probably be supplied in a heat sink mount and should be bolted to the case.

Two other important points are that the diodes on the base of each darlington should be included to suppress inductive spikes. The capacitor and its associated resistor across the 240Vac winding must also be included for similar reasons. It should also be noted that despite the capacitor and inductive nature of the



**Fig.21.** Battery to 50Hz mains converter

# BATTERY DRIVEN MAINS

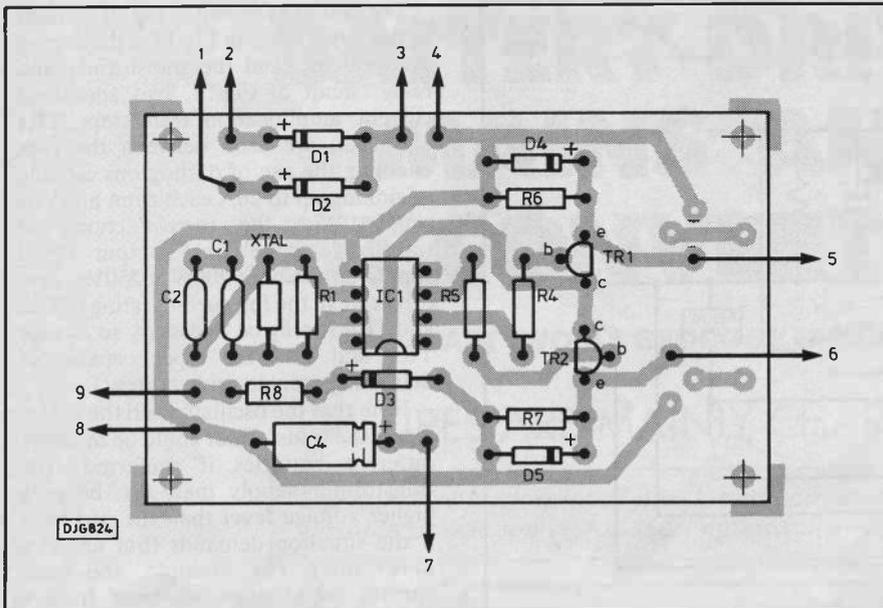


Fig. 22. Pcb layout for the battery to mains converter

## COMPONENTS

### RESISTORS

R1	10M
R2	1Ω 10W
R3	220k
R4,R5	2k (2 off)
R6-R8	1k (3 off)

### CAPACITORS

C1	68p
C2	47p
C3	470n 250V min wkg.
C4	22μ16V (or larger)

### SEMICONDUCTORS

D1,D2	IN5401 3A 100V (2 off)
D3	IN4001 1A 50V
D4,D5	IN4148 (2 off)
D6	led
TR1,TR2	BC549 or similar npn (2 off)
TR3,TR4	MJ1004 175W 20A npn darlington, or TIP132 70W 8A npn darlington, or select to suit needs (see text). (2 off)
IC1	M706B1 50Hz time base

### MISCELLANEOUS

XTAL	3.2768MHz crystal
T1	0-12V 0-12V transformer at current to suit needs, max 20A

FS1-FS3 Fuses and holders to suit current (3 off)

Mains input and output sockets, 12V heavy duty battery, heat sinks to suit TR3 and TR4, relay 240Vac 3pc contacts to suit current, battery input socket, case to suit, connecting wire to suit currents concerned, printed circuit board 286A.

### CONSTRUCTOR'S NOTE

The PCB is available from Phonosonics, 8 Finucane Drive, Orpington, Kent, BR5 4ED.

transformer, the output waveform will not be a pure sinusoid, though it will be far more rounded than the squarewave input.

**Remember when testing or using this circuit that mains ac voltages will be present and adequate safety precautions must be observed at all times. The stepped up supply can be just as hazardous as that coming from the normal mains. If in doubt seek qualified advice.**

## EXPERIMENTAL BOOSTER

I have shown a fair selection of possible circuits for generating both ac and dc high voltage supplies from a battery source. Any of the circuits can be modified by using alternative

components to suit individual needs of frequency, current and voltage. I will conclude by showing one other circuit that should make interesting experimenting, in Fig. 24.

It is a variation on the cmos inverter circuit, but uses a ferrite inductor as both voltage amplifier and frequency control component. The value of the inductor determines the feedback frequency from its output via the resistor back to the first inverter. Each of the subsequent inverters acts as a high gain amplifier that keeps the circuit oscillating. The ac output voltage level from the inductor can rise to several hundred volts under the correct conditions. The three main factors are the inductance and output capacitance values, and the load put on the inductor's output. The load also includes that of the feedback resistor, and of any attached monitoring equipment.

It will appear at first sight that this full voltage will appear at the input of the first inverter. In practise the swing at that point is only a few millivolts due to the limiting factor of the resistor.

It is a circuit worth experimenting with. Try varying the inductance, capacitance and resistance values, as well as the output load applied. Be sure to keep the suppressing diode in circuit prior to the inductor to avoid killing the chip — the inductor could produce an adverse voltage at the input to the inductor if a significant current or voltage change occurs on the inductor's output. It's best to have a spare chip or two available in case of experimental mishaps! The variable resistor is used to vary the maximum output level from the inductor.

This last circuit is one which I have used as the ht source for powering an

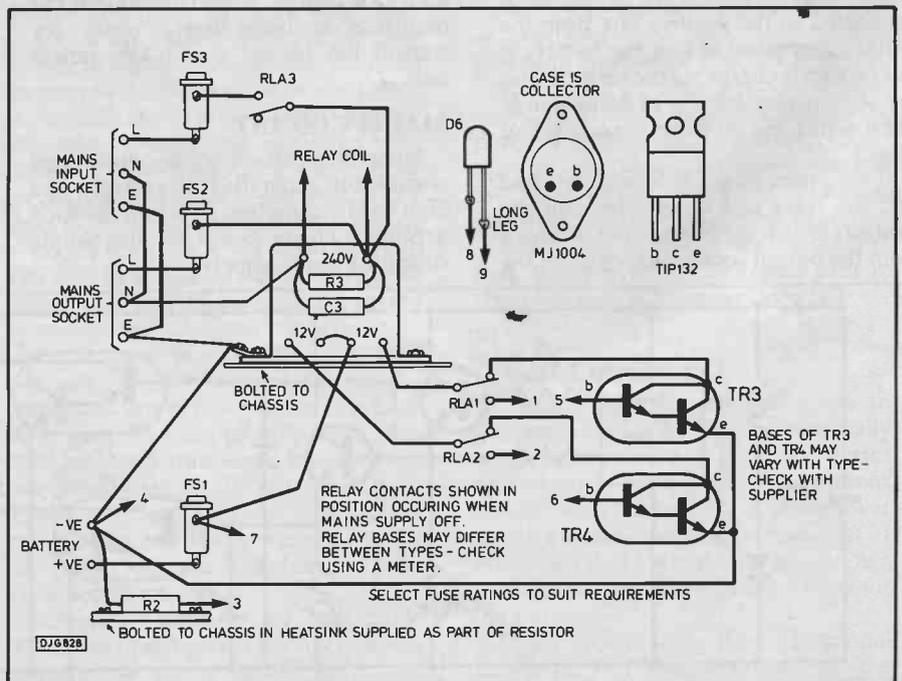


Fig. 23. Wiring details for the battery to mains converter.

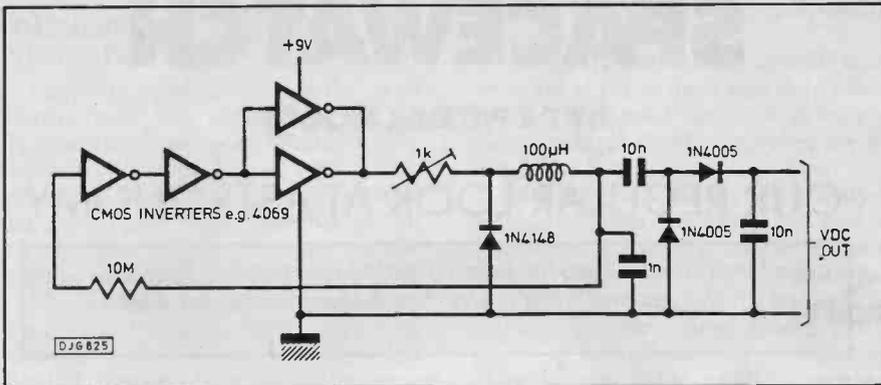


Fig.24. Experimental dc to ht generator

experimental geiger counter. There are probably other uses for it where a high voltage is needed at only a very low current. The final ht can be further boosted by feeding the output to a voltage multiplier circuit, like those in Fig.16. One area in which a negative ht version might be exploited is in air ioniser circuits.

## SUPERCHARGED

What ever application you have in mind for battery to ht generators I hope that I've given you food for thought. Remember, though, to keep your batteries charged!

PE

## SUB-AQUA TV

Scuba diving and watching nature programs on tv are a couple of my many addictions and so it was with great interest that I followed the Reefwatch programme on BBC1 in May. The waters off Eilat are famous for their clarity and variety of colourful sealife, and the live underwater tv images were superb.

I was also interested to see how the deeper the cameras went so, as divers will know, the red end of the colour spectrum gradually diminished. At one point it seemed that the divers were getting very deep and I was beginning to speculate on the length of the camera cables.

The scene then cut back to the surface and it looked as though night was falling. In the middle of the day?

My mind then surfaced as well and it dawned on me that it was the Box at fault and I could smell that old familiar "something's shorting!" aroma. With wife about to wail "thar she blows" I dived for tv mains plug before Armageddon acquired domestic relevance. But no burning fiery furnace was about to erupt - it was a leaking flower vase on top of the tv robbing the Red Sea of its ordained hue. Through a crack narrower than Moses' parting, water was seeping through the vase and trickling deep down among the circuits. And into the

pot that presets the red balance, which was progressively losing track of its intended resistance.

Fan heaters can be a vital part of workshop repair gear (nearly as important as a hammer) and a couple of hours of forced warm draught reinstated the drought conditions preferable to hitech vision. Thankfully, the screen returned to its rainbow tints without a trace of water colour. Can't help but wonder, though, how many tv engineers make their living because of leaking floral displays on top of goggleboxes. And I guess their maintenance manuals must be brimming with flow charts ...

Ed.

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# SPACEWATCH

BY DR PATRICK MOORE

## OUR REGULAR LOOK AT ASTRONOMY

*The family castle is up for sale, Hubble faces trouble in space and on the ground, and a star has been discovered which is about to vanish ...*

Despite the virtually unanimous opposition from all astronomers, Herstmonceux Castle has finally been offered for sale, and there now seems no hope of retaining it as the site of the Royal Greenwich Observatory. The RGO itself is to move to Cambridge. Presumably the priceless Library and archives will be either pigeonholed or (more probably) dispersed; the Exhibition will dismantled; the training of young astronomers will cease, and what will happen to the telescopes of the Equatorial Group is anybody's guess. Neither do we know the cost to the country, though £6,000,000 is a reasonable estimate. What the advantages are can be explained only by the Science and Engineering Research Council!

As one staff member of the RGO said, the only course now is to salvage what can be salvaged from the wreck. It has

been said by the SERC that the Royal Greenwich Observatory will remain a separate unit. Pessimists forecast that within a few years it will quietly vanish, to be absorbed into the astronomy department at Cambridge University. Time will tell.

On a brighter note, NASA has announced that it proposes to start planning two important space missions for the 1990s. One is a rendezvous with a comet and an asteroid. The other is the Cassini mission to Saturn (named in honour of the Italian astronomer G.D. Cassini, the leading planetary observer of the 17th century, who discovered the Cassini Division in Saturn's rings as well as four of the planet's satellites, Iapetus, Rhea, Dione and Tethys). The Cassini mission will pay particular attention to Titan, which I discussed in my article last month.

Pulsars continue to surprise us. The

latest novelty is a pulsar in Sagitta, PSR 1957+20, which has been studied from Arecibo by a team consisting of A. Fruchter, D. Stinebring and J. Taylor. It is a rapid pulsar, rotating 622 times per second, and every 9 hours is eclipsed by an invisible companion, remaining obscured for 45 minutes. Apparently the invisible companion has a diameter  $1\frac{1}{2}$  times that of the Sun, but no more than 3 per cent of the solar mass; the two components are very close together, and the companion may be a 'brown dwarf', intermediate in type between a true star and a Jovian planet. It is suggested that its outer layers may be in the process of being stripped away by the pulsar and dissipated in space, so that eventually — in no more than a thousand million years or so — the companion may have been completely destroyed. The idea of an evaporating star is certainly new, but it does seem to be a strong possibility.

## The Sky This Month

The summer of 1988 is a reasonably good time for planetary observers. Venus dominates the morning sky, and by the end of July it rises about two hours before the Sun; it is then far brighter than any other celestial object apart from the Sun and the Moon, and will be about 40 per cent illuminated. Also in the morning sky are Mars — still rather low, but brightening steadily — and Jupiter, which will have risen by midnight. Mercury is officially a morning object, though it is so far south of the celestial equator that British observers are not likely to see it with the naked eye.

Saturn, which reached opposition last month, is still very much in evidence, and the rings are wide open, though unfortunately the planet is inconveniently low down, and southern observers have the best of matters (as so often seems to happen!).

The Moon is new on July 13, and full on the 29th. There are no solar or lunar eclipses this month.

The annual Perseid meteor shower begins at the end of July. This will be a favourable 'Perseid year', because when the shower is at its peak, around August 12, the Moon will be new and will cause no interference. I will have more to say about the Perseids next month.

Among the stars, the evening sky is graced by the so-called Summer Triangle, with the brilliant blue Vega almost overhead after dark and the other two members of the Triangle, Deneb and Altair, also very much in evidence. The three are at very different distances from

us. Altair is  $16\frac{1}{2}$  light-years away, Vega 26 light-years and Deneb as much as 1800 light-years. It follows that Deneb must be the most luminous, as indeed it is — perhaps 70,000 times as powerful as the Sun.

It is interesting to reflect that so far as Deneb is concerned, the Earth is still 'radio quiet', and will remain so for well over 1500 years yet; but to Altair and Vega, we are already 'radio noisy'. If we assume the highly improbable — that there are inhabited planets in these two systems, and that they have radio receivers capable of picking up our transmissions — denizens of Altair will now be receiving our broadcasts of 1972, while those of Vega will be receiving our broadcasts of 1962.

Actually, Vega is one of the stars found to have a huge infra-red excess, indicating the presence of cool material which may be planet-forming. Altair is different, and is distinguished by its very rapid rotation; even though no telescope will show it as anything but a speck of light, we know it to be egg-shaped.

During July evenings the Great Bear is in the north-west, while this is the best time to see Antares, the red supergiant in Scorpius, and the lovely star-clouds of Sagittarius which hide our view of the mysterious centre of the Galaxy. In the east, the Square of Pegasus is starting to come into view by midnight. Arcturus, the brilliant orange star in Boötes (the Herdsman) is still prominent in the north-west; to find it, follow round the 'curve' of the Great Bear.

## THE HUBBLE TELESCOPE: NEW MISGIVINGS

Scientists everywhere await, with impatience, the launchings of the Hubble Telescope — a reflector with a 94-inch mirror, to be put into a path round the Earth. Operating from above the atmosphere, its performance will far surpass that of any telescope on the surface of the Earth.

The Hubble Telescope should have been in orbit long before now. Like everything else, it was delayed by the Shuttle tragedy. New schedules were announced regularly — and, just as regularly, revised. The situation was akin to that experienced by passengers awaiting the departure of a British Airways flight 'delayed by the late arrival of the incoming aircraft', though with the Hubble Telescope the delay

amounted to months or years instead of hours!

Now, the launch date for 1989 has been questioned yet again. There could be a further prolonged delay. And in any case, there is another problem to be faced: the Sun.

Solar minimum is past, and activity is picking up again; during the first part of 1988 there have been several major spot-groups, one of which produced a good display of aurora. It is never easy to forecast the time of maximum, but it looks as though we may be thinking about 1990 or 1991 — just the time when the Hubble Telescope will be in full operation. But as is well known, increased solar activity makes the Earth's upper air expand, and the density at any set level increases, which also means increased drag (this is why the Skylab space-station came down

before NASA expected, scattering fragments over Australia, though it must be added that our own expert, Desmond King-Hele, had given ample warning). If there is a marked increase in atmospheric density at the altitude of the Hubble Telescope, there may be a need for 're-boost' after only a few months in orbit, which would cause serious complications.

What are the alternatives? It may be that the Hubble Telescope can be put into an orbit higher than that originally planned. It may be that the danger is less than feared. On the other hand, there is always the chance that the launch will have to be put off until after solar maximum. The trouble here is that the telescope itself is already deteriorating because of the long delay. Indeed, the scientific consequences of the Shuttle disaster have been dire. **PE**

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## Ring in the View

View-as-you-chat has come a step closer according to recent report from the Far East. It seems that Japanese manufacturers have come to an agreement on standards for video telephones.

Mitsubishi and Sony have already introduced video phones, which although currently conforming to

different formats, will eventually comply with the new agreement.

It seems that live video pictures of callers are still some way off and that the present technology only allows for single still pictures to be transmitted. The restricted bandwidth of domestic telephone lines limits the transmission rate to between five and six seconds, and apparently the users must not speak

during picture transmission.

For the moment I feel that video phones will have more novelty value than practical purpose. Once they become higher quality real-time systems they will undoubtedly find wide spread appeal. In the meantime I am thankful that I can still answer a phone early in the morning without having groped for a razor first. **Ed.**

# I DON'T ALWAYS AGREE

BY WAYNE GREEN

## VIDEO MAY TURN THE PAGE OF HISTORY

*Disagreement often results from misunderstanding. With the aid of video text books low cost education could breach the frontiers of illiteracy and ignorance, broadening the horizons of knowledge*

**"I DON'T ALWAYS AGREE ..."**  
That's the chorus of my readers here across the Pond. "I enjoy your articles but I don't always agree with them."

I want to know "why the hell not?". If readers don't agree, is it because I'm wrong ... or are they? Now, if they've done their homework and have the facts to prove I'm wrong, I want to know about it. Or am I up against them substituting conviction for information? It's a great deal easier just to believe in something than to understand it. Perhaps that's why you don't see many scientists in politics.

### SPEAKING IN POLITICS ...

You may recall that recently I ran for Vice President of the USA, in the New Hampshire primary. Pulled 32,000 votes — more than many names you'll know in Britain. More than DuPont, Gephardt, Jackson, Hart, and so on ... Ha!

They spent zillions in tv promotion and advertising — I spent zilch, merely going around the State, speaking to Lions, Rotary, Chambers of Commerce, etc, explaining the need to revamp education and build electronics and computer clubs as a way to get youngsters interested in technology and communications. You in Britain could learn a thing or two as well.

### QUALIFYING EDUCATION

Education, I feel, is America's most serious problem. The latest national Science Foundation report states that the education provided to American kids puts the US dead last in a 13-country list. There are many things which need to be done to improve the American education system, and yours too I'll bet. My proposed electronics course being but one.

My proposal even gets around the lack of qualified science and maths teachers — which could add a minimum of ten years to any teaching project. US teacher's groups have been fighting off technological aids to education with surprising success. I'd encourage the development of home education and



educational support systems — testing new ideas and using those that work the best. I'd sure want to encourage the development of a series of videos to help people get their education certificates — to help functional illiterates learn to read and write, even to pursue special interests.

### VENI, VIDEO, VICI

Once we've teaching systems that work, we'll be ready to start selling these to other countries — in English and in the native language. This could make it possible some day for even the smallest country to provide a high quality education from the first grade right through college graduate work, and at a reasonable cost. Now that could really change the whole world!

Having visited many third world countries and talked at length with electronics diy-ers living in them, I'm familiar with their special problems: educational, political, social. I know of no simpler solution than education to what ails these countries.

A first class, low cost education would be far more valuable than economic and military aid, and incredibly less expensive. Though it wouldn't be all that popular with many dictators.

If we can get the fundamentals of

electronics into our schools we'll be on the road to regaining our lost consumer electronics industries back from the Far East. Perhaps if we can get more kids interested in the excitement of amateur electronics, we can break the pattern of mediocrity that locks so many people into lives of so little value to themselves and the world. Perhaps, if we try, we can rescue kids from turning into human plankton and turn them into scientists.

### PRACTICAL VIDELECTRONICS

Let's imagine the text book of 1999, less than eleven years from now. I see it as a monthly video magazine, making it possible for the material to be up to date in a way never even imagined for text books. In the monthly text on the fundamentals of electronics is a chapter on how alternating current was invented by Nicola Tesla — the brilliance of his idea and how it solved the problems of delivering electricity over long distances.

Another chapter might discuss the foundations of computer languages and chip instruction sets. Then there'd be a column on project building suitable for kids of any age, maybe even a review of some new superconductivity kit, or whatever the latest discovery is by then. Of course there'd be a column on school computer clubs — perhaps encouraging them to network with other school clubs via ham radio or the phone. I'll bet we could generate a generation of science hobbyists.

### DXING ELSINORE?

Of course this could unleash a lot of new hams and cb fanatics. With millions of kids in each grade, all exposed to the ham virus via a ham column, who knows? We might have a million hamlets running round with df gear, going on treasure hunts every weekend. Other kids would be doing videos for fun to swap with other school video clubs ... making more hams. Young hams would be expanding our satellite communications, setting new records for miles per watt, working hundreds of countries

CONTINUED ON PAGE 53

# SEMICONDUCTORS

## PART 9: PRACTICAL THYRISTORS AND TRIACS BY ANDREW ARMSTRONG

### TRIGGERING CIRCUITS

*In many triac applications, circuitry kept at earth potential for safety generates the mains control signal via a triac. Several ways of isolating the signal circuitry are possible, and in some cases isolation is not required at all.*

Part 8 published last month considered only the theoretical aspects of thyristors and triacs. This month we shall look at some practical circuits and building blocks.

First of all, I shall return to the gto (gate turn off) thyristor. The triggering waveform shown last month was highly idealised, and in practice nobody would bother to generate such a waveform. The negative signal needed to switch off a gto can be generated easily and automatically by using a pulse transformer.

Switching on the current to the trigger transformer produces a positive signal on the secondary of the transformer, and this triggers the gto. When the gto must be switched off, the current to the primary of the pulse transformer is switched off, and the resulting back emf on the secondary switches off the gto. It is important to connect the pulse transformer with the correct polarity.

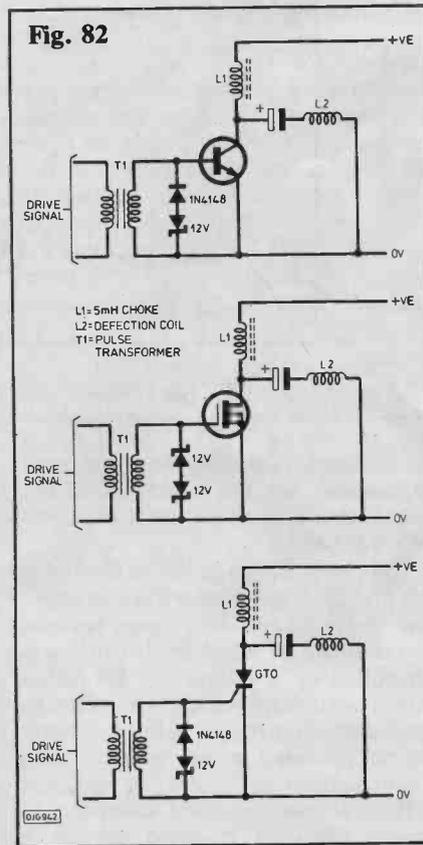
Fig.82 shows a horizontal deflection output stage for use with a small cathode ray tube. The section of circuitry is shown three times for comparison, with a bipolar transistor, a power mosfet, and a gto. The zener diodes to limit the voltage spike are beneficial in each case, but note that the power mosfet does not need an antiparallel catch diode.

In each case the negative voltage generated on the output of the pulse transformer when the primary current is switched off is useful. It removes charge from the base region of the transistor, or discharges the gate capacitance of the power mosfet, or switches off the gto.

This is a particular application for which three very different devices are all suitable. It is likely, however, that for higher powered circuits of a similar type the gto would be most suitable. On the other hand, the switching speed of the gto is limited, so that at higher frequencies such as those encountered in switched mode power supplies the gto would not be suitable at all.

#### ISOLATION

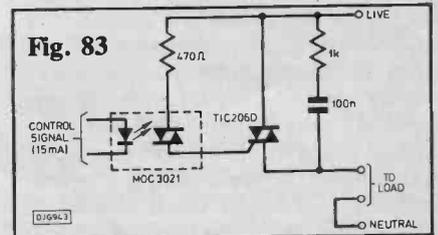
A more important aspect of the pulse transformer is that it provides isolation between control circuitry and high volt-



age circuitry. Pulse transformers are often used to separate triggering circuitry from triacs connected to the mains. It is even possible to connect the triac in series with the live connection to the load instead of the neutral one, thus slightly enhancing the safety of the circuit.

A word of warning here. Though it is safer, if all else is equal, to connect a triac in the live rather than the neutral line, a triac cannot be relied on to isolate a load from the mains for safety purposes.

Another means of isolating control circuitry from the mains is to use an opto-isolated triac. For low currents the opto-isolated triac can do the work on its own, otherwise it may be used to trigger another, more substantial device. This application is illustrated in Fig.83.



Some opto-isolated triacs incorporate zero level triggering circuitry, so that they will only switch on near to a mains zero crossing, and thus avoid generating interference. It is, of course, impossible to phase control a load using this type of isolator.

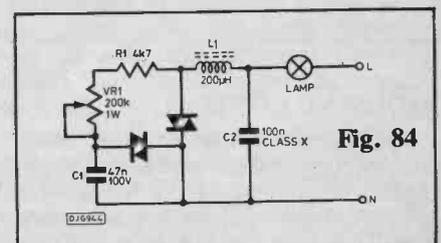
To assist in choosing thyristors and triacs, three tables of data are included at the end of the text. Table 5 covers thyristors, Table 6 covers triacs, and Table 7 covers optoisolated thyristors and triacs.

#### DIMMERS

One application in which isolation from the mains is not normally a requirement is the light dimmer. In this application, safety isolation is provided by the plastic spindle of the control potentiometer. Most domestic light dimmers are housed in plastic cases which provide adequate protection from live circuitry.

Domestic lamp dimmers use an rc network to provide a phase shifted signal derived from the 50Hz mains. The signal is used to trigger the triac via a diac.

A diac is very much like a triac but without the gate terminal. It is made in such a way that it will break down and trigger itself when approximately 30V appears across it in either direction. The circuit shown in Fig.84 illustrates this principle. When the voltage on C1



reaches 30V the diac switches on and discharges C1 into the gate of the triac. This switches the triac on, which in turn switches on the lamp. Once the triac is switched on, no further current flows in R1 and VR1, so minimising their dissipation.

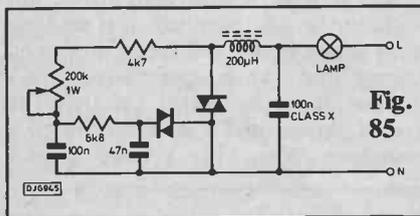
Clearly, the sooner that the triac can be triggered during a mains half cycle is when the mains voltage has risen to just above 30V. This means that there is a small part of the mains cycle during which the triac cannot be triggered. This is not a serious handicap, because very little energy is contained in this tiny fraction of a cycle. Furthermore, if the triac were to be triggered by a brief triggering pulse such as would be generated by the discharge of C1 via the diac, it would not remain on. At very low voltages the load current would not reach the holding current of the triac.

Note that this circuit includes suppression components to filter out interference which would otherwise be transmitted down the mains wiring. The time constant of L1 and C2 is chosen to reduce ratio interference to levels which would normally not cause a problem. Omission of these components would result in serious radio interference. The interference would be at its worst when the triac is triggered at the peak of the mains half cycle, ie approximately 340V.

This simple light dimmer circuit suffers from a hysteresis effect. The problem is that not all the charge is removed from C1 between one trigger pulse and the next. Consequently the trigger point on one half cycle affects that on the next and so on.

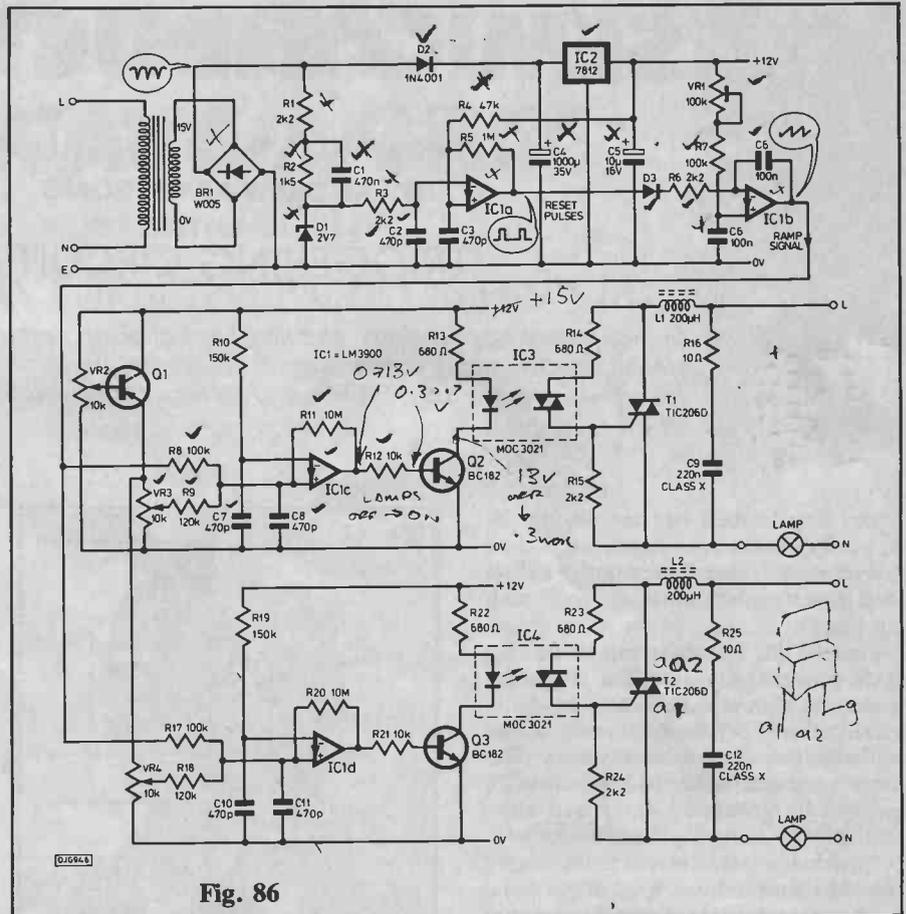
The amount of charge remaining on C1 at the end of a half cycle depends in part upon the load resistance. The load is a lamp whose resistance depends upon its temperature. You see the hysteresis effect in the following way: the lamp dimmer must be advanced to a substantial brightness setting before the lamp comes on. Then the dimmer may be backed off to achieve a lower brightness level.

The circuit shown in Fig.85 uses an extra rc time constant to improve the situation. This circuit provides smoother control.



## ISOLATED CONTROL

As mentioned earlier, it is often necessary to operate control circuitry at earth potential, while the triacs being controlled are connected to the mains. There are many different approaches to



the problem, depending on the precise application, but the method with the widest usefulness is probably the opto-isolated triac.

The circuit shown in Fig.86 illustrates this principle, using opto-triacs to phase control two lamps. This design features two channels in which the brightness is controlled by a voltage. In the circuit shown the control voltage is provided by two potentiometers, with a master control provided to dim both channels simultaneously.

If this principle were extended to further channels it could provide a simple stage lighting unit. If instead the control voltages were derived from audio signals then the design could provide a very effective sound controlled light unit.

The principle on which the unit operates is to generate a repetitive ramp waveform synchronised to the mains. The ramp generator is reset around the mains zero crossing, and continues to ramp up until the next reset pulse. The ramp and the brightness control signal are added together via two resistors to produce a current to feed into the input of a Norton opamp. This current is compared with a current fed into the other input of the opamp. The size of the ramp is adjusted so that the ramp on its own does not quite switch the comparator, even at its tip. The addition of just a small brightness control signal causes the comparator to switch near the

tip of the ramp, and bigger brightness control signals cause earlier triggering.

The top part of the circuit is the power supply and ramp generator. IC1a is used as a comparator to generate reset pulses whose timing is determined by the rectified but unsmoothed dc on the output of the bridge rectifier. D2 serves as a blocking diode to permit smooth dc on one side and unsmoothed on the other.

Because the timing information is derived via a mains transformer, rather than straight from the mains, this is not necessarily in perfect phase with the mains. Typically mains transformers give between 5° and 10° phase lag. This can cause problems if a very narrow reset pulse is used, because the tip of the ramp can trigger the triac on the mains half cycle *after* the one on which the ramp started. To avoid this problem a certain amount of phase advance is given by C1.

D1 limits the voltage excursion to a level which will not damage the input of IC1a and both inputs of the opamp are protected from interference by 470pF capacitors. The net result is a clean ramp reset pulse with the correct timing. This pulse is used to reset an integrator which ramps up to approximately 7V during one half cycle.

At first sight the integrator may look a little strange; this is because the circuit is using a Norton opamp, whose inputs operate on current rather than voltage. That is to say that the output voltage of the opamp is equal to its gain times the





For example, if the voltage drop across an SSR is 1.5V, and it is controlling a 30A circuit, the power dissipation will be 45W. A device of this nature is likely to be used in an industrial situation where the ambient temperature may be as high as 40°C. Typically, a maximum case temperature of 80°C may be specified, to achieve which requires a heat sink of better than 1°C/W heat sinking capacity.

One more device which we must mention is the Chipswitch made by International Rectifier. This is a type of solid state relay which uses back to back optically coupled high voltage switching ics whose switching element is a power

mosfet. These devices can withstand higher voltage slew rates than triacs without breaking down. They are available in a range of currents and voltages, but the majority are rated for mains operation. These devices are still rather expensive for amateur use, but can be valuable industrially because they can often be used without a snubber network.

This concludes the section on thyristors and triacs. After a month's break, I shall continue the series in the October issue with a look at the design and usage rules which apply to the more common logic families.

PE

## BOSFET SSRS

Just as we go to press on Andrew's article on Triacs, International Rectifier have announced the release of two miniature photovoltaically coupled solid state relays. The PVA 10 series of SSRS use IR's bosfet power ics and can switch current up to 160mA. They have output capacitances as low as 3pF and switching speeds of less than 25µs, making them ideal for situations ranging from thermocoupling to data transmission. Ed.

## SPECIAL REPORT

Continued from page 48 with under one watt using digital communications.

## REVIEWING KNOWLEDGE

Could all school courses be taught with monthly magazines? Why not? Most subjects can be turned into living experiences. History, for example, can be fascinating. Ask anyone who's read any of the great historical paperbacks that abound. None of that crummy names and dates memorisation screwball. Just think how many great historical movies there are that could be made

available on video tape as educational assists!

And at every turn, kids could be encouraged to learn more on their own; to join groups to learn. Kids could research their own city or town history and do their own video on it or put together a book. With desktop publishing becoming so inexpensive and simple, this tool will soon be available to many school students.

Then there's the insect world, much of which has to be studied in depth. Even a monthly magazine type of text would have difficulty keeping up with the kids if they got interested in bugs. You know, in all of history, man has yet to exter-

minate one single species of insect? And not for having failed to try.

## ADDICTIVE

Maths, too, can be fun. Maths is a living science. Every now and then you read of a youngster who's solved some long standing maths problem. When I was in high school we had a maths club where kids enjoyed the challenges of maths together. A video magazine would make it possible to bring the excitement of maths to many more kids.

Betcha, though, if I went on to politics and religion you'd be disagreeing with me again ...

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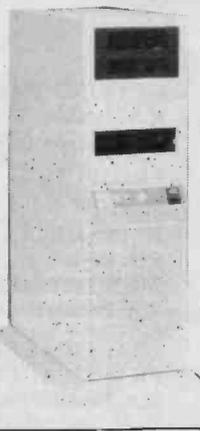
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4044B 0.38	4524B 0.44	40192 0.56	7446 0.60	74LS165 0.15	74LS165 0.15	74LS371 0.90	40LS608 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4045B 0.72	4525B 0.38	40193 0.56	7451 0.20	74LS166 0.15	74LS166 0.15	74LS372 0.90	40LS609 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4046B 0.45	4526B 0.70	40194 0.66	7470 0.30	74LS167 0.15	74LS167 0.15	74LS373 0.90	40LS610 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4047B 0.44	4530B 0.90	40195 0.80	7472 0.20	74LS168 0.15	74LS168 0.15	74LS374 0.90	40LS611 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4048B 0.28	4531B 0.60	40208 2.95	7473 0.25	74LS169 0.15	74LS169 0.15	74LS375 0.90	40LS612 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4049B 0.18	4532B 0.52	40240 1.36	7474 0.36	74LS170 0.15	74LS170 0.15	74LS376 0.90	40LS613 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4050B 0.20	4534B 2.63	40244 1.36	7475 0.30	74LS171 0.15	74LS171 0.15	74LS377 0.90	40LS614 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4051B 0.36	4536B 1.38	40245 1.36	7476 0.25	74LS172 0.15	74LS172 0.15	74LS378 0.90	40LS615 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4052B 0.36	4538B 0.59	40257 1.35	7483 0.60	74LS173 0.25	74LS173 0.25	74LS379 0.90	40LS616 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4053B 0.36	4539B 0.65	40373 1.10	7485 0.60	74LS174 0.25	74LS174 0.25	74LS380 0.90	40LS617 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4054B 0.52	4541B 0.65	40374 1.10	7486 0.35	74LS175 0.28	74LS175 0.28	74LS381 0.90	40LS618 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4055B 0.52	4543B 0.64	43403 3.58	7490 0.50	74LS176 0.28	74LS176 0.28	74LS382 0.90	40LS619 1.55	ICL7135CPL 15.50	ULN2804A 1.70	HPL-4200 5.82	
4056B 0.52	4544B 1.50	45000 15.14	7492 0.45	74LS177 0.75	74LS177 0.75	74LS383 0.90	40LS620 1.55	ICL7135CPL 1			



# DOWN-TO-EARTH ELECTRONICS

BY TOM IVALL

## THE LOCK'S COMPUTERED-UP

*Still waters run precisely as deep as they are told to, not a drip less and not a drop more.*

The other day I came across a beautiful grey-and-white heron standing solitary in shallow water. It was on a virtual island formed by a sharp loop in the River Thames. I was strolling there to get far from the maddening complexities of electronics for a few hours. The heron was mainly interested in fish. Little did either of us know that electronics had already crept up on us. The gently rippling water which the heron was standing in and which was soothing my brain by some kind of meditation process was actually being controlled in level by a sophisticated computer-based electronic system.

We tend to think of the rôle of electronics as being several layers removed from the production of the basic means of life (food, clothing, shelter). Predominantly a technology of information and signal processing, it seems at first to have very little to do with the primary sector of the economy (extraction and application of the earth's resources) and not much more with the secondary sector (processing materials, manufacturing etc). It's certainly prominent in the tertiary sector (services, transport, trade, entertainment etc) and fully at home in the quaternary sector (administration, finance, education, research and other knowledge-based activities). With this general pattern lodged in the mind, it comes as rather a surprise to find electronics working with something so down-to-earth as environmental water.

But when you look a bit closer at what is really happening you find that electronics has applications in all of these sectors. The bulk of the information processing is certainly done in the quaternary sector, but in the others a little bit of processing goes a long way, so in a sense it is more influential. In the Thames system, for example, the entire flow of a river — some 50 million gallons of water a day in the lower reaches — is being automatically controlled on an experimental basis through nothing larger in data processing capacity than an IBM PC computer.

The essential purpose of this scheme, John Walker of the Thames Water

Authority told me, is to keep the river at a required level. Written on a table of stone at the TWA are the sacred words: Standard Head Water Level. And the Authority has a statutory duty to maintain this level upstream of each of the 44 weirs on the river. Traditionally this has been done by the lock-keeper at each weir, who opens or closes the weir gates according to the flow rate with the aim of maintaining the SHWL to within  $\pm 3$  inches.

If the TWA failed to hold this stipulated level the result could be either flooding of the surrounding land at one extreme or grounding and possible damage to boats at the other. Either way the Authority is legally responsible for any damage caused.

*"...on a table of stone are the sacred words — Standard Head Water Level..."*

Although the SHWL has been maintained by manual control for many years it is an onerous job for the lock-keeper or his relief, requiring 24-hour cover seven days a week. Rivers don't conveniently stop flowing at the end of the human working day. Emergencies sometimes occur, such as sudden influxes of drainage water after heavy rainstorms coming off large areas of concrete like London Airport or the M25 motorway. One lock-keeper lost his life trying to remove a massive obstacle that was blocking his weir in the middle of the night.

In this situation the TWA thought it would be a good idea to try and maintain the SHWL by making the weirs operate automatically. The intention was not to put the lock-keepers out of a job but to eliminate the many short-term corrections they have to make to the weirs, sometimes while everyone else is safely asleep. At each lock and weir the lock-keeper would still be in charge of the automatic system, setting it to give the required water level and over-riding it manually if necessary.

After doing a feasibility study, which gave encouraging results, the TWA installed a pilot plant at Caversham Weir

near Reading, Berkshire. This control system is now running and will be on trial for about a year. If it proves successful the Authority will go ahead and automate all the other weirs on the river in a similar way.

The basic principle is very straightforward — a closed-loop control system which raises or lowers the eight weir gates at Caversham according to the river level measured at the upstream side of the weir. A bank of ultrasonic level transducers, made by Sarasota Automation Ltd, measure this water level. Their electrical output signals are taken once every five seconds and then undergo arbitration, averaging and smoothing in the IBM PC to get a reliable value.

The lock-keeper inserts the required level of the river on a keyboard. In the computer this set value is compared with the actual level measured by the transducers and the differences between them is calculated. The result is a deviation, or error-signal in control engineering language. This deviation value is then processed by an algorithm which applies proportional plus integral terms to it, as in an industrial process controller. Integral action is introduced to nullify spurious deviations caused by river flow disturbances.

After this processing the level deviation value is used to operate another algorithm for selecting among the eight weir gates and determining by how much they are to be opened or closed. So out of the computer come eight binary signals for commanding the electrical gear which raises or lowers the motorised weir gates.

These gates are pivoted or radial types. They control the flow of water passing underneath them as they are raised or lowered by cables and winches driven by electric motors. In the Caversham scheme the three-phase drive motors are included in closed-loop position control servomechanisms, with transducers to measure the actual angular positions of the gates. So the command binary signals coming from the computer are in fact desired values of gate angle for setting these control loops.

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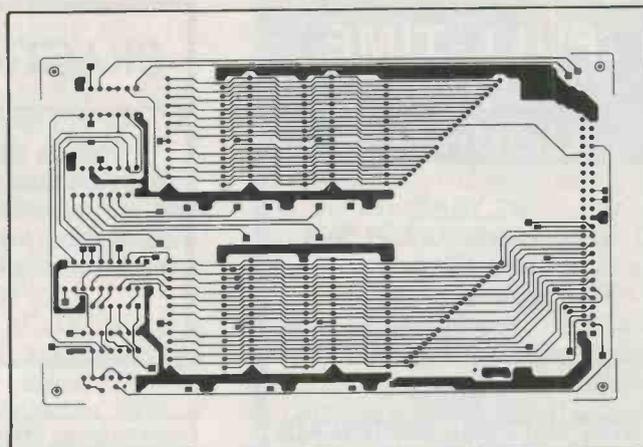
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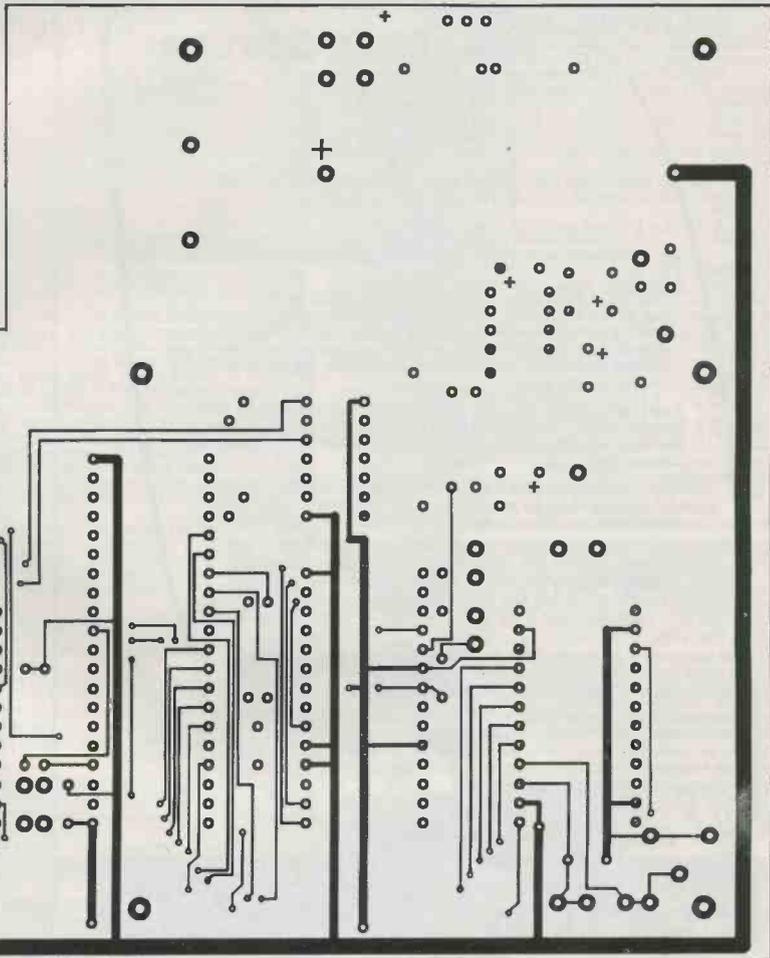
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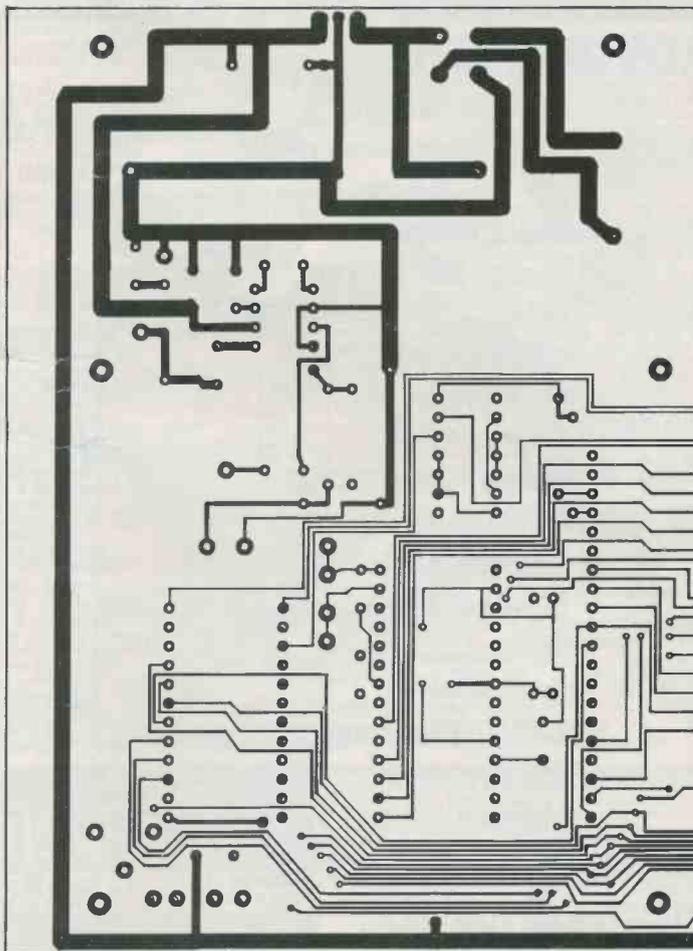
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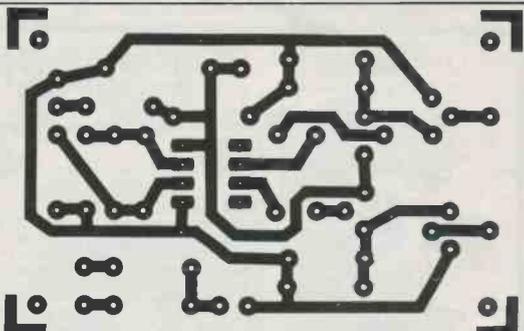


Speaking  
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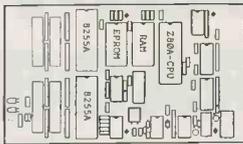
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